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SAFETY OF URBAN TRANSPORT WITH FOCUS ON PEDESTRIAN PROBLEMS

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CONTENTS

1. Observation of elderly pedestrians on signalized crossings and of jaywalkers in the vicinity of pedestrian subways

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1.1. INTRODUCTION

In a new research on the observation of pedestrian behaviour, we have selected two opposing forms of behaviour for study, starting from the crossing situation. The dangers involved in certain cases of rule-complying behaviour are opposed to the dangers of consciously breaking the rule and taking extra risk.

The crossing behaviour of elderly pedestrians was one problem to be studied. As they are known for better observing the rules than other age groups of road users, we wanted to know, how safe they really are and what sorts of problems they have to cope with, when choosing the "safest" way to cross the road. The other area of investigation was to see the circumstances of conscious crossing violations and the motives underlying them. We analyzed the extremes of rule-compliance and risk taking.

1.2. BACKGROUND DATA

In 1994 474 pedestrians were killed in Hungary. This means that 30 percent of the fatal victims of road accidents (1562 persons) were pedestrians.

Although the ratio of pedestrians killed has shown a continuous decrease in the last few years (it was 38% in 1986, for instance), it is still high as compared with the countries of high motorization: in the majority of West-European countries 18-20% of the fatal accident victims lose their lives as pedestrians. We cannot be sure that the decreasing number of pedestrian accidents and victims is a sign of the improvement of pedestrian safety. It is more probable that the mobility of pedestrians has decreased due to the development in motorization.

Before 1988 pedestrians constituted the group most at risk in road traffic also in Hungary, but from that time on more people are killed as drivers of cars or passengers than as pedestrians, first of all outside built-up areas.

Within built-up areas it is still pedestrian accidents that have the highest number of fatal victims, so it has been a priority task to prevent them. It deserves attention that of the 474 persons killed as pedestrians in 1994, 181 (38%) were over 60 years of age. So it is first of all the elderly, for whom the participation in traffic as pedestrians means an increased accident risk.

To identify the means and possibilities of prevention, it is important to acquire a profound knowledge of the accident circumstances. The first step is to analyze the circumstances of accidents that have happened.

Of the 4647 personal injury pedestrian accidents that occurred in Hungary in 1994 4046 (87%) occurred within built-up areas and 601 (13%) outside built-up areas.

The table below shows the personal injury pedestrian accidents that occurred in 1994 by accident type.

	NUMBER	OF	ACCIDENTS	
Accident type	Fatal	Seriously injured	Slightly injured	*Total*
Pedestrian crossing in front of (behind) stationary vehicle	11	115	193	*319*
Pedestrian hit in stop of public vehicle	8	48	711	*127*
Pedestrian hit on straight road section, on marked crossings	43	233	347	*623*
Pedestrian hit on straight road section, outside marked crossings	116	700	788	*1604*
Pedestrian hit in road curves, on marked crossings	4	19	20	*43*
Pedestrian hit in road curves, outside marked crossings	0	1	1	*2*
Pedestrian hit in road junction, on marked crossings	32	257	288	*577*
Pedestrian hit in road junction, outside marked crossings	24	108	141	*273*
Pedestrian hit when proceeding parallel to traffic	39	155	189	*383*
Other pedestrian accidents	6	35	54	*95*
Total	*283*	*1671*	*2092*	*4046*

Table 1:
Distribution of personal injury pedestrian accidents in 1994 in built-up areas in Hungary by accident type

Pedestrians being hit while crossing on straight road sections, outside marked crossings, has been the most frequent pedestrian accident situation (1604 in 1994) in built-up areas for many years.

The number of pedestrian accidents where pedestrians were hit while crossing on marked crossings on straight road sections, in curves or in junctions -- that is where pedestrians have the right of way according to the Highway Code -- is 1243, which is 30% of the total number of pedestrian accidents having occurred in built-up areas.

In the following we focused our attention on the age group of people over 65, being at the highest risk of getting involved in pedestrian accidents.

The table below shows the distribution of pedestrians over 65 years of age, injured or killed in 1994, by the place of the accident and the accident outcome.

	NUMBER	OF	PERSONS	*INJURED*
PEDESTRIAN TRAFFIC	Fatally	Seriously	Slightly	*Total*
On marked crossings	39	158	131	*328*
Between refuge island and pavement	3	11	15	*29*
At stop of public transport vehicle	3	22	21	*46*
In road junction, outside "zebra crossing"	18	55	35	*108*
On the road at other places	88	230	163	*481*
Total	*151*	*476*	*365*	*992*

Table 2:
Distribution of the number of pedestrians over 65 years of age hit in built-up areas in 1994, by the place of pedestrian movement and by accident outcome

Although most (481) pedestrians over 65 have been hit at "other places" on the roadway, the number of elderly people hit on marked pedestrian crosswalks -- that is theoretically on places under protection -- is very high as well.

Let us analyze the distribution of the number of the 992 elderly pedestrian victims according to whether there was a traffic signal on the spot and if so, whether it was functioning as usual or showed a flashing yellow light, or it was out of order (Table 3.).

		TRAFFIC	LIGHTS		
PEDESTRIAN TRAFFIC	None	Yes, in order	Yes, flashing yellow	Out of order	*Total*
On marked crossings	244	53	28	3	*328*
Between refuge island and pavement	22	6	1	0	*29*
At stop of public transport vehicle	39	5	2	0	*46*
In road junction, outside "zebra crossing"	104	3	1	0	*108*
On the road at other places	472	7	2	0	*481*
Total	*881*	*74*	*34*	*3*	*992*

Table 3:
Distribution of the number of pedestrians over 65 years of age hit in built-up areas in 1994, by the place of pedestrian movement and by the presence or functioning of pedestrian lights

Most elderly pedestrians (881) were hit at places where there were no traffic lights; the accident occurred on the roadway or at other places in 472 cases and on the marked crossing in 244 cases. 74 pedestrians were hit at places furnished with normally functioning traffic lights, 53 of them on marked pedestrian crossings. 34 elderly pedestrians were hit at flashing yellow lights, 28 of them on marked crossings.

1.3. THE VIOLATING PEDESTRIAN

Places where pedestrians cross the road avoiding to use pedestrian subways or overhead crossings are especially dangerous. Pedestrians are supposed not to hinder the proceeding of vehicles here and the drivers don't accept their priority. They don't count with the presence of pedestrians at such places to such an extent than in the case of road junctions or marked pedestrian crossings.

The establishment of pedestrian subways or overhead crossings is very expensive, but these structures are theoretically suitable to provide complete protection to the pedestrians. Experience shows however that many of the pedestrians don't use them, which spoils their efficiency to a great extent. It is therefore important to reveal the characteristics of the people not using these establishments, to know the motives for not using them and to investigate, what these rule-breaking crossings at road level look like.

A site in Budapest has been chosen, where several pedestrians are hit near the pedestrian subway (in 1993 4, in 1994 3 pedestrian accidents occurred here).

This place is near one of the central railway stations of Budapest. One of the exits of an underground station joins the pedestrian subway. Passengers leaving the underground station can directly enter the railway station, or any sidewalk of a broad, heavy trafficked road. It is a two direction road with six lanes (parking lane, traffic lane and the inner lane leading traffic to a bridge). The ramp of the bridge begins here. On the next lane vehicles are coming down from the bridge with high speed . On the next two lanes traffic near the bridge is proceeding.

If someone wants to cross the road on road level, he/she is exposed to several risks. Traffic is heavy and almost continuous. (This is especially true for traffic coming down from the bridge.) In the lane leading to the bridge there are often traffic jams, while on the next lane -- coming down from the bridge -- vehicles proceed at a speed of 50-60 km/h. Vehicles often mask (hide) one another; crossing the road requires full attention. A special risk may be that traffic is very slow or stopped in one lane because of traffic jams, while vehicles in the next lane are proceeding with high speed.

The exits of the pedestrian subway are not equipped with traveling stairs. There are 30 stairs leading to road level. At an easy pace it takes 2 minutes to get to the other side of the road using the pedestrian subway.

Pedestrians crossing at the road level have been video-recorded. Experience shows that it was in the early afternoon period that most pedestrians crossed here, without using the subway. (We recorded 18 pedestrian crossings in an hour, the number of crossing pedestrians was 26). 58 surface crossings were recorded, the number of crossing pedestrians was 90. The majority of crossings followed the line of the subway. (The pedestrians crossed the road at the place of the subway, but the crossing took place on the surface.)

Our assumption was that those elderly (ill) people choose to cross at road level, for whom it is difficult to use the stairs. The results didn't prove this assumption. There were only 3 people among those crossing above the subway who had apparent walking difficulties, for whom using the stairs would have been very exerting.

The majority of the crossing pedestrians were between 16 and 35 years of age. The estimated age of 3 pedestrians was between 60 and 70. Among the pedestrians crossing against the rule there were 63 men (70%) and 27 women (30%). 30 pedestrians were crossing alone, while the majority in pairs.

No serious conflicts have been recorded during the observations until now. The explanation for this may be that the pedestrians in question were fully aware that they should give way to the vehicles and that they should adapt their behaviour to the movements of the vehicles. The drivers gave priority to the violating pedestrians only in the case of traffic jams, because of which the vehicles were moving very slowly. (There was only on exception, when an elderly man with a walking stick was crossing.)

The majority of the crossings took less than 1 minute. (The longest crossing lasted for 77 seconds, the shortest for 9 seconds). In the first part of the crossing the pedestrians were not running, they gathered information and were waiting when necessary (even for 30-40 seconds). It seems however that in the second part of the crossing there is no more patience and the majority of the pedestrians begin running.

In the case of young pedestrians one could see on their movements that they were practiced in crossing on the road level. No sign of fear or anxiety could be detected from their movements. They got used to danger, or they simply didn't realize the risk. They tried to cross the road with the slightest possible time loss. We observed several times that they were proceeding on the lines separating the lanes, parallel to traffic, trying to use in this way the time which they were forced to devote to giving priority to the vehicles.

By making interviews, we wanted to get acquainted with the motives of not using the subway. Those, who really were in a hurry, stayed away from the interviews, because of refusing it due to time pressure. Most of the pedestrians were hurrying because they didn't want to miss their train. Those in a hurry significantly overestimated the time which could be spared by crossing on the surface. They thought that crossing against the rules resulted in a time gain of 5-10 minutes. The time gain was actually not more than 1-1,5 minutes.

The rule-breaking crossing behaviour of those pedestrians who were willing to be interviewed was motivated first of all by the love of comfort (laziness). The majority simply didn't want to use the stairs, although nothing limited their motions. Only one man said that he was unable to use the stairs because of obliterated arteria disease, and one pregnant woman referred to using the stairs as physical stress.

At the site of the investigation -- because of the nearby railway station -- there are many people from the countryside, not having local knowledge. They can find their way better on the road level than using the subway. Many of them didn't even know that it was possible to cross the road using a subway. One of the entries of the subway is really not conspicuous enough, it isn't within the direction of the main pedestrian flow, a small detour (of about 10 meters) has to be made to reach it.

It happened not only to country people, but also to people living in the capital that they have arrived to the road level at the wrong place. If someone lost the direction, he didn't go back, but tried to approach his destination on the surface. He/she wanted to avoid the burden of using the stairs and orientation is easier on the surface too.

The overwhelming majority of the pedestrians crossing at level didn't regard their behaviour for risky at all. Only the man with obliterated arteria disease and a 63 year old woman (who usually doesn't avoid using the subway) reported to feel fear while crossing the road.

1.4. PROTECTED CROSSING -- UNPROTECTED ROAD USER

There is usually no doubt about the increased risk of elderly pedestrians in traffic, but this well-known fact still seems to receive little attention in road safety activities. By the arguments summarized below I would like to stress the difficulties experienced by the elderly, crossing the road at the "safest" locations of the road network, at light signals.

Three signalized crossings were selected for the measurements. Three hours of observation at each crossing directed our attention to some characteristics that may be regarded as general. One site is of low, two are of high pedestrian volume. A narrow refuge island directly at the observation site 1. gives some illusion of being protected in the middle of the road at one of the locations. At site 2. there is a tram stop directly at the crossing. At site 3. selected for the measurements, there is turning vehicle traffic in one direction. The selected sites are located on a road with two lane traffic plus tram rails in both directions.

We focused on collecting the following information during the observation hours: accompaniment, apparent difficulties because of some "extra load" (heavy bags, walking stick, shopping cart, dog etc., making the movement more difficult or being a sign of walking difficulty), attention paid to traffic (or the lack of attention), the pace of movement (tempo) and whether or not the elderly pedestrians were able to reach the opposite kerb during the green phase. Apparent signs of fear, anxiety or relief after reaching the safe sidewalk could be noted in some cases. Pedestrians estimated by the observers to be over 60 years of age were the subjects, and only those who began crossing the road during the green (or blinking green) signal.

The crossing and watching behaviour of 376 elderly pedestrians -- 227 women (60%) and 149 men (40%) -- were observed. The first evaluation of the results shows the following characteristics.

74% of the pedestrians observed were walking alone, 23% in the company of contemporaries. 2% needed to be accompanied, and the number of elderly people walking with a child was as low as one per cent only. Our investigation covered only the green-walking pedestrians, that is those beginning to cross with green (93%) or blinking green (7%) signal.

35% of the pedestrians were looking left before crossing. 30% were looking only straight ahead and 35% were not paying attention at all. 54% of the pedestrians observed were walking at a normal pace, 22% were slow and 24% had apparent walking difficulties. 32% were looking right at about the half of the roadway. 27% were looking only straight ahead and 41% were not paying attention. 15% of the people observed managed to reach the opposite kerb in green or blinking green. 85% of them had to complete the crossing in red.

The differences between the crossing and watching behaviour of men and women are worth analyzing separately. It could be observed that the elderly male pedestrians were somewhat more assertive, unhesitant while crossing and they showed a fewer number of apparent fear reactions. They seem to be characterized by less walking difficulties (28%/17%). In the sample more men were accompanied by contemporaries than women (27%/20%). Slowness of movement was also more characteristic for women than for men (24%/17%). A considerable difference has been observed in watching behaviour: 44% of the men were looking left before stepping onto the road, while this number was only 29% for women. Watching becomes less frequent while in the middle of the road: only 35% of men and 30% of women is looking right. Attention paid to traffic is more characteristic for male pedestrians in the sample. 33% of the men and 46% of the women did not pay attention to traffic while crossing.

A total of 14% of the female and 18% of the male elderly pedestrians managed to reach the opposite kerb in green signal. 86% of the women and 82% of the men had to complete the crossing in red.

> Site 1: Of 62 elderly people crossing only one man has reached the opposite kerb in green; none of them stopped at the refuge island. Many pedestrians (32% of the women and 21% of the men) tried to speed up at about the second half of the crosswalk. The surface of the crossing deserves special attention. Its bad quality puts an extra load on pedestrians with any kind of walking difficulties, or simply wearing high heeled shoes.
>
> Site 2: At this crossing 18% of both men and women managed to reach the opposite kerb in green. 82% reached the opposite side of the road in red.
>
> Site 3: 14% of the women and 23% of the men were able to cross on green. 86% of the women and 77% of the men reached the opposite side of the road in red.

The apparent signs of difficulties experienced by the elderly participating in traffic as pedestrians can be defined as follows:

- very slow movement, physical handicap
- using a walking stick
- carrying heavy bags
- using a shopping cart
- irrational (illogical) behaviour (e.g. running across the road)

- looking in the wrong direction
- looking several times to both directions
- lack of attention

The latter seems to have different reasons (of mental, physical or social origin, or a combination of those), for instance:

1. The pedestrian is completely absorbed in some other activity while walking across the road (conversation, having an ice-cream etc.)
2. The full attention of the elderly is required by walking. In this case the pedestrian has to concentrate on not falling over and he/she has no capacity to pay attention to traffic at all.
3. In the cases when two similar age elderly pedestrians are walking together, one is usually leading the other, trying to pay attention to traffic. The problem of being slow remains there, even if some attention is paid to the vehicles.

Further characteristics are

- illogical decision making
- shortening the length of way
- pottering about, sleep-walking, going about dreamily
- going and not seeing anywhere (with bended head)
- trying to hurry up.

In some cases we observed risky situations arising because of the slowness of the pedestrians on the crossing.

In the selected crossing situations there was practically no need for the pedestrians to communicate with the drivers, except for some cases. One has the impression that in many cases it would have been difficult or impossible for the pedestrian to communicate, because of apparent difficulties. We do not know, whether in these cases it is a conscious decision from part of the elderly to choose the safest way of crossing, a signal controlled junction to cross the road, trying to reduce the risk involved.

The following crossing strategies (and possible philosophies behind them) could be followed.

> "Green means safety. I have to pay attention to the light and start immediately when it turns green, so that I can get through." The danger involved in this thinking may be that a car driver doesn't observe the light signal and tries to get through the crossing in the last moment, when the light is changing to red for him, but it is already green for the pedestrians.

The elderly cannot be expected to behave in a rational manner in every situation and the instruction teaching the importance of a checking glance before starting to cross is rare. In this way the elderly are at increased accident risk when starting to cross without looking, whether the approaching vehicles are going to stop. This is often the case, as the elderly tend to pay attention to the signal only, looking straight ahead. The continuation of the crossing becomes problematic, when the light turns red and the pedestrian is only in the middle of the road yet. He/she may try to walk quicker, to stop or to keep going at the same tempo. Any of the cases can be stressful, if not directly dangerous.

2. "I can trust the others. If they can get through, so can I." This is not always the case, as the elderly pedestrian may not realize his own limitations. He may be slower than the others and so he may get involved in risky situations. Crossing in a group seems to give a feeling of security, even when it is not finished with the group.

3. Although we didn't deal with pedestrians crossing in red, we must note that a considerable part of elderly pedestrians began crossing in red at one side of one of the sites. It seemed completely safe and doing so there was more time left for finishing the crossing possibly in the green signal. It is a bit confusing that it seems to be more safe at this particular place to start at the red signal than to wait for green. Such a false setting of the lights may weaken the general intention to obey the rules.

The observed problems are difficult to change, since they depend on the given physical state and the given everyday life of the road user group in question. The social implications of the problem include health care as well as the frequent and necessary self-support of the elderly, which seem to determine their mobility in many cases. Taken the present situation, the need for mobility of the elderly (and its inevitability in some cases) for granted, it is desirable to improve at least those circumstances of their traffic participation, which are relatively easy to improve. Unfortunately, the present day practice is often the opposite: the traffic environment itself puts extra load on the elderly pedestrians.

The extra difficulties include the **time pressure** when using a light controlled pedestrian crosswalk as well as the **bad quality of the surface** of the crossing, which requires the full attention of the old pedestrian, if he/she wants to cope with the situation. It is a real achievement to cross the road in many cases, especially on a crossing, where even the younger pedestrians cannot manage to reach the opposite kerb during the green signal.

If we speak of the safety of the elderly pedestrians, the question of responsibility arises. From the present investigation we excluded those basic situations, in which the elderly can be blamed, because of exhibiting unsafe behaviour. However, pedestrians trying to observe the rules, but not being in the position to perform such behaviour which ensures the safety of the whole crossing procedure, cannot and should not be blamed for their accidents. By stressing this I would like to underline the importance of a more "elderly-friendly" traffic environment and the responsibility of those groups of the society -- both experts and laymen -- who plan, accept and sustain a given level of road safety.

1.5. CONCLUSIONS

The preliminary results of our investigations draw the attention to the influence of the traffic environment on behaviour and safety and the importance of traffic engineering measures. In the case of elderly "green-walkers", who are not able to cross the road safely because of physical handicaps, there seems no other way to improve the situation than to give more time, more "green time" to them. In the case of the other group -- although there may be some hope that education can help preventing non-compliance -- from the safety point of view it is better to shape the environment so that it doesn't allow risky behaviour, or that at least it should attract and facilitate the use of safety devices and structures.

2. New pedestrian-crossing regulation: changes in the behaviour of pedestrians and car drivers

An observational study

Uwe Ewert

2.1. *INTRODUCTION AND OBJECTIVE*

With effect from 1 June 1994, Switzerland's traffic regulations were changed to give the pedestrian the right of way at a pedestrian crossing when there is an evident intention on the part of the pedestrian to use the crossing. This makes the position of pedestrians much stronger because they are no longer required explicitly to signal car drivers that they intend to cross the road.

The objective of this study was to find out whether and to what extent the behaviour of drivers and pedestrians had changed in the year since the new regulation came into force.

2.2. *STUDY DESIGN*

Accordingly, before-and-after surveys were carried out. The pre-test took place at the end of May 1994. Four further observation sessions took place at intervals of approximately three months: in August and December 1994, and in March and May 1995. Initially, observations were made at a single pedestrian crossing only, but this was increased to three crossings for observation sessions 3 to 5. The study design is shown in Table 1. The before-and-after observations were made on the same day of the week in order to minimize the effect of day-to-day fluctuations.

Location	May '94	August '94	December '94	March '95	May '95
Berne, suburban area	X	X	X	X	X
Berne centre			X	X	X
La Chaux-de-Fonds (French-speaking)			X	X	X

Table 1:
Data collection locations and times

Because a full cross-over design was not available, analyses were done in two ways: First, the data from the Berne suburban area were used to determine the longitudinal section of pedestrian and car-driver behaviour development. These findings were then checked to see if they were also applicable to other locations and whether there were any changes between observation sessions 3 and 5. However, in the interests of simplicity the following presentation will be confined to the longitudinal-sectional development.

2.3. REPORT FORM

The report form (see Appendix), which was filled out by university student researchers, was intended for the recording of obvious patterns of behaviour only. Behaviour which could not be clearly observed (for example, eye contact) was not recorded. Reporting concerned only situations in which a pedestrian and one or more motor vehicles were involved. Apart from sex and approximate age, it was noted whether the pedestrian stopped before stepping on to the road, and whether vehicles drove past the pedestrian without stopping. It was also recorded whether there was a braking or stopping vehicle and whether the pedestrian had already stepped on to the road in such cases – in other words, whether the driver stopped voluntarily or was forced to stop by the pedestrian's presence in the road.

2.4. RESULTS

During the first observation session, 290 pedestrians were observed; during session 2 there were 228; during session 3, 206; during session 4, 118; and during session 5, 103 pedestrians.

At the time of the pre-test, 62.1 per cent of those observed were female, 37.9 per cent male. During the observation session immediately following the introduction of the new regulation, 65 per cent of those observed were female; during the third observation session, 72.4 per cent; during the fourth session, 63.6 per cent; and during the fifth, 74.8 per cent. These differences are not statistically significant (chi-square = 9.46, df = 4, p = .051).

The age profile of the persons observed also did not vary across the five observation sessions. A one-way analysis of variance revealed no significant differences (F = 2.83, df = 4, p = .220).

The first step in the analysis of the results was to establish whether the proportion of pedestrians who stopped at the pavement edge had changed. During the first three observation sessions, approximately 95 per cent of all pedestrians stopped while they were still on the pavement when there was a possibility of conflict with a vehicle. In sessions 4 and 5 this proportion dropped to 89.8 and 92.2 per cent respectively. This difference is significant (chi-square = 11.47, df = 4, p = .022). It is possible that more pedestrians were taking advantage of their new rights at pedestrian crossings. However, at approximately 10 per cent, the proportion of such pedestrians is very low.

The next part of the analysis was concerned with discovering whether the number of vehicles which drove past a waiting pedestrian had changed. During the first observation session an average of 2.65 vehicles drove past a waiting pedestrian. In observation sessions 2 – 5 the averages were 1.66, 1.71, 1.25 and 1.48 vehicles, respectively. This difference is highly significant (F = 19.6, df = 4, p = .000). A Scheffé multiple comparison test showed that only the results from observation session 1 differed from the other four. This effect is likely to have been due to the regulation change.

Analysis was then focused on the proportion of braking or stopping vehicles. However, only those encounters between car drivers and pedestrians in which a pedestrian was standing and waiting at the edge of the road were analyzed. This was done in the interests of better comparability of the results. The proportion of encounters in which a vehicle stopped or braked rose between observation sessions 1 and 3 from an initial 12.5 per cent to 29.8 per cent and 46.3 per cent, and then dropped in sessions 4 and 5 to 34.9 per cent and 31.6 per cent, respectively. This effect is highly significant (chi-square = 67.2, df = 4, p = .000).

The high level of significance is largely due to the difference between the results obtained in observation session 1 and the results from the other four sessions. Nevertheless, the decline in readiness to stop which was evident in observation sessions 4 and 5 must be considered the critical region. Moreover, one cannot exclude the possibility that there was a certain coincidental nature about the increased readiness to stop shown in session 3. The willingness to stop seems to have stabilized at a level of approximately 30 per cent.

The only remaining question is whether the car drivers stopped voluntarily or were forced to do so by the behaviour of the pedestrians. The proportion of encounters in which the car drivers were forced to brake because a pedestrian was already in the road has not changed significantly (p = .30), even if there was a numerical reduction in such conflicts (from 43.9 per cent to approx. 30 per cent).

2.5. CONCLUSIONS

One can deduce from this study that the change in the law concerning behaviour at pedestrian crossings, has led to changes, especially on the part of car drivers. The proportion of pedestrians who wait at the edge of the pavement has hardly changed. On the other hand, the average number of vehicles who drive past waiting pedestrians before they can cross the road has dropped from 2.6 to 1.5. The proportion of cases in which a car stopped to allow a pedestrian to cross the road rose from 12.5 per cent before the introduction of the new regulation to 29.8 per cent, 46.3 per cent, 34.9 per cent and, finally, 31.6 per cent one year after its introduction. The analyses show that the position of the pedestrian has been improved by the change in the law, and that a proportion of car drivers indeed observe the new regulations.

2.6. APPENDIX

Observation of pedestrians crossing the road

General information

Identification number of researcher ☐
Number of subject ☐
Time (hour) ☐

Observations

Sex	male		☐
	female		☐
Approximate age	young child	(< 9)	☐
	older child	(10 – 14)	☐
	young person	(14 – 18)	☐
	young adult	(18 – 30)	☐
	young middle-aged	(30 – 44)	☐
	old middle-aged	(45 – 60)	☐
	elderly	(> 60)	☐

Pedestrian stops (feet alongside each other)
no
yes

If yes, number of cars which fail to stop (slashes or number) ☐

Car that decelerates or stops
no
yes

If yes, was the pedestrian already on the road when the car started to decelerate?
no
yes

3. The "speed" activity in the first national road safety program in Croatia

Mladen Gledec

In order to decrease the speed and the degree of traffic danger on some arterial roads, the town of Zagreb has introduced speed limits on these roads higher than the general speed limit for the inhabited areas, a year ago.

In this paper some of the results of this experiment are presented and discussed, based on the evaluation study carried out for the purpose of this project.

3.1. INTRODUCTION

In the first National road safety program in Croatia, established by the Government 17. June, 1994, the activity "speed" was established as one of four safety activities.

Its intention was to reduce the speed of the vehicles on our roads generally, and the special objective was supposed to be: the respect of the highest allowed speed on 85% of the roads, with the acceptable exceeding of the limit for at most 10 - 15%.

In the operational plan for this part of the program a number of various activities were planned, and their realization started by the beginning of 1995. As the activities are still ongoing, we cannot speak about the achieved results, but it seems sure that they will be just selective.

Although not directly, but as a part of the realization of the National program, and on the path of the entirely identical meaning and the objectives defined in the Program, and synchronously with it, the experimental program of the introduction of higher (i.e. more adequate) speed limits on some of the "fast" city roads was introduced in Zagreb.

That experiment was carried out based on a previous study, which was realized on a number of arterial roads in the town, and on the conclusion to start with the speed limits higher than for the inhabited areas experimentally and selectively. For that purpose four city roads were chosen, for which it was estimated that they had the best preconditions for higher limits, and the new higher limits for them were set between 70 and 90 km/h.

It was also established that this experimental project should last for a year; from June 1994 to June 1955. Some of the results of this experiment are shown in this paper.

3.2. THE PROBLEMS

The evaluation study should establish the effects of the project of higher speed limits introduction and whether the defined objective - decrease of real speed and decrease of danger- has been attained, and to which extent.

According to this, the conclusion could be made as to what to do after the experimental period, on these as well as on other similar roads.

3.3. METHODS OF OPERATION

Since a few different effects could have been expected from the introduction of higher limits, the following proportions were monitored:

- traffic flow,
- the speed characteristics of traffic,
- the rate of incidents on particular road sections,
- the attitudes and opinions of the drivers.

And parallel to this, all of the preventive actions were monitored; (from the operational plan of the National program), which were, together with the established new higher limits, supposed to attain the defined objectives.

Beside the chosen roads, some similar roads were monitored for the purpose of control, so that the possible effect of some other factors and circumstances to these "criteria" indicators could be monitored.

The monitoring of all four indicators was carried out in four subsequent periods, which was supposed to give the image of the situation:

- immediately after the introduction of higher limits,
- three months later,
- six months later, and
- a year later,

on the experimental and control roads.

The traffic flow was monitored by round-the-clock filming under the usual conditions of traffic.

The speed characteristics of the traffic flow were established on the vehicles in the circumstances of a free traffic flow; (time of monitoring at least 5 seconds), and in the conditions of day-time visibility, with a civil radar and without the knowledge of the drivers.

The rate of the incidents of particular sections was established on the basis of the police records of accidents, and the risk analysis was made by a special computer program - "IISSPCM"; (from the information about the accidents and their consequences, and from the data about the traffic flow on that sections).

The attitudes and opinions of the road users were established by questionnaires for the drivers, at two different points on the experimental roads.

3.4. THE RESULTS

3.4.1. Traffic flow

During the monitored period the intensity was increased on all roads, for an average of 2%, and without some recognizable changes in their structure. There were no differences between the experimental and control sections of the roads, thus we can conclude that higher speed limits had no impact on the proportion and structure of the traffic flaw, which was to be expected.

3.4.2. The speed

Pictures 1, 2, and 3 there present the following characteristics: average speed, the speed of the 85th percentile, and the coefficient of the speed variation on the experimental and control sections, “before” and 4, and 12 months “after” the introduction of the higher limits.

On all the experimental sections there was a tendency of decreasing the average speed, and on all the control sections, these speeds, as well as average speeds were increased or the same as in the previous period.

The speed of the 85th percentile was reduced on almost all the experimental sections, and on the control sections, these speeds were increased as well as average speeds in relation to the previous period or they were the same.

On the control sections the dispersion of speeds was reduced or remained at the same level. On the experimental sections different tendencies were noticed. On some of them the dispersions of the speed were reduced - which is good, on some of them they remained the same, and on some of them the differences were even increased, which is not good.

On all the control sections the average exceeding of the speed limit was increased, which, of course is not good.

The fact whether these changes are the results of incidental variations or the consequence of higher limits and other activities was checked by the use of the statistical test of significant differences - “T-test”.

In Table 1, we present the results of the application of T-test on the speeds in the phase “before” and at the end of the phase “after”, i.e. at the end of the 12 months period after introducing experimental higher limits.

SECTION	T - RESULT	DEGREE OF FREEDOM
01	5,54*	176
02	0,49	174
03	4,08*	178
04	3,95*	174
05	1,10	172
06	5,93*	173
07	0,54	173
08	5,81*	172
09	2,15*	184
10	2,17*	175
11	2,39*	178

Table 1:
The significance of the differences between sections, “before” and (12 months) “after”.

Note: *“ * “ indicates the statistically significant difference at the level of 95% probability.*

As it is evident, the significant decrease of the speed on almost all the experimental sections is noted.

3.4.3. The accident risk

The accident risks in the monitored years, for both, experimental and control sections, are shown in Table 2, and Table 3.

SECTION	YEAR				CHANGE (%)
	1993	1994	93-94	1995	
01	9,8	9,3	9,6	8,0	- 17
05	9,3	8,1	8,2	11,2	+ 37
06	1,1	0,9	1,0	1,0	-
07	2,6	4,0	3,3	7,1	+ 115
08	2,7	6,8	4,8	4,5	- 6
09	10,1	11,7	10,9	5,8	- 47
10	4,9	4,0	4,5	1,8	- 60
11	4,1	2,0	3,1	4,6	+48
Average	*5,5*	*5,9*	*5,7*	*5,5*	*- 4*

Table 2:
The accident risk on the experimental sections

SECTION		YEAR			CHANGE (%)
	1993	1994	93-94	1995	
02	7.4	4.9	6.2	3.6	- 42
03	4.5	6.3	5.4	8.5	+ 57
04	4.9	5.8	5.4	5.3	- 2
Average	*5.6*	*5.7*	*5.7*	*5.8*	*+ 2*

Table 3:
Traffic accident risk on control sections

If one observes road sections in groups - experimental and control sections, the following tendencies can be seen:

a) experimental sections

- risk level in the period “before” - 5.7,
- risk level in the period “after” - 5.5,

which corresponds to the decrease of the average risk level for about 4%;

b) control sections

- risk level in the period "before" - 5.7,
- risk level in the period "after" - 5.8,

which corresponds to the increase of the average risk level for 2%.

If, then, the risk level has in the mean time increased a little, or at worst, it has stagnated, the risk level at experimental sections has slightly decreased, which is obviously the effect of introduced higher limits and other activities which have been being carried out.

It should be said that the degree of the decrease in risk of traffic accidents is very similar to the degree of decrease in actual speed, which can be seen in the following tables: 4, 5 and 6.

SECTION	BEFORE	AFTER	CHANGE (%)
01	86	77	- 11
05	82	80	- 3
06	92	79	- 14
07	86	85	- 1
08	83	74	- 10
09	89	85	- 5
10	74	70	- 5
11	78	74	- 5
Average	*84*	*78*	*- 7*

Table 4:
Change in the average speed at experimental sections (km/h)

SECTION	BEFORE	AFTER	CHANGE (%)
01	97	88	- 9
05	98	91	- 7
06	102	93	- 9
07	96	96	0
08	95	82	- 14
09	106	93	- 12
10	82	78	- 5
11	88	80	- 9
Average	*96*	*88*	*- 8*

Table 5:
Changes in speed of the 85th percentile at the experimental sections (in km/h)

SECTION	BEFORE	AFTER	CHANGE (%)
01	14.1	12.2	- 13
05	15.0	16.1	+ 7
06	14.7	17.6	+ 20
07	12.5	12.7	+ 2
08	12.9	11.3	- 12
09	17.3	12.5	- 28
10	10.4	10.8	+ 2
11	13.6	12.8	- 6
Average	*13.8*	*13.2*	*- 4*

Table 6:
Changes in variation coefficient at the experimental sections

Therefore, the decrease in risk of traffic accidents - of 4% - highly corresponds to the decrease of speed at the experimental sections; of the average speed for 7%, of the 85th percentile speed for 8%, and of the variation coefficient for 4%.

That these changes in speed are the indicators and predictors of the traffic accident risks, has been shown by the regression analysis carried out between: the average speed and traffic accident risk for the status "after", which has established the correlation coefficient between these values from 0.44. To be sure, this value is not statistically significant at the level of 95% probability, but it is surely near to being significant, and therefore important.

3.4.4. Attitudes and opinions of the road users

The level of drivers' familiarity with the values of limits at certain places has increased from the previous 57% to 83%, which speaks a lot about drivers' attitudes towards the higher limits.

At the same time, when explicitly asked about the justifiability of such step, drivers have mostly replied positively, and in most of the cases they considered the limitations justifiable.

3.4. DISCUSSION ON THE RESULTS

The previous results have shown that the introduction of higher speed limits on some of the main roads in the city of Zagreb has resulted in the actual speed, and in a certain decrease of the actual danger degree.

According to the noted results from numerous previous similar experiments and studies (Salusjarvi, Nilsson, Fieldwick and others); a connection between the level of speed and the risk degree significantly stronger than here established, as well as a certain "progression" and not a "digression" with the decrease of risk degree related to the changes in speed. But, two important conditions should be carried in mind.

First, the risk analysis in the period "after" covered one year period only, which is in the case of traffic accidents a short period. Therefore, the picture of the actual danger degree in the following period could be very different. Second, not all observed sections have the same number of crossings with the largest number of traffic accidents, and the accidents on crossings were observed as accidents in the section in whose structure the related crossings were in. Namely, it is very probable that the accidents on crossings are very weakly connected with the speed in the sections, and that they in fact make the real results vague.

3.5. CONCLUSION

The introduction of higher speed limits, together with the police observation activities and other informational and publicity activities, have led to a significant decrease of speed in almost all sections in which experimental higher limits were introduced. But, this positive "synergetic" effect, was not equally present at all road users because, despite to the general decrease of speed level, the dispersed speed values at some sections were even raised. Therefore, it could be established that most of the ("average") drivers, at the experimental sections lessened their speed values, but those who were the fastest have lessened their previous speed values insignificantly, or have not lessened them at all.

Regardless of the fact that the decrease of speed level is a positive result, a partial decrease of speed dispersion is not satisfactory.

Although, the speed level at the experimental sections has been generally lessened, the intensity of the decrease, primarily because of those (permanently) fastest drivers, is not completely satisfactory. Namely, the level of relative speed exceeding is not at some of the sections on the level to 10%, but goes between 10 and 14%.

Upon the introduction of higher limits there appeared an average risk decrease of car accidents or of the danger degree for about 4%. The value of this decrease is very close to the value of the average decrease: medium speed, speed of the 85th percentile, and the speed variation coefficient in traffic circulation at these sections.

Between the risk level of traffic accidents and the medium speed values of vehicles there is a certain connection, which has a tendency towards being statistically significant, which certainly means that further large traffic accident risk decrease is possible to be reached with further decrease in speed, as well as with their mutual differences in traffic circulation.

The introduced higher speed limits were mostly welcomed by drivers, and similar measures at other similar places were asked for. Their significantly improved perception in relation to the perception of the speed limitations in all other places shows that the higher limits on these roads were welcomed. If one remembers everything previously said on the results we reached, it could be concluded that the introduction of higher speed limits on some of the roads was a real motion study move.

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4. Overview of traffic safety problems - vulnerable road users

Åse Svensson

This presentation covers selected parts of a preliminary report in the RS7 OECD group on traffic safety and vulnerable road users. The report deals with "traffic safety and intermediate methods" and is a summary of articles received from different OECD countries.

4. 1. FACTORS AFFECTING SAFETY FOR VULNERABLE ROAD USERS

The aim of this work is an attempt to describe general patterns that can be found in connection with the appearance of accidents. The major source is intermediate data like conflict data and behavioural data. It has sometimes, however, been unavoidable to refer to studies based primarily on accident analysis since corresponding studies with surrogate data are missing. This is not so devastating as many parts of the traffic safety discussion is quite unanimous and rather independent of which type of data the analysis is based on. The common denominator for a lot of the traffic safety work is to find out what it is in the traffic process that causes safety problems. As it has been stated so many times before, it is quite impossible to extract one single cause and advise one single solution to all safety problems for vulnerable road users. It is instead a combination of factors, behavioural and environmental, that prepares the ground for unsafe situations.

From a general traffic safety point of view and especially from vulnerable road users' point of view, the traffic environment must allow the road users to make mistakes. Making a mistake should not inevitably result in being killed or severely injured. Low speeds is the fundamental principle for a safe environment. If we could make sure that all interaction between road users was performed at low speeds then it is possible to set up the following additional traffic safety principles to improve safety for vulnerable road users.

- Good view

- Easy to make decisions. It should not be too complicated to understand how to behave at an intersection.

- Enhanced attention in critical situations. The demand for an adequate level of attention is crucial.

- No feeling of right of way. The road users should not have an obvious feeling of right of way. It makes the road users less prepared for unforeseeable situations.

- A big feeling of responsibility. Road users must feel that they have responsibility for other road users' life and health. The responsibility must be mutual.

- Equality is the basis for good interaction in traffic. All road users must to a great extent take part in traffic on fairly equal terms.

- A sense of uncertainty about coming events is good for traffic safety. It makes the road users better prepared if something unforeseen happens. The uncertainty should however not be so big that it creates stress. On the other hand, there should not be any uncertainty at all when it comes to identifying hazardous situation. When the road user for instance approaches a certain type of intersection, the traffic environment must give distinct messages about the imminent demand of increased attention.

- Support for a socially acceptable behaviour. The traffic system is our greatest social system and it must work according to certain acceptable social rules.

- Integration. Very often the conditions in urban areas do not make it possible to let vulnerable road users cross in a grade-separated way. The alternative is to integrate the vulnerable road users with motorized traffic, to let the road users meet and interact, in order to "force" car drivers to interact safely.

4.1.1 Speed

There is a very close relationship between vehicular speed and safety. There are two aspects on this relationship. First the probability of an accident to take place at all, the accident risk, is dependent on the involved road users speeds. Secondly the outcome of the accident, the consequences of the accident, is highly dependent on the speed at the moment of collision. As the word implies, cyclists and pedestrians are more vulnerable than for example car drivers and passengers in case of an accident. There are many studies supporting this relationship between speed and safety and Eero Pasanen has for instance applied a mathematical model to the connection between driving speed and the safety of pedestrians (Pasanen, 1992). Here Pasanen defines pedestrian safety as the risk of being killed. It includes the probability of an pedestrian to get hit by a vehicle and the probability of getting killed when being hit. The explanatory variables in the model are vehicle speed, driver's brake reaction time, deceleration of the vehicle and time that the pedestrian remains in the vehicle's collision course. As a result of this model a speed of 50 km/h means a risk of death that is almost eight times higher compared to a speed of 30 km/h. If collision speed is less than 30 km/h, injuries to the pedestrian are often moderate. On the other hand if collision speed exceeds 60 km/h the pedestrian probably dies.

Eero Pasanen has also analysed 18 video recorded traffic accidents at two intersections in Helsinki (Pasanen, 1993). Comparison with police statistics show that 80% of the injury accidents were captured on the tape. Ten pedestrian accidents and eight including only motor vehicles. The free-vehicles, vehicles not in queue, have an important role to play in these accidents. A vehicle is defined as free if the time gap to the previous vehicle exceeds 3 seconds. All pedestrian accidents involve a free-vehicle though only 40% of the reference traffic consists of free vehicles. Eight of the pedestrian accidents involved a straight on moving vehicle. When speeds were analyzed Pasanen found that the average speed of the vehicles involved in the eight accidents was 47 km/h i.e. 9 km/h higher than the average speed of all reference vehicles. Compared to the average speed of free vehicles in the reference traffic, the average speed of the collision vehicles were 4 km/h higher.

4.1.2 Interaction

Good interaction between road users is interpreted as safe interaction. If we turn this argument upside down then the very opposite would be that bad interaction between road users creates unsafe situations. Bad interaction is often characterized by anonymity and priority to the own mobility often at the expense of safety. An interesting part here is to think of who it is that dares to put the own mobility in front of safety. Up to a certain level, a majority of the road users are prepared to give up some safety for the benefit of mobility. When the risk exceeds what is acceptable from the instinct of self-preservation then the vulnerable road users are too vulnerable to consciously do this trade off. If the vulnerable road users still give priority to the own mobility at this point it must be assumed that the vulnerable road users are not fully aware of the risk they expose themselves to. This is for instance the case for red running pedestrians and cyclists. As an example it might be worthwhile mentioning that a typical pedestrian behaviour is to start crossing some seconds before receiving green assuming that the signal will turn green very soon and that all conflicting traffic has red. The pedestrian assumes he is walking safely, and is not prepared to interact and is for that reason even more vulnerable. The main responsibility for bad interaction most often lies with the motorized traffic. Car drivers are at least protected by a hard shell and are therefore in the position of being able to do a trade off between safety and mobility at a rather high level of risk. Thanks to all passive safety measures introduced to-day, a car driver easily gets the feeling that he can not be injured. The big number of red-running cars is a good example of this. Red-driving cars is a major safety problem for pedestrians. Good interaction is achieved when motorized traffic, either voluntarily or by force, limit their mobility and let the vulnerable road users have a more equal position in the traffic process compared with car riders. It seems as if force is a much more successful way of doing it, at least in the short run. It is unavoidable to once again mention the significance of speed. High speeds create an environment where the interaction between the road users is bad and therefore increases the probability for unsafe situations to appear. It is possible to promote interaction by lower speeds and by letting the road users get physically closer in space.

4.1.3 Expectations

Difference in expectations between road users and the fact that people sometimes have a wrong expectation of the prevailing situation, is the third factor to be brought up here in the context of factors contributing to the appearance of accidents.

How different road users' expectations can cause problems - the case with the marked zebra crossing. In Sweden, the most common measure to promote safe crossings for pedestrians, has been to introduce marked pedestrian crossings. No safety evaluation was ever conducted to establish the true safety potential. It was so obvious that pedestrian safety must increase if they were provided with an area of their own to cross at. Painting white stripes in the road and putting up signs was very cheap compared to other more sophisticated measures. It also turned out to be a very good measure to introduce with the intention of calming parents that were concerned with their children's safety, since everybody believed in it's safety potential. In 1988 Lars Ekman finalized a study where pedestrian risks on marked pedestrian crossings were compared to risk at other locations of crossing. His findings were (are perhaps still today) very controversial. Ekman concludes that the risk is higher for a pedestrian to cross on a marked zebra crossing or on a signalized marked crossing than at other intersectional crossings. Control was made for car flow and the presence of children and elderly but that could not explain the poor result of marked pedestrian crossings.

The main result is that the number of accidents per crossing pedestrian is two times higher at crossings compared with similar locations without marked pedestrian crossings. The behaviour of the car drivers as they approach a marked crossing is studied by analyzing the approaching speed and speed profile. The speed profile shows that the car drivers to a very small extent stop and let pedestrians pass. Neither does a higher degree of pedestrians present influence the approaching speed.

One explanation, according to Ekman, to the higher risk on marked pedestrian crossings could be that the pedestrian expectation of the marked crossing's safety effect is higher than the respect car driver's show for the marked crossing. Here we have a clear case where the different road users' expectations can cause problems. Everybody is taught from childhood that the marked pedestrian crossing is the place for pedestrians to cross. This puts pedestrians into a sense of security. They are not so attentive to dangerous situations that they according to statistics should be. Pedestrians use the marked pedestrian crossing with a false security. Drivers on the other hand consider the road as their territory and pedestrians should not attempt to cross until the motorized vehicles have passed by. At locations where pedestrians feel less safe i.e. at locations with no crossing facilities, they act more cautious. The pedestrians know that they cross the road "at their own risk" and are therefore more attentive to dangerous situations.

How expectations of the normal situation can cause problems - The difference between the normal, most frequent, situation which has been handled in a safe way many times before and the prevailing in some sense extreme situation that leads up to a hazardous situation. That is, the problems arise when the expectations are not in accordance with the prevailing situation. According to the traffic safety principal about "uncertainty", traffic safety do benefit if there is a sense of uncertainty about coming events. It makes the road users better prepared if something unforeseen happens. To expand this a little, the "normal" situation can either be site and perhaps time specific or situation specific.

Site and time specific - Let us say that we have a car driver that drives through a certain intersection daily. He never meets a pedestrian or a bicyclist there. So one day he happens to pass the same intersection, but at an other time of day. He knows back in his head that there is nothing in this intersection that demands him to be extra attentive - the feeling of security is high. If a pedestrian or cyclist appears in this latter case, the buffer for handling the situation in a safe way has dramatically decreased.

Situation specific - There is a report by Summala et. al. 1995 where the connection between bicycle accidents and drivers' visual search at left and right turns is studied. This study is based on the findings in the Helsinki City accident data base, Pasanen 1992. Analyses indicated a higher accident risk between vehicles crossing a cycle path while entering the intersection to turn right and cyclists coming from the right than for vehicles turning left. So drivers' scanning behaviour was studied from video recordings in two T-junctions. The result supported the hypothesis that right turning drivers scanned the left leg more frequent than the right leg thus failed to notice the cyclists coming from the right. There was no difference in approach speed between the right turning and left turning vehicles so the difference in scanning behaviour can not be explained by difference in approach speed. An other, in this context very interesting, finding is that drivers tend to prefer detection of more frequent danger and pay less attention to information about less frequent danger. This finding supports the basic hypothesis that there is a distinct difference between the normal situation in an intersection, the situation that road users are used to and has found a strategy to handle, and the abnormal situation that creates a dangerous outcome. In the two T-junctions the normal situation would be that the most frequent and dangerous interaction for the drivers turning right is the traffic coming from the left. More attention is paid to the left leg. When the abnormal situation appears and a cyclist is coming from the right, the cyclist is usually not discovered since the driver does not include the right leg in his scanning of the intersection.

This example can be situation specific. Normally the risk of getting into safety problems is created by the motorized traffic from the left. Therefore the car driver focuses his attention to the left leg. Now, if the same driver approaches a similar intersection with the same precondition of turning right but with the big difference that he has to pass a two-way cycle path first, then the risk is imminent that he fails to detect a bicyclist on the cycle path coming from the "wrong" direction.

In both situations the traffic environment has failed to give the correct message to the driver, there is no feeling of uncertainty, the driver has not enhanced his attention enough and is therefore not prepared to handle the prevailing situation.

Other examples on this topic are:

- The general shortcomings of two-way cycle paths at intersections. The message to the motorized traffic is not clear enough, drivers do therefore not expect cyclists to appear from the "wrong" direction. Both the car driver and the cyclist travel with the feeling of having right of way.

- The problem with too complicated intersectional design and signal strategies that are hard to understand. This makes people do bad decisions due to wrong expectations.

- The problem with red-runners. Other road users do not realize the necessity to interact when the own signal shows green. The feeling of having right of way when the signal shows green is too strong in signalized intersections..

5. Automatic counts - unused source of information

Risto Kulmala

5.1. *WHY AUTOMATIC COUNTS?*

Traditionally, measurements of traffic behaviour for road safety research have been done manually. This has been only partly caused by the lack of sophisticated other means of data collection. We also know that interpretation of human behaviour is very difficult and requires usually the close presence of a qualified human observer. Nevertheless, we can foresee a transition from manual measurements and counts to an increased use of automatic ones for several reasons.

Firstly, technological advances have produced new, reliable means of collecting data on traffic behaviour also in a quite comprehensive way.

Secondly, automatic counts produce objective data in a repeatable manner. All manual forms of data collection suffer from reliability problems related to the observers' subjective interpretation of the behaviour.

Thirdly, automatic counts provide a means to collect extensive data sets of traffic behaviour usually for a relatively modest cost.

Furthermore, automatic counts are the only practical way to collect data on traffic behaviour in rare circumstances, when it is difficult to predict the occurrence of such conditions. An example of this is data collection from slippery road conditions, which is extremely difficult by manual means. If the observers would rely on weather forecasts, they could very seldom make observations on slippery road surfaces as the road maintenance would have spread salt or sand on the road before the observers had reached the location. The road maintenance operators also rely on forecasts and their forecast services are the most sophisticated in any country. Hence manual observers would have to be in constant stand-by close to the road sections to be studied, which is extremely tedious and costly. With automatic counts, comprehensive data collection on speeds, headways and flows is possible with minor costs (see e.g. Rämä et al 1996).

Finally, a large number of systems collecting and registering data on traffic behaviour exists already and the number of systems in full operation is rapidly growing. So far, only a few of these are being utilized for collecting data on traffic behaviour for safety research purposes as their main applications lie elsewhere. Nevertheless, these systems produce data that could very easily be also utilized in safety research with very low additional costs and labour.

5.2. EXISTING TECHNOLOGIES

The technologies for automatic counts can be divided in three main categories based on the location of the measurement devices or sensors. Roadside systems can be either 1) pavement based or 2)non-intrusive (requiring no physical contact to the vehicle). In addition to roadside systems, a number of 3) in-vehicle systems are used. The technologies used in the various categories are: (TTP 1995)

Pavement based

- inductive loop
- magnetic, magnetometer, microloop
- pneumatic tube
- weigh-in-motion (WIM) sensor systems

Non-intrusive

- acoustic
- infrared
- microwave
- millimetre wave
- optical, video

In-vehicle

- tachographs
- satellite based systems
- black boxes

The systems collect data on an individual basis (usually vehicle by vehicle) concerning the road users' location at a specific moment of time or during a period of time. They can also provide data on their speed, headway in time and space in relation to other road users, and their cargo.

These technologies are currently being applied to the following purposes:

- traffic counting and monitoring
- vehicle classification data collection
- road occupancy data collection and occupancy based traffic control (e.g. signal control)
- incident detection and management
- violation enforcement (e.g. speed control, toll roads)

- vehicle identification (e.g. automatic debiting)
- freight identification (e.g. hazardous goods monitoring)
- security and surveillance (e.g. parking establishments)

5.3. USE OF AUTOMATIC COUNTS IN ROAD SAFETY RESEARCH

Accidents are often looked upon as break-downs in the interaction between road users. The interaction between road users can be described as a continuum of events, often described in the form of the safety pyramid (see e.g. Hydén 1987).

On the basis of the pyramid lie the largest number of events with very low accident risk. On a road section, this can be measured by road user passages i.e. traffic flow. Some forms of traffic flow or passages have higher risk than others, e.g. vehicles speeding or following too closely. Overtakings are also a form of interaction with an accident risk higher than just a normal passage. Some interactions within e.g. overtaking situations have also higher accident risk than others i.e. are closer the top of the pyramid. Interactions with a very close resemblance to accidents and situated close to the top of the pyramid are conflicts.

Automatic counting systems relate to all parts of the safety pyramid, starting from the bottom to the top:

- exposure data
- encounters
- driving behaviour
- conflicts
- accidents

Exposure measures quantify the amount that the road users are exposed to the risk of being involved in a road accident. Different types of accidents are connected to a different type of exposure measure. E.g. for motor vehicle accidents the number of vehicle kilometres could be a reasonable measure of exposure for most purposes, whereas for accidents involving vulnerable road users (VRU) the number of kilometres travelled by VRUs is probably insufficient as an exposure measure. The VRU's risk of accidents is almost totally caused by motor vehicles and the amount of motor vehicle traffic should also be taken into account when determining the exposure for VRU accidents. One solution is to use e.g. the product of motor vehicle kilometres and VRU kilometres or the square root of that product as the measure of VRU exposure.

Very many of the automatic counting systems in operation today produce data suitable for the estimation of exposure. Many systems produce data on traffic flows on road sections, ramps, toll booths etc., often aggregated in time. The aggregation period varies from 30 seconds to 24 hours, usually being less than an hour. The flow data cover almost solely motor vehicles, and flow data is even classified by vehicle type. Automatically collected data on VRU flows hardly exist. These systems as well many in-vehicle systems enable us to measure the amount of exposure in risky conditions, e.g. in the dark, in poor weather conditions etc. This naturally requires links to other databases describing the occurrence of such conditions.

The number of incidents is available from many traffic management systems and especially specific automatic incident detection systems. This number is a relevant exposure measure for so-called secondary accidents or chain accidents on congested road networks. The number of violations is also a valid measure of exposure, e.g. for accidents involving cars driving against red at traffic signals, although it can also be used as a measure for traffic risk, e.g. the percent of drivers speeding.

Automatic counts could be especially useful for counting the number of encounters i.e. instances where two or more road users would have been simultaneously present at the same spot in the road system without any evasive action or other reaction from at least one of the road users. This number would probably be the most valid measure of exposure for accidents involving VRUs. The promising developments in the automatic detection of VRUs for traffic control and other purposes should be continued in order to implementing reliable encounter counting systems in the future. We can foresee that combined with e.g. image processing systems, an automatic encounter detection systems could pick out the interesting events in the traffic process for further analysis.

Automatic systems can also be used for studying traffic behaviour of various sorts. Image processing systems make it possible to score pedestrians' street crossing route, waiting times at kerb etc. In-vehicle systems make is possible to study driving habits, decelerations and accelerations etc.

Automatic systems already in use enable us to obtain extensive data sets on drivers' speed and headway choice. This type of data can be easily used for counting the number of disturbances or otherwise risky situations in the traffic flow. When we know the speeds and headways of individual vehicles in the traffic flow, we can estimate risk indices such as time-to-collision (TTC). A powerful demonstration of the possibilities of such tools has been presented by Oppe et al 1995. Systems enabling on-line estimation of the state of risk in the traffic flow could revolutionize the concept of traffic management, by transforming it from the management of incidents and accidents to their prevention. Systems like these only require data registration vehicle by vehicle, which , unfortunately, is not the case today when the data are collected for other that safety purposes.

Manually done conflict studies are quite costly especially at locations with a low expected number of conflicts, where the data collection period must often be several tens of hours in order to obtain a sufficient number of conflicts for research purposes. Automatic conflict scoring systems based on image processing could be answer here (see e.g. Odelid & Svensson 1993). These systems could screen sets of video tapes, detect automatically encounters, interactions and potential conflicts, analyze them for the presence and severity of evasive actions, and finally produce a collection of the most interesting situations for manual checking and further analysis.

Automatic counting systems also correspond to the top of the pyramid - accidents. Semi-automatic data collection systems by video already exist (Pasanen 1992), and here image processing could be used as with conflict situations. The incident detection systems of today already detect the occurrence of accidents automatically. Linking the incident data to the traffic flow data at the time preceding the incidents could provide valuable understanding in the safety processes in traffic flow. The data exists but has not been used for safety research. In-vehicle systems have also shown their value in the analysis of events leading to the accidents. Tachograph discs are often analyzed for the purpose of reconstructing accidents of lorries (e.g.

Kallberg & Anila 1994). The increasing introduction of digital tachographs, satellite based freight and fleet management systems, and black boxes in heavy and other vehicles produce valuable data for safety researchers to study the events leading to accidents, and the role of various factors in accident occurrence.

5.4. CONCLUSIONS

In the preceding pages I have tried to suggest ways to utilize automatic counts in road safety research. I think that automatic data collection and datasets based on these offer clear benefits. The technology already exists and automatic counting systems are in full operation around the clock on the road and street networks all over the world. These systems produce extensive datasets containing data that could be used directly or with minor modifications in road safety research. The main modification required is that data should be collected and stored vehicle by vehicle and not aggregated just to save storage space.

Partly, the neglect has been caused by the fact that the road safety research methods are not suitable as such for the analysis of data produced by the automatic systems but rather tuned in for the use of manual observations in the field. The manual observations by humans is still the best way to study human behaviour, where an interpretation and insight into the motives and purposes of different actions and manoeuvres are required. New methods for the on-line evaluation of safety of the traffic process can be and have already been developed. Methods and systems of these type can revolutionize the concept of traffic management as well as road safety work itself, by a transition into the era of risk-actuated automatic accident prevention systems.

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6. Safety Performance functions- tools for improved use of safety and exposure data

Lars Ekman

This is essentially the summary of my report ”On the Treatment of Flow in Traffic Safety Analysis - a non parametric approach applied on vulnerable road users”. The full report is available at our department.

The treatment of flow in the area of traffic safety has a long tradition. The influence flow has on the number of accidents is, however, often considered so obvious that it tends to be trivial. I can show that the relation between flow and accidents holds interesting information. Knowledge about such relations may be very useful for several purposes.

Traffic flow counts or other expressions of the traffic exposure are often only used to construct accident rates. Quite often the concept of accident rates is used synonymously with ”risk”. There is, however, a great risk ‘!’ in mixing these two concepts. The word ‘risk’ is spontaneously interpreted as danger or hazard for someone involved in a certain activity. In common life, risk is used as a very broad concept including both the probabilities of an unwanted event, as well as the consequences of this event. The concept of accident rate is often used to avoid this ”over-interpretation”, but nevertheless also this concept needs to be treated with care.

Based on the way accident rates are used three main streams in the use of accident rates and exposure have been found. These three groups were derived from how different researchers used or interpreted their results. The three approaches are:

- The probability approach
- The effectiveness approach
- The standardization approach

The first approach is what is referred to when discussing accident rate in general. The other two approaches constitute a classification system based on the way in which the computed rates seemed to be interpreted.

In order to compare countermeasures, or conduct other types of traffic safety comparisons where the flow varies, it is vital to know the full shape of the relation between accidents and flow. Such relations are called Safety Performance Functions (SPF). If we focus on the situation for individual road users the equivalent Risk Performance Functions (RPF) may be used to increase the comparability. The traditional comparison of accident rates is equal to assuming the SPF is a straight line, and thus the RPF is a constant.

The main aim of this work is to develop a ”transparent” system for estimating SPFs and RPFs. One step towards a transparent and, thus, interpretable treatment of accident and flow data is the development of a system for aggregating approaches in order to create aggregates with equal, or at least manageable, precision. The aggregation is based on relevant flow and is made in such a way that all aggregates represent the same number of the relevant road users.

In order to generate a non-parametric function, without built-in presumptions of the overall relationship between flow and accidents, moving averages line is used. A series of computer programs is developed in order to describe the accuracy of the resulting functions. Two computer intensive methods: simulation and bootstrap, are used. With both these methods, "exact" confidence intervals are produced.

Bootstrap is based on random selection, with replacement, from the original data observations. With this method several new data sets are constructed. The procedure is completed all the way throughout the analyses, over and over again, each time producing a bootstrap replicate of the end result. In order to estimate the confidence intervals the procedure has to be repeated about 1000 times.

Confidence intervals are then computed by a process of interpolation. The confidence intervals may only be produced in the range where there are several observations in the original data set. A special routine to handle this "edge problem" has also been developed.

The stability of and the power of the computation of confidence intervals is tested with the use of synthetic data sets produced by a random process. The 80% confidence intervals seems to be slightly "conservative" i.e. covering the true value in more than 80% of the cases.

The method developed was applied to a data set consisting of accident records, conflict observations and traffic flow counts for different road user categories from 95 non-signalized intersections in the cities of Malmö and Lund.

The result on bicycle and pedestrian safety is illustrated by the following Risk Performance Functions:

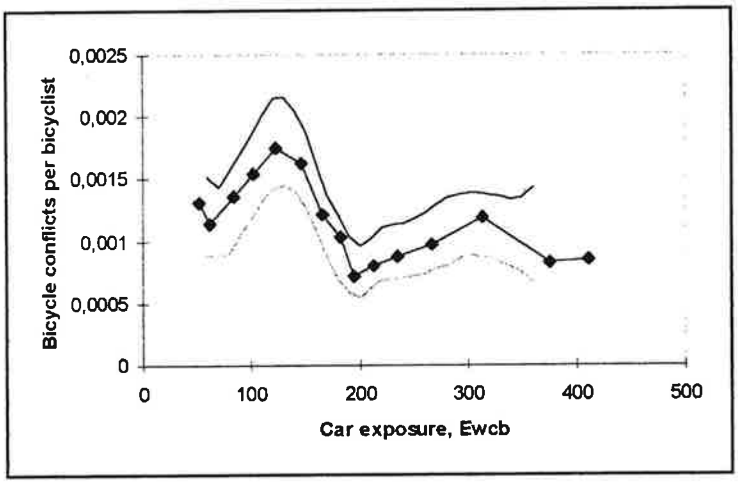


Figure 0.1:
Bicycle conflicts per bicyclist versus accumulated and weighted car flow (Ewcb). Moving average line (RPF) with an estimated 80% confidence interval

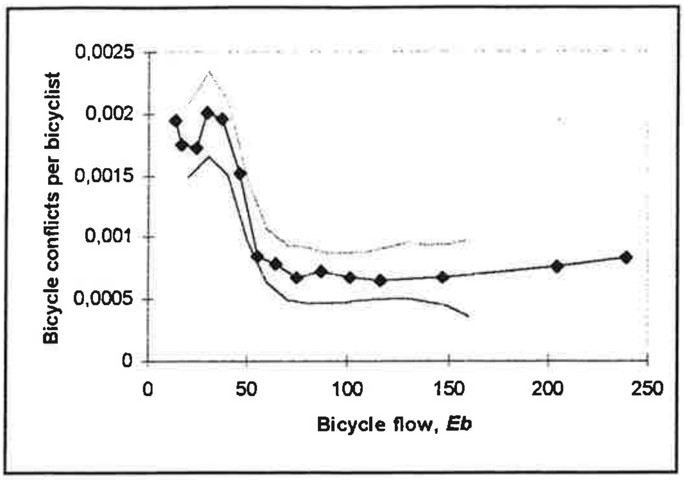


Figure 0.2:
Bicycle conflicts per bicyclist versus bicycle flow(Eb) Moving average line (RPF) with an estimated 80% confidence interval

The results regarding bicycle safety are:

- the conflict rate for bicyclists is twice as large at locations with low bicycle flow compared to locations with higher flow
- the conflict rate for bicyclists seems to be high at locations within a limited range of car flow
- bicycle flow seems more significant than car flow for the conflict rates for individual bicyclists
- the conflict rate is generally higher for bicyclists approaching intersections from the minor street compared to those coming from the main street
- the difference in conflict rate between low and high bicycle flow is larger than differences due to the design variables tested: the width of the road and major or minor street

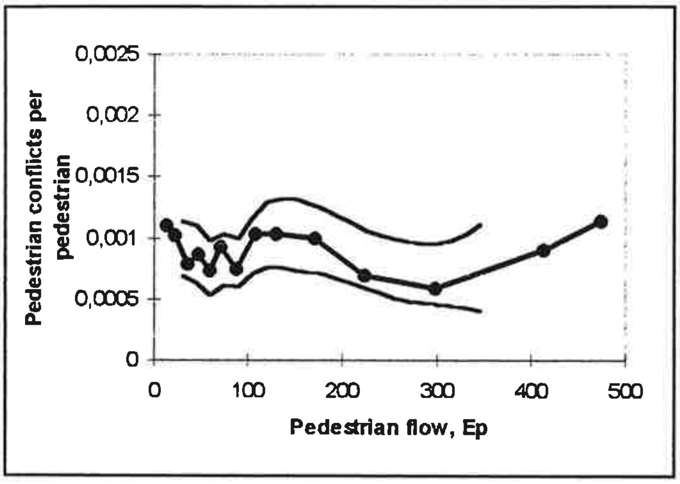


Figure 0.3:
Pedestrian conflicts per pedestrian versus pedestrian flow. Moving average line (RPF) with an estimated 80 % confidence interval

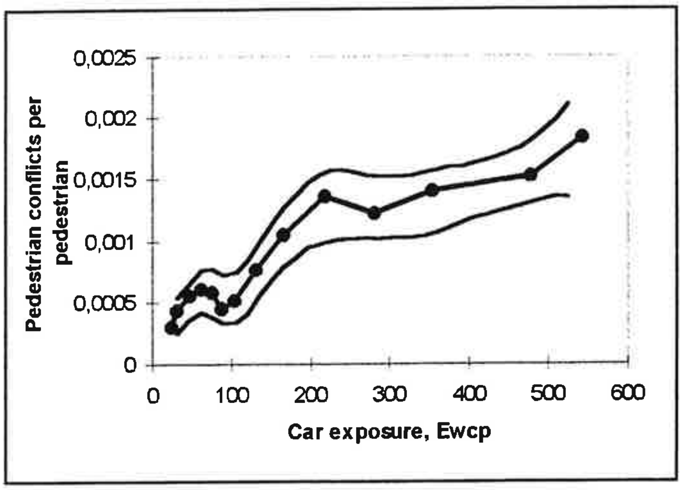


Figure 0.4:
Pedestrian conflicts per pedestrian versus car exposure (incoming cars per hour). Moving average line (RPF) with an estimated 80% confidence interval

The results regarding pedestrian safety are:

- the conflict rate for pedestrians is largely unaffected by pedestrian flow
- car flow seems to be of great importance for the conflict rate for pedestrians
- the increase in conflict rate by increasing car flow seems to be a ”step function” rather than a linear function
- zebra marking seems to increase the conflict rate for locations with low pedestrian flow, irrespective of car flow
- refuge seems to give a decrease in conflict rate which is larger than the increase ”caused” by the zebra marking
- it has not, however, in this study, been possible to show that the width of the street or whether the street is a main street or minor street, has any significant impact on conflict rate for pedestrians

The empirical application has confirmed that:

- the method of aggregating and averaging gives a function with good visual interpretability
- the bootstrap method gives an accurate and useful description of the stability of the estimated non-parametric function
- the relationship between conflicts and flow is complex
- knowledge about such relations could improve traffic safety evaluations that include comparisons between groups of locations with different flow
- analyses of the non-parametric functions may be the base for suggesting active flow manipulation as a traffic safety measure

- information about the effect of flow on safety may be used to generate hypotheses about the processes underlying traffic safety problems

Thus, the question is not anymore whether flow contains valuable information for traffic safety analyses, but rather, if we are going to make use of that information in improving traffic safety.

7. Master (Managing Speeds in Traffic on European Roads)

Ralf Risser

7.1 INTRODUCTION TO THE BASIC PROBLEM

Very much is known about problems connected to inadequate speeds - much of which is about "excessive speeds". However, adequate speed has not been defined in a more general sense, yet, and I doubt if it will be defined (in a strict sense) in the future. What should adequate speed imply? How can a traffic process be described that is characterized by adequate speed? I want to develop my contribution to the reduced MASTER-project by the following arguments (I, II, ...)

7.2 SOME ADDITIONAL ARGUMENTS

I) In spite of the difficulties mentioned above, let us assume that we can come near a definition of adequate speeds. It will not be possible to achieve such a definition only by referring to physical parameters (radiusses of curves, lane widths, friction coefficients, vision conditions, etc. ==> safe operational speed). Rather, it will be necessary to consider interactive aspects;

> more "objective" ones, like capacity aspects that depend on interaction, like waiting times from side roads, difficulties to join main roads, etc. ("Interaction 1");
>
> and more "subjective" ones, like route choice aspects for pedestrians and cyclists because of difficulties to cross the road, noise, etc.; disturbance of residents - an interaction aspect in the widest sense - ,anxiety of parents for their children, anxiety of elderly as VRUs, anxiety of elderly and of beginners in fast going traffic flows, etc. ("Interaction 2")

II) If we knew everything about adequate speeds from the physical perspective, it would be rather easy to develop technical solutions that allow or provide for what we define as adequate speeds in different situations. What we still would not know is if road users would feel the same way and if they would accept recommended or set speeds. ("Acceptance 1")

III) But things are more complicated than that: Even if we only concentrated on the drivers (and not on other, especially vulnerable road users who are effected by the speeds chosen by "the drivers"), we would have to consider interactive aspects. And there, the probability that they (=drivers) would not agree with what we find out would be even higher than in II ("Acceptance 2").

IV) Pedestrians´, cyclists´, residents´, elderly´s, etc. perception of speeds is not (or at least not mainly) dependent on "objective" criteria, but on many context aspects, part of which are emotional, aesthetical, etc.. Without communicating with them it would be impossible to come nearer to a type of recommended or automatically set speed that is accepted by these groups ("Acceptance 3").

V) If drivers do not accept recommended or set speeds, or speed recommendations in general, they react in a way that is often difficult to predict: by political obstruction in case of powerful groups, by ignoring speed limits, by reducing their vigilance, by choosing other routes [than wanted], by reducing their mobility, by reacting with frustration or anxiety "privately" *(reactance" and "behaviour adaptation")*

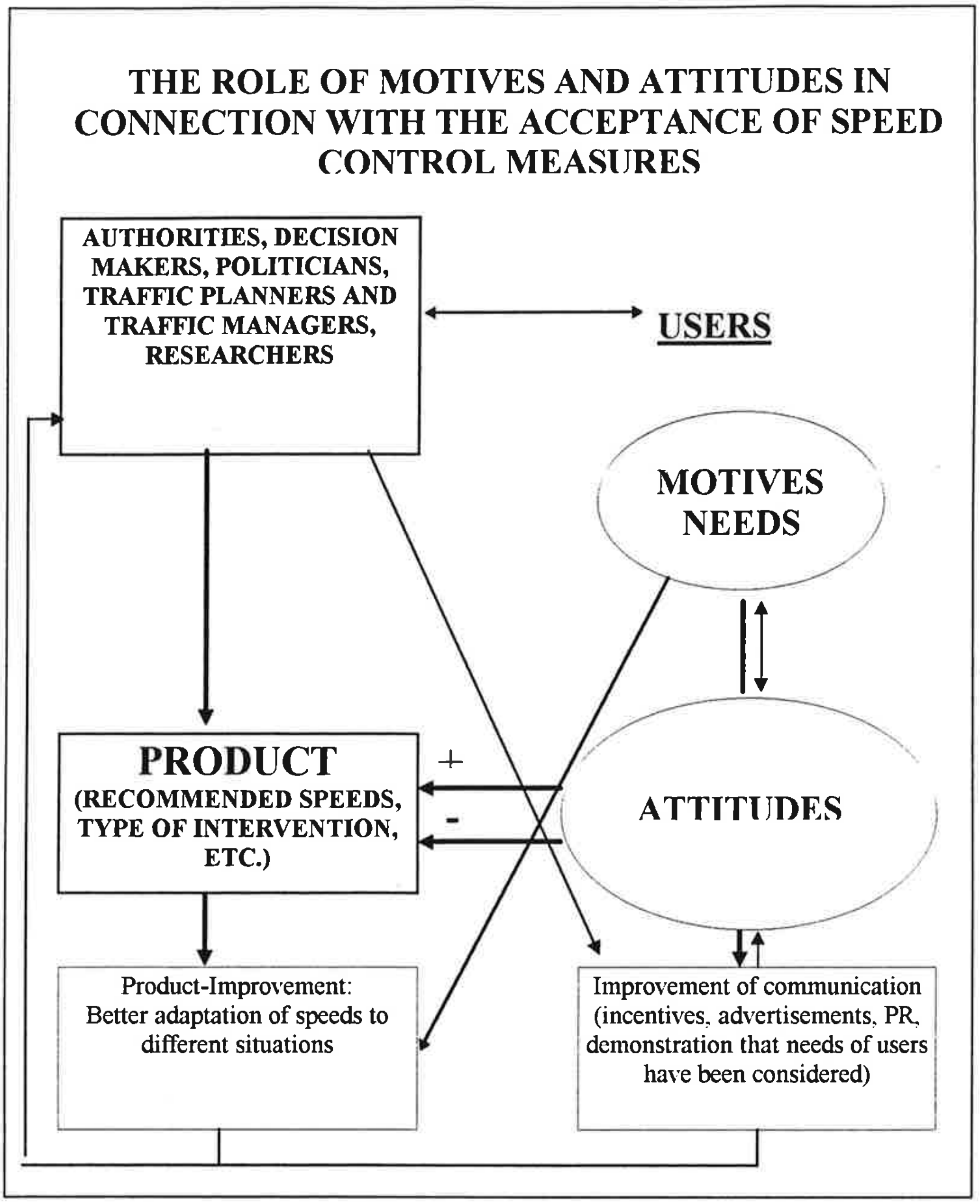
VI) As far as acceptance by drivers is concerned, the type of intervention will play a decisive role (e.g., to which degree does it influence the drivers´ ***freedom of decision***)

7.3 A SHORT CUT TO CONCLUSIONS

1. The definition of "adequate speeds" depends on technical parameters **and** on interactional aspects
2. "Adequate" depends to a large degree on road users´ view. Different groups will have very different views on comparable situations ("Acceptance 1", "Acceptance 2" and "Acceptance 3").
3. Different definitions of "adequate" speed by different road user groups result in the necessity for authorities to find **compromises** between clashing interests
4. What authorities want to sell as "adequate speed" has to be based on technical parameters **and** it will have to refer to the road users´ view ("Interaction 1" and "Interaction 2", and "Acceptance 1", "Acceptance 2" and "Acceptance 3")

7.4 A STATEMENT IN MARKETING TERMS

Both **the "products"** (established types of situations and interactions, ways of displaying recommended speeds, etc.) and the **communication policy** (advertising, public relations work including arguments for certain solutions when communicating with pressure groups, etc.) **have to be based on technical aspects and on the users´ view.**



THE ROLE OF MOTIVES AND ATTITUDES IN CONNECTION WITH THE ACCEPTANCE OF SPEED CONTROL MEASURES

7.5 CONCLUSION WITH RESPECT TO SOCIAL-SCIENTIFIC WORK

Communication with the road users plays an important role in this project (interaction and its perception, acceptance, interest clashes, reactance, behaviour adaptation). I.e., studies dealing properly with this aspect have to be done. Wps 1.2 and 2.3 are such studies. The time for these studies was calculated at an absolute minimum already in the beginning: 10.5 (+2) mms for (international) attitude studies that fulfill quality requirements is a minimum.

8.Urban density and accident susceptibility for young pedestrians

Brigitte Cambon de Lavalette

Pedestrian accidents are particularly prevalent during childhood : in 1994 in France, pedestrians under 15 represented 28% of pedestrian accidents as a whole. For children, the resulting injuries are not only associated with mortality and morbidity with the serious consequences that ensue, but also they affect there day to day life in big cities. Traffic is a constant source of danger and as such is in part responsible for restricting the autonomy of young children and their use of space in large urban areas. The educative role of the city is deferred until children have grown older which does not seem to be the case in small towns or rural or even semi-urban communities, where a child comes into contact with his natural environment at an earlier age.

In this paper, our objective is to substantiate current hypotheses concerning the type of psychological or even cognitive factors thought to be at the root of the accident-causing errors attributed to young children in traffic. Then, we will try to identify what, hypothetically, could be hazardous urban situations for children.

The interest of the question is to envisage road crossing layouts better adapted to a child capabilities, facilitating their movements and their autonomy in large urban areas which seem to be in themselves somewhat hostile towards this population category.

8.1. DIFFERENT POINTS OF VIEW ON THE VULNERABILITY OF CHILDREN IN THE CITIES.

Our interest for the question originated from different points of view on the subject, as followed.

8.1.1. Vulnerability factors of children in traffic

Over the past twenty years, considerable research work has dealt with accidents involving children. It is known that young children are over represented in pedestrian accidents as a whole, although this cannot be attributed to their being more exposed to danger than during other periods of their lives (Johan & Engel, 1983). On the contrary, they cover shorter distances on foot and spend less time in traffic than adolescents or adults. If they are more accidented than other categories, it is more likely to be due to factors endogenic to childhood : their behaviour in traffic. What should a pedestrian do to cross a road, and what can lead to error? To locate the error, reference is usually made to a description of the activity, which theoretically is necessary to perform a given task, in this case crossing a road. Firth (Firth, 1982) identifies six different stages that are, in theory, essential :

when preparing to cross:

- choosing where to cross: on or not on a pedestrian crossing ... (1)
- when to cross, which is then decided after 4 successive and indissociable stages:

  observation, i.e searching for relevant information (relevant to safety) on the environment (2),

  the perceptive process (physiological and cognitive) used to analyze the information acquired during the previous phase (3),

  a comparative evaluation of the perceived objects (4), the decision of whether or not to cross, in which case the pedestrian restarts the task at phase 1 or 2 as above (5).

  the crossing itself (6).

The performance of each stage varies in importance in relation to the safety of the crossing. Thus, the choice of where to cross could be unfortunate (e.g. no visibility), and the pedestrian could compensate for this deficiency by increasing his alertness. Inversely, the stages linked to perceptive behaviour would seem to be essential : crossing the road without monitoring the traffic, the crossing can only be safe if there are no vehicles on the road at this precise moment in time. However, as has been noted, perceptive behaviour or more simply paying attention to traffic, is relatively complex and involves a succession of several different types of activity, before the behaviour can actually become effective: observing, analyzing information, evaluating this information, decision-making.

8.1.2 Current hypotheses

8.1.2.1. The attention children pay to traffic

Paying attention, to traffic raised several questions. The first was to find out whether this actually exists, in other words : do children fail to look before crossing, does the observation phase really take place? Although it is very difficult to monitor this in an accident situation, it is now thought, e.g. Thomson (Thomson, 1991), that children tend to pay more attention to traffic (quantitatively) than adults. This, in fact, refers to the degree of attention given to traffic. There are two contradictory hypotheses on this subject, one dealing with evaluating speed and anticipating vehicle movement and the other with collecting visual information.

8.1.2.2. Evaluating speed

Assuming that children fail in tasks where they are asked to anticipate the movement of a mobile object (Piaget, 1964), some authors (Lee, 1984, van Schagen, 1988) thought that the accidental error would appear when evaluating vehicle speed and choosing when to cross. For others this error could, in the case of children, appear when collecting and analyzing visual information.

8.1.2.3. Searching for visual information and deciding when to cross

According to Vurpillot (Vurpillot, 1971), children up to the age of about 9, search for visual information without structuring in relation to what is required of them. This is unreliable. In traffic, where there are also many details they are unable to see because of their small size, failure to structure when searching for visual information that can be of use when crossing could certainly be a vulnerability factor. In this context, we carried out the following experiment (Laya, 1989).

Three groups of subjects, one comprising adults and the others young people aged 6 1/2 and 11 were shown a series of slides representing a street as seen by a pedestrian about to cross. They were asked to assess for each slide, whether it was possible to cross or not. While the subjects were looking at each slide, we recorded their ocular movements and fixation points. The results show that the number of fixations on a same object (e.g. pedestrian crossing, a vehicle...) were greater with the youngest subjects, as if they needed more time and exploratory activity to identify an object (this has in fact been noted by Vurpillot in other situations). Also in this group, however, fixations were limited to the crossing area, and were rarely found in the more distant areas; as if only the crossing area needed to be monitored. In the adult group, ocular fixations were immediately divided between the "strategic" areas: the crossing point, and the different axes from which vehicles could approach. The behaviour of the group comprising 11 year olds was sometimes similar to that of the younger group, and sometimes similar to that of the adults, depending on the complexity of the situation in question. If this visual exploration strategy were applied in an actual situation this would mean that:

1. a child would take longer than an adult to perform the visual exploration phase,

2. looking is not sufficient to guarantee a child's safety, visual monitoring must not only cover the area that the pedestrian is about to move into, but also enable him to anticipate the approach of a vehicle on courses that may conflict with that of the pedestrian.

It was also noted that, the greater the amount of visual information contained in the visual situation shown, the more visual scanning was restricted to the crossing area. This led us to suppose that the complexity of the " visual scene" provided by a situation where the pedestrian must cross the road, could prove more difficult for young pedestrians to analyze perceptively, and could result in more errors when crossing roads.

8.1.2.4. Discussion

The two types of hypotheses were not however exclusive one to another, as some accidents could have resulted from an erroneous evaluation of the speed of approaching vehicles and others from poor visual exploration. Recently, however, Demetre (Demetre, 1992) resumed research work into the evaluation of crossing times and reached different conclusions on the part it plays in the errors made by young pedestrians. He compared, in a simulated situation, the decisions made by young children and by adults to cross when a vehicle was approaching. According to the results obtained, the decisions made by children are no more hazardous than those made by adults. On the other hand, children are more likely than adults to overestimate risk, and miss a greater number of opportunities to cross, which is in line with other research work which noted that children wait longer than adults before deciding to cross. He suggests that the dangerous decisions made by children in traffic result from errors of attention when collecting information, and not from an erroneous time evaluation.

This result strengthens our view that it is highly probable that the accident-causing error for young pedestrians:

- originates when the child is visually exploring the state of traffic to decide whether or not to start crossing (task phase 2) .
- is more likely to occur in urban situations that are saturated with visual information.

The research on which these considerations were based was almost completely carried out in a laboratory or in semi-simulation. Very little covered actual accidents and if it did, it was obviously only for retrospective studies. However, as seen by Grayson (Grayson 1975) it was difficult to reach conclusive results by observing a phenomenon as sensitive as, for example, the direction of a glance. Furthermore, is it not true that the shock caused by an accident involving a child acts retrospectively on the memory of witnesses and to an even greater extent on those involved? Other research has been directed towards child behaviour outside the accident phenomenon. It was performed in a semi-simulated situation, either by recreating a specific situation in a laboratory (Cambon de Lavalette, Laya) or on an actual street (Lee, van Schagen, Thomson). However subjects were asked to reenact part of their behaviour e.g. the decision they would have made in such a situation.

This research dealing with the cognitive factors assumed to be involved in driving behaviour, is extremely interesting as it provides a way of devising a conceptual tool with which to further investigate the accident-causing phenomenon in childhood. From a methodological standpoint however, this research is open to criticism. It deals essentially with the standard behaviour, supposedly spontaneous, of children in traffic and not their behaviour in an accident situation Furthermore, the situations are not actual road situations. Lastly, the behaviour is described using a statistical method. As the accident-causing phenomenon is extremely rare, how therefore can the observations be categorized? Is it not true that the residual data in fact represent potential accidents? In sum, it has become essential to match these hypotheses based on a spontaneous activity with real accidents that occur during the course of this same activity. This is not however an easy task.

It is in no way possible to attempt to control phenomena as tenuous as the value of a glance in the course of an unpredictable event. We are therefore faced with a need to develop a second level of hypotheses, relating for example to situations in which this event could occur. This is what has been done in this instance, by assuming that the density of the urban fabric may provide an environment in which accidents involving children are more likely to occur.

To summarize, a certain amount of research has been aimed at identifying the factors which, when present in young children, could be considered to have led to the act that triggered the accident : namely their poorly structured visual attention in relation to the urban environment. If this assumption were proved valid, it would then be probable that the frequency with which accidents involving children occur increases as the environment renders perceptive structuring more difficult. This was suggest by some results as followed.

8.2. URBAN VARIATIONS IN CHILD ACCIDENT.

A previous research work on the accident susceptibility of young pedestrians (B. Cambon de Lavalette, 1993) was aimed at providing a better definition of the population categories at risk. A very significant variation in the accident susceptibility of young children was noted in relation to the size of the urban areas in which these accidents occured. In this research, we compared the frequency of accidents involving children under 15 in several different urban categories. These categories ranged from rural communities, urban areas with populations of under 5000, 5000 to 20 000, 20 000 to 50 000, 50 000 to 100 000 up to the city of Paris. Not all the children seem to be exposed to the same risk, those in large urban areas being more frequently exposed to risk than those in the other categories. The results also showed a constant accident susceptibility risk according to the size of the urban area. The larger the urban area, the greater the number of accidented children. The city of Paris, where a far greater number of children are involved in accidents, is unique in this respect : 8 times more than in rural communities and twice as many as in urban areas with over 100 000 inhabitants. Greater Paris, if the inner city is excluded, is no different to other large urban areas. The reason for this variation can probably be found in the density of the urban fabric. In Paris, space is used to a maximum. It is probable that a specific factor of cities is the intensive use made of public areas, and the uniformity of this density throughout the city. So in view of current hypotheses on child accident factors, it would appear that the density of the urban fabric may, in fact, produce an environment in which accidents involving children are more likely to occur.

8.2.1 Research project.

We therefore assumed that a complex environment that contains a wealth of all types of information and from which pedestrians have to quickly make a relevant choice, should make the task more difficult to perform and be the cause of additional error, and consequently accidents. Urban environments such as these correspond relatively well to the environment found in city centers where there is complex structuring of the urban fabric and where, due to city life itself, vehicle and pedestrian traffic is constant and where visual stimulation, other than traffic, acts as a continuous "fading" for passers by. The concept of density is relative to that of population, land-use, buildings, interchanges, flows and space. This type of environment, with both the complexity of its spatial layout and the density of visual information must, for children, prove difficult when collecting visual information (due to a masking effect), visual structuring and selecting information. They could therefore be involved in more accidents when moving in this type of environment than in a more peaceful environment, where it is easier for them to cross roads.

This assumption may perhaps prove to be true in the work carried out on children in central Paris where their vulnerability is twice that of children living in other large urban areas. This has still to be substantiated.

If this can ultimately be proved, we are also fully aware that other variables influence accident occurrence upstream from the accident itself and before the pedestrian has performed the action that led to the accident : time spent in traffic i.e. exposure for example. Main roads with a reputation for being "hazardous" (due to their density and the speed of vehicle traffic) are used less frequently than others. There are also fewer accidents involving children on these roads.

Epidemiological research has revealed a link between the number of accidents and data related to the urban environment. For instance, it has often been noted that accidents involving children occur in the vicinity of their homes. The hazardous nature of the environment is not the only variable in question, the frequency with which they cross this area also increases their exposure to danger. If the accident susceptibility of a certain type of urban environment is to be studied, the number of children who live there has to be taken into account.

Other population-related variables have also been noted. According to Rivara (Rivara, 1985) children from low-income families appear to be more accidented than others. Similarly, he also found a relationship between accidented children and the size of their living space, in that these children are more likely to live in small apartments. It is probable that the lack of living space encourages them to play more frequently in the street.

In order to prevent interference from the child exposure rate variable in their area of residence (the greater the number of children the greater the number of accidents), the urban density coefficient will be weighted using the number of children living in the area. The SEG of the parents will also be taken into account.

The result of "household surveys" carried out by INSEE (French Government Statistical Office) will provide additional information on the mobility of children in urban areas.

8.3. CONCLUSION

In this paper, we saw that child capacities are poorer than adult's to perform the task to crossing the street, particularly in scanning the environment as a whole. So, we can expect that, on average, the more the traffic environment will be complex, the more the task will be difficult to perform by children. If so, the density of urban fabric (e.g. the number of streets at crossing place, number of crossing place, traffic density, shops, local live...) will make the task more difficult for children, and provide more errors and accidents.

It will be necessary now to evaluate child accidents from this point of view.

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9. A Typological Analysis of Pedestrian Accidents

Hélène Fontaine

9.1.ABSTRACT

For more than 20 years, in France as in many other countries, the number of pedestrians killed in road accidents has tended to decrease. The stakes remain high, however : 1,126 pedestrians killed in France in 1994, and this user category is particularly vulnerable in accidents. To further our knowledge of pedestrian accidents, an analysis of data supplied in reports drawn up by the police forces for road fatal accidents was carried out. Its aim is to highlight the different types of pedestrian accident victims. A typology of pedestrian accidents is proposed based on a multifactor analysis, followed by a classification.

This classification clearly identifies four groups :

- pedestrians age 65 or over crossing the road in a built-up area,
- children in accidents in built-up areas while running or playing,
- drunken pedestrians,
- intermodal changes, secondary accidents.

The resulting typological breakdown should then serve as a basis for in-depth analysis to improve our understanding of these accidents and propose suitable action.

With a view to learning more about road accidents, the INRETS "Accidentology" programme provides for the cross-sectional treatment of themes based on data collected at different levels of information. Pedestrian accidents are one of the themes addressed in this cross-sectional approach. The stakes are high : 1,126 pedestrians were killed in road accidents in France in 1994, i.e. 13% of all deaths on the road, children and elderly people being over-represented.

Research on accidentology is often based on corporal accident statistics, i.e. accidents in which at least one person is killed or seriously or lightly injured[1]. Three levels of accident information may be taken into account :

- *national statistical files based on BAACs (Corporal Accident Analysis Forms)*. They have the advantage of being exhaustive, since a BAAC is drawn up by the police for every corporal accident. The national data base into which these reports are fed provides substantial general information on all corporal accidents. The national statistics published by the French Inter-Ministerial Road Safety Observatory (ONISR, 1995) are based on this data.

- *corporal accident reports*. These serve as a basis for subsequent legal action. These reports, also drawn up by the police for every corporal accident, give a detailed description of events and mention the statements made by the different parties involved. They show a plan of the accident scene and sometimes include photographs. They provide an overall view of the accident, but are not as detailed as the detailed accident analyses (see below).

- *detailed accident analyses*. Detailed accident analyses drawn up by multidisciplinary teams sent to the scene of the accident as quickly as possible are often a source of details that might otherwise be missed, such as traces of braking or skid marks, or interviews with witnesses in the heat of the moment (Ferrandez et al, 1986). The aim is to analyze the accidents, to reconstitute what happened in the pre- and post-collision phases, to pinpoint the processes that generate danger and injuries, to identify specific counter-measures and to evaluate safety measures.

Much can be learned by taking these different levels of information into account. Statistical analysis reveals correlations between previously coded criteria. Rather than explain the causes of the accidents, these correlations reflect a "statistical proximity". The detailed accident analyses make it possible to go further in identifying accident factors and mechanisms and the effects thereof on a limited number of cases. This identification then has to be validated by statistical analyses of more representative accident samples and using criteria evidenced by more clinical approaches. This "to-and-fro" process between different levels of information helps to take our knowledge of accident processes a stage further.

This is the context in which this first analysis of pedestrian accidents came about (Fontaine and al, 1995). The purpose here is to present a statistical description of this category of users, based on police reports on fatal accidents that occurred between March 1990 and February 1991 and collected exhaustively by the Accidentology and Biomechanics Laboratory run jointly by car manufacturer Peugeot and Renault. The aim of this descriptive analysis is to identify some very distinct groups of pedestrian accident victims. The results of this typology may then serve as a basis for more in-depth analysis to learn more about how these accidents happen and what might be done to prevent them.

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[1] killed : victim who dies on the spot or within 6 days of the accident

seriously injured : victim whose condition requires more than 6 days in hospital

lightly injured : victim whose condition requires between 0 and 6 days in hospital

9.2. METHODOLOGY

We adopted a multidimensional approach to reveal the interactions between the different analysis criteria and thereby deduce homogeneous types of pedestrian accident. The data in the fatal pedestrian accident file is either qualitative (sex) or quantitative (age). Multiple correspondence analysis is a technique for describing qualitative data. It helps to transform similarities or likenesses between individuals and relations between variables into geometric distances easy to illustrate on simple graphs (factorial plans). The method is applied to qualitative variables using their modes or items. Thus the quantitative variable 'age' is transformed into a qualitative variable with four modes : under 15, 15 to 29, 30 to 64 and 65 and over.

The sample analyzed comprises 1,275 pedestrians killed in road accidents. We decided to select 17 active variables that serve to define the axes of the factorial analysis :

- 9 describe the pedestrian involved in the accident : age, sex, reason for outing, type of outing (alone, in a group), action of pedestrian, position, obstacles to progress, intermodal change, alcohol ;
- 8 are related to the environment or the type of accident : situation in or outside built-up area, straight line or curve, day of week, month, light, weather conditions, type of vehicle, secondary accident.

Criteria correlated with the above variables, such as socio-professional category and age (children come under the "schoolchildren" category and elderly people under "retired") were added as illustrative variables. These do not count in the calculation of factors but are shown on the factorial plans.

The factors thus obtained are then used in an increasing hierarchical classification that reveals very distinct groups of pedestrians involved in fatal accidents. The aggregation criterion is the Ward criterion (Saporta, 1990). The dendrogram or classification tree reveals a significant number of classes. Calculations were made using the SPAD programme.

9.3. RESULTS OF THE MULTIPLE-CORRESPONDENCE ANALYSIS

Axis 1 distinguishes pedestrians in accidents in built-up areas in the daytime from those in rural areas at night. Axis 2 is linked to the age, action and alcohol rate of the pedestrian. The factorial plan formed by axes 1 and 2 (figure 1) reveals certain likenesses : the group of elderly pedestrians in accidents when crossing the road in built-up areas in the daytime, the group of children running or playing, the group of pedestrians with high alcohol rate in accidents in rural areas at night. The hierarchical classification based on the results of this multiple-correspondence analysis will highlight these groups of pedestrians.

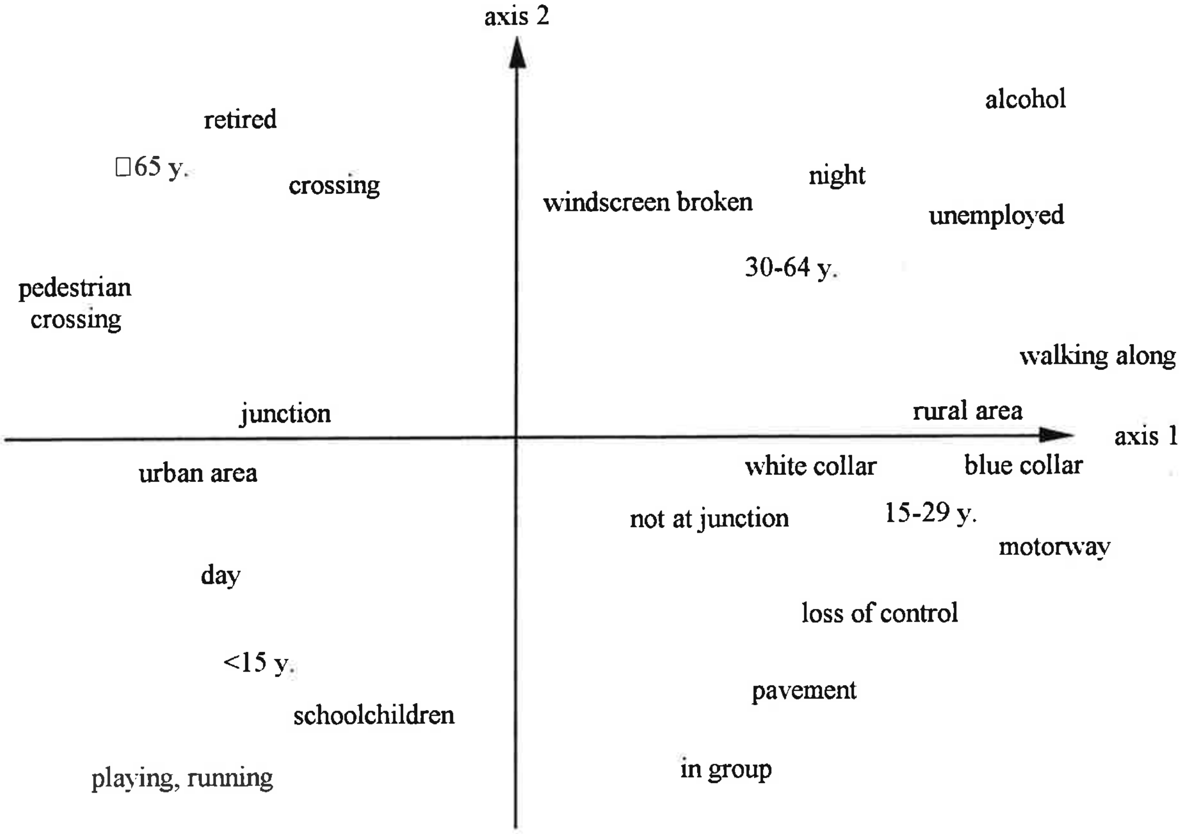

Figure 1:
*Analysis of multi-factor correspondences in pedestrian accident victims - axes 1 and 2 (*Source: fatal accident reports)

9.4. RESULTS OF THE CLASSIFICATION

The hierarchical classification highlight 4 clearly distinct groups. The 4 classes described never strictly separate the individuals according to the variable modes. The names we have given to the four groups are very summary : when we say "elderly pedestrians" we do not mean all elderly pedestrians but an over-representation of this mode in the group under consideration. In each class we present the most characteristic variables and modes, showing on a graph the percentage in the class and the percentage in the whole pedestrian population. This description includes both active variables and illustrative variables. We classifies the most characteristic variables and modes in relation to a test value corresponding to the mean deviation from the norm (Morineau, 1991). This is tantamount to comparing pedestrians of the class with all pedestrians for each of the variables studied, measuring the distance between the percentage of the variable in the class and in the population taking into account the numbers in the variable and the class. These criteria were considered distinctive when the test value was over 3, corresponding to 3 standard deviations. The higher the test value, the more important the variable as a distinguishing factor.

9.4.1.Class 1: elderly pedestrians

This class is made up of 42% of pedestrians. Pedestrians age 65 and over account for 75% of the class, while they make up 39% of the pedestrians in the fatal accident file. Pedestrians are over-represented, of course, but so are women. The accidents occur when the pedestrian is crossing at (or within 50 yards of) a pedestrian crossing, in a built-up area and at a junction, often with traffic lights. These accidents generally take place on weekdays, between 7 a.m. and 12 noon or between 2 and 6 p.m. The pedestrians are usually out on their own, shopping, in a shopping centre. We find here familiar results (OECD, 1985).

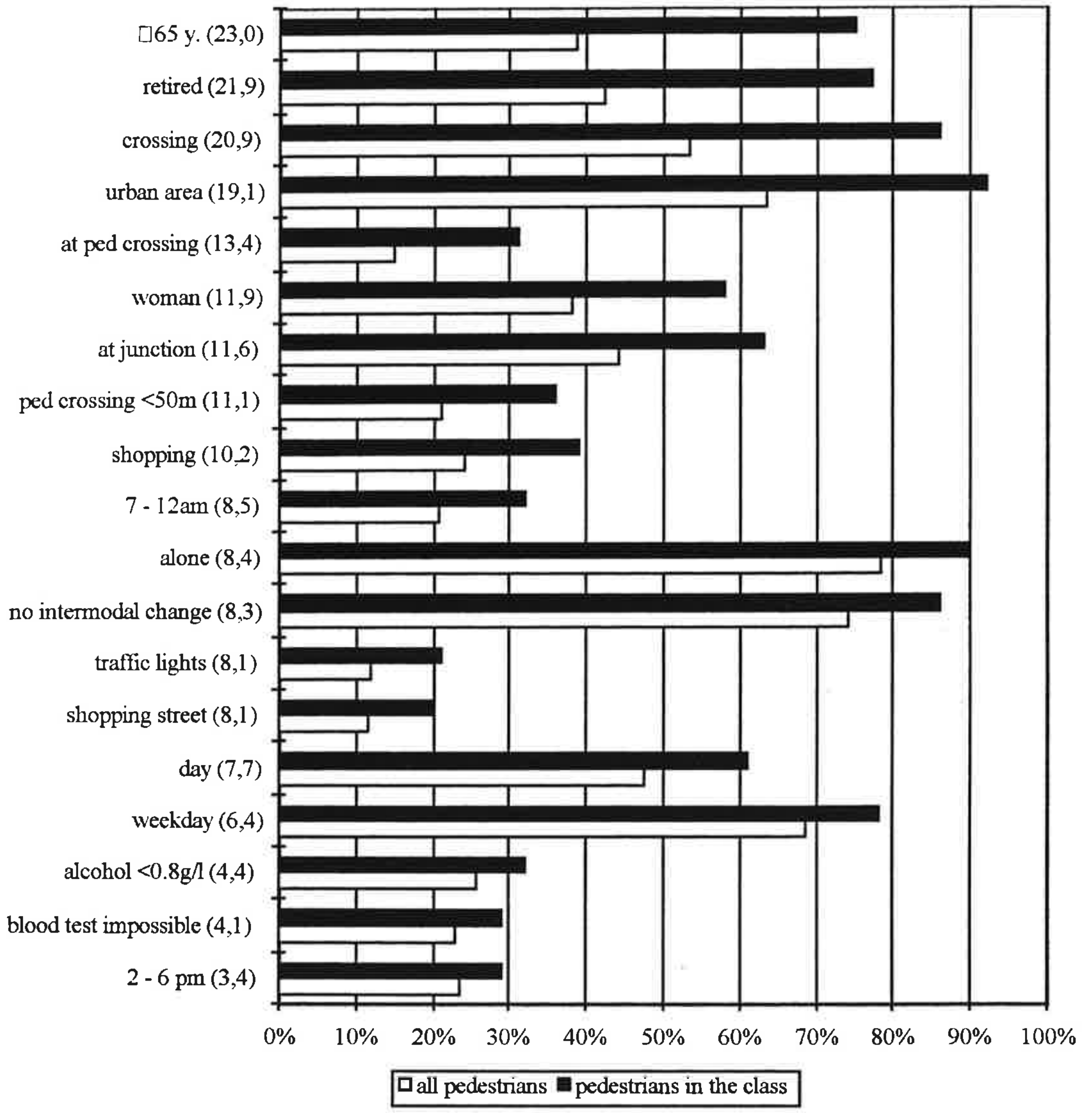

Figure 2:
Characteristics over-represented in Class 1 pedestrians compared with all pedestrians (the figure in brackets is the test value). Source : fatal accident reports.

9.4.2. Class 2: pedestrians in accidents at night, in rural areas, with high alcohol rate

This class comprises 34% of pedestrians. In 9 cases out of 10 these accidents occur at night, in 7 cases out of 10 on country roads with no junction, and in 5 cases out of 10 at the weekend. Alcohol levels in excess of 0.8 g/l are well represented : 42% as against 16% for all pedestrians[2]. The pedestrian is most often a man in the 30-64 age group, and to a lesser extent the 15 to 29 age group. Blue-collar workers and the unemployed are over-represented. The pedestrian is generally walking along the road and had been to a club, a bar or a party. The colliding vehicle is a private car 8 times out of 10 and the windscreen was broken, showing how violent the collision was. These characteristics are also found in other analyses (Everest, 1992).

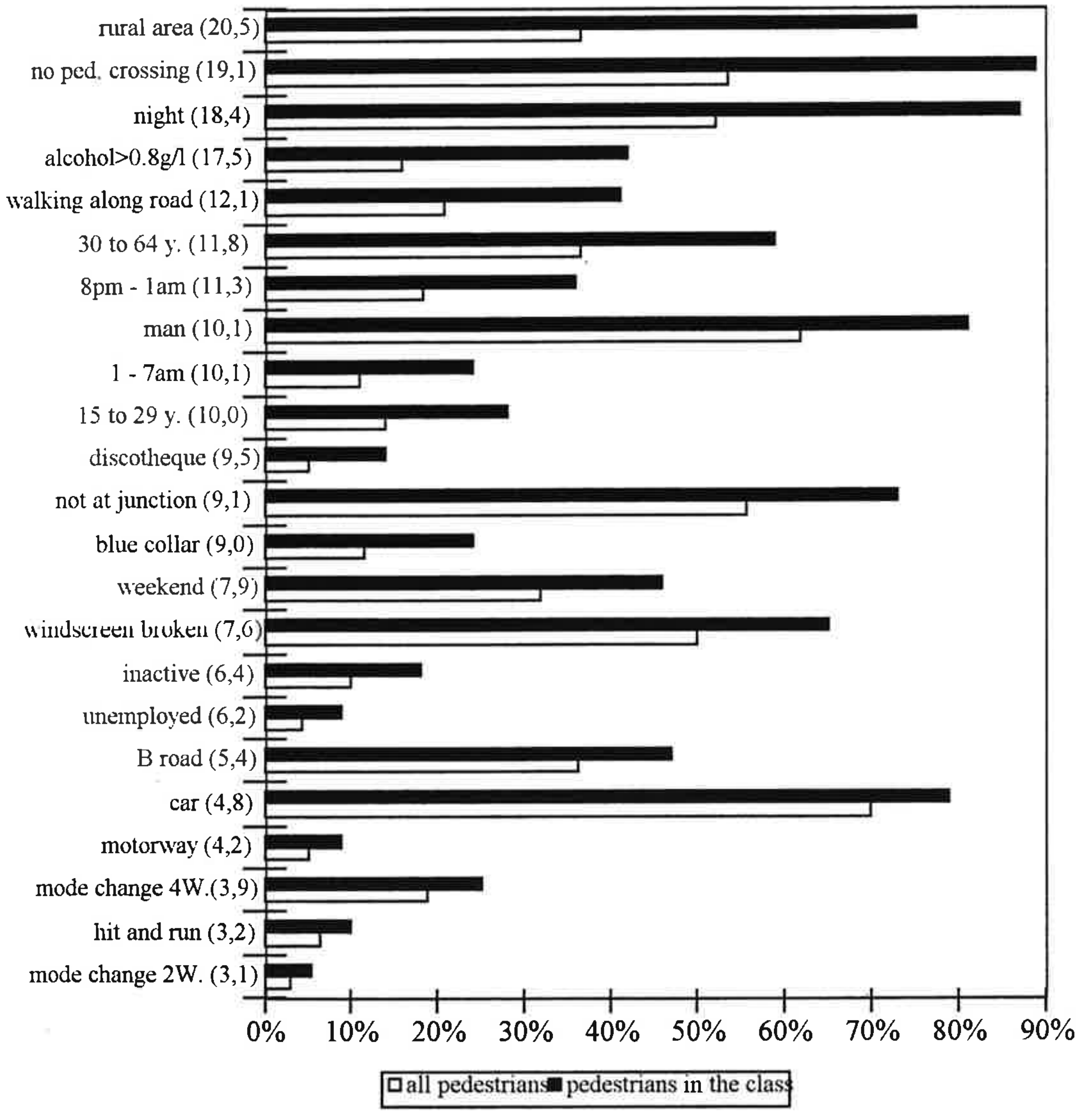

Figure 3:
Characteristics over-represented in Class 2 pedestrians compared with all pedestrians (the figure in brackets is the test value). Source : fatal accident reports.

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[2] This is the percentage of all pedestrians in fatal accidents, whether their blood level is known or not.

9.4.3. Class 3: children

This class comprises 13% of the pedestrians and is characterized by the presence of children under 15 years of age (78% vs 11% of all pedestrians). In almost 7 cases out of 10 the pedestrian was running or playing. 17% of these pedestrians circulate in groups. The accidents happen by day, in built-up areas and generally in the months of March to June, a period during which children are perhaps out most often without any parental supervision. The over-represented reasons for being out are "leisure" and "home-work journey", which in this case probably means "home-school", the two having been combined in the analysis to avoid groups with too few members. Here we find a large number of factors evidenced in research on accidents to children (Assailly, 1992), (Cambon de Lavalette, 1994), (Grayson, 1975), (Lynam and Harland, 1992). Changes of mode with public transport vehicles are also over-represented in this class.

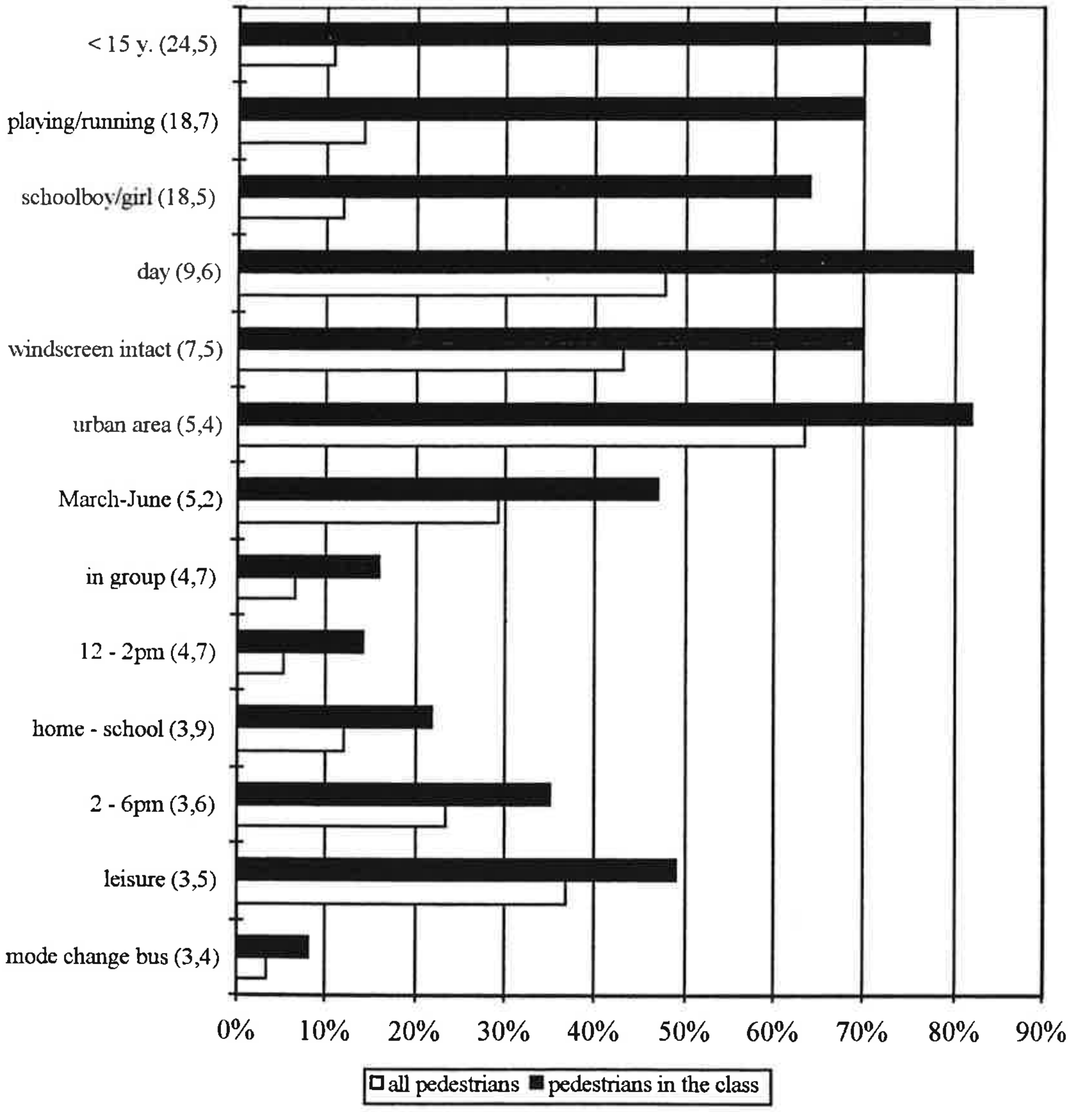

Figure 4:
Characteristics over-represented in Class 3 pedestrians compared with all pedestrians (the figure in brackets is the test value). Source : fatal accident reports

9.4.4. Class 4: secondary accidents

In this class, which comprises 11% of all pedestrians, the victim was on a pavement in 64% of the cases. This group is characterized by secondary accidents or collisions, i.e. the pedestrian accident occurred subsequent to an initial accident or incident. A driver may lose control of a vehicle, for example, then hit a pedestrian on the pavement, or after an initial accident involving several vehicles the drivers may alight (becoming pedestrians) and then be struck by other vehicles. Changes of mode with a light vehicle (LV) or a heavy vehicle (HV) are over-represented, as are collisions with fixed obstacles. Most of the pedestrians (58%) are in the 30-64 age group and 31% were on their way to or from work. 14% of these pedestrian accidents occurred on motorways (compared with 5% for the whole pedestrian population), and 29% happened on bends in the road (compared with 13% for the whole population).

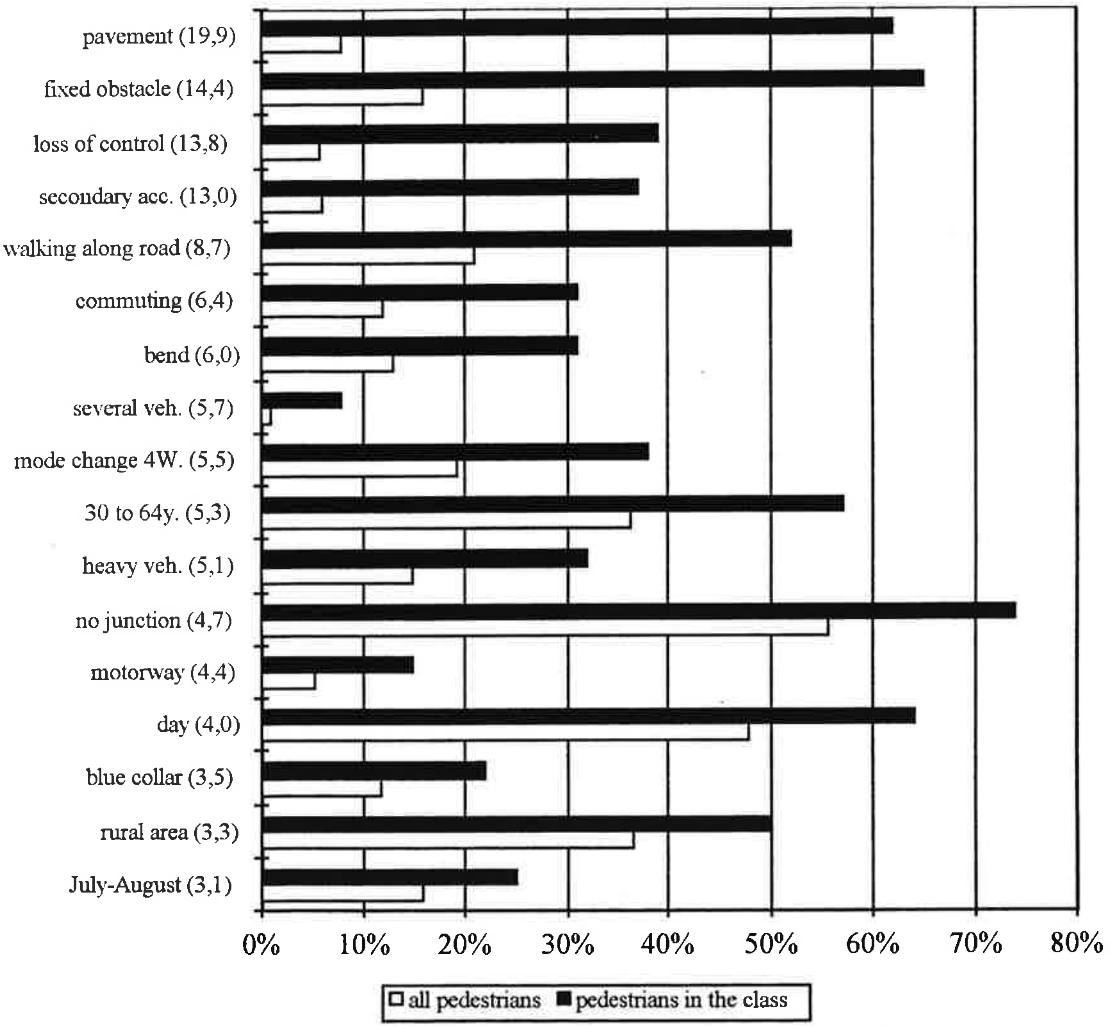

Figure 5:
Characteristics over-represented in Class 4 pedestrians compared with all pedestrians (the figure in brackets is the test value). Source : fatal accident reports.

Figure 6 summarizes the main characteristics of the four groups thus obtained. Individuals in the same class are homogeneous and well differentiated from the other classes. These classes reflect the pattern of pedestrian exposure : elderly people crossing the road, children playing or running in the street, pedestrians under the influence of alcohol at night on country roads, and changes of mode. Two of these classes reflect familiar results : accidents to children and to elderly people. Alcohol, secondary accidents and intermodal changes, however, have drawn less attention (Muhlrad, 1995). They are categories which involve more violent collisions insofar as the accidents generally occur in the country. There is enough at stake for it to appear important to study these types of accident more closely, either by further analysis of the accident reports or by detailed analysis of the accidents.

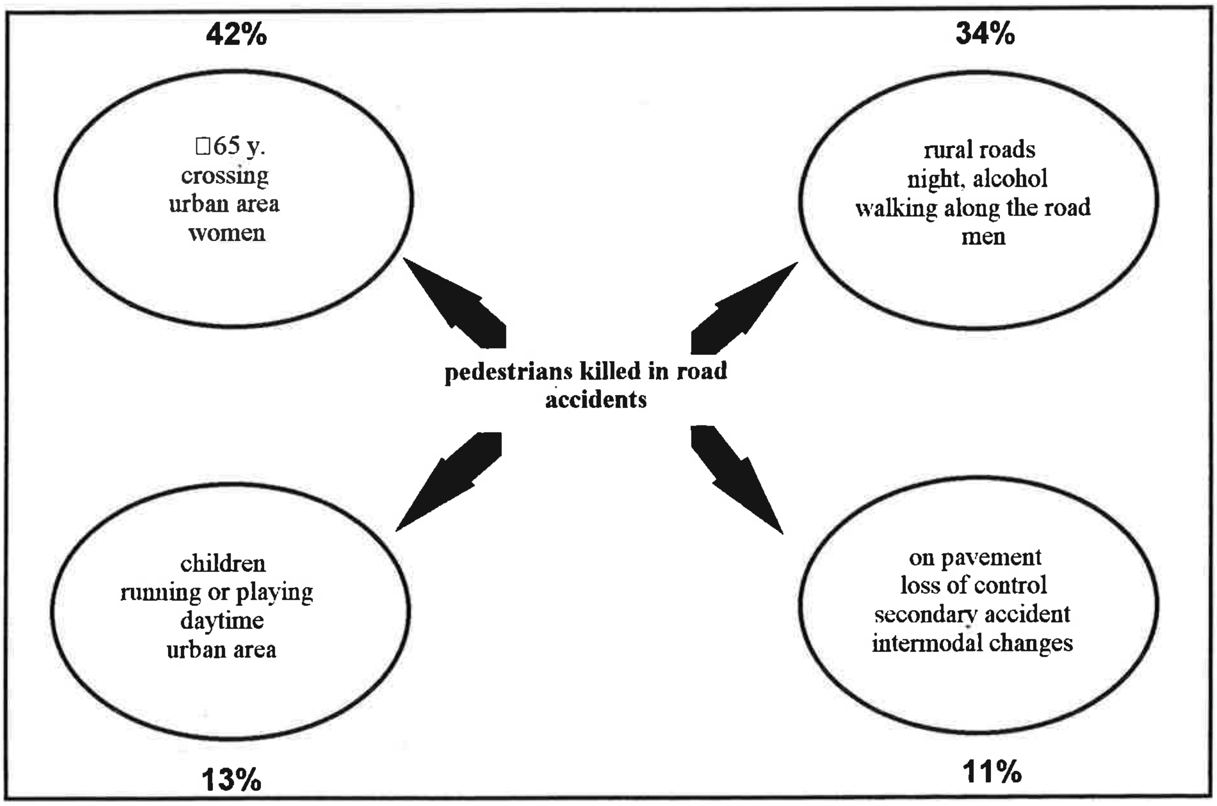

Figure 6:
Types of pedestrians killed in road accidents. (Source : fatal accident reports).

The typology merely reveals the most distinctive characteristics, i.e. those over-represented in each class compared with the pedestrian accident population as a whole.

9.5. CONCLUSION

To improve our knowledge of pedestrian accidents, a descriptive analysis of data from the accident reports drawn up by the police in the event of fatal accidents was undertaken. The idea was to identify types of pedestrian accidents in order to provide a basis for subsequent research on related themes.

The classification of pedestrians involved in accidents clearly identifies four groups :

- pedestrians age 65 or over crossing the road in a built-up area, with women over-represented;
- children in accidents in built-up areas while running or playing;
- pedestrians in accidents at night on country roads while walking along the road, with more than 0.8 g/l of alcohol in the blood;
- pedestrians on the pavement, loss of control of vehicle, secondary accidents, changes of mode.

The typology produced by this analysis reveals correlations between criteria, without necessarily indicating a "causal link" with the accidents. The accident reports and accident analysis forms drawn up by the authorities have their limitations when it comes to explaining road accidents. In the case of fatal accidents to pedestrians, for example, if there are no eye witnesses the driver's account is the only one reported, and drivers obviously tend to arrange the story in their favour.

This type of analysis is also limited in the lack of risk exposure data. Exposure may be expressed by various indicators (Ward and al, 1994) : distance walked, time spent walking, number of roads crossed... The relevance of an indicator depends on the population studied : the number of roads crossed is more significant in the case of elderly pedestrians, while the time spent in the street is a better reflection of children's exposure to risk.

Further research is therefore needed to improve our knowledge of risk exposure to put the situation in better perspective, and we must analyze certain types of pedestrian accident in greater depth, by re-examining the accident reports and taking other analysis dimensions into account, or by studying detailed accident analyses identifying accident mechanisms.

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10. *WALCYNG*: How to enhance WALking and CYcliNG instead of shorter car trips and to make these modes safer

Christer Hydén

Car traffic has become a threat to quality of life in urban areas. Accidents and other safety related problems are examples, local emission problems another. More generally, it is evident that car traffic in most urban areas has grown so much that many important aspects of urban life are inhibited to such an extent that the question of sustainability has become an important topic.

Short car trips play a very important role in this context: It is an amazing fact that the frequency of the use of car for shorter distances is very high. On average - in European countries - approx. 15 % of all car trips are shorter than 1 kilometer, 30 % shorter than 2 kilometers and 50 % are shorter than 3-5 kilometers! Consequently there is a great potential of reducing the number o f car trips if it was possible to convince car drivers - in one way or the other - to leave there cars for short trips and replace it by walking or cycling.

Much is known about this, and lots of efforts are also made to create a change. So far, however, it is obvious that there has not been a systematic enough approach to the problem. WALCYNG is a project with the aim of changing this. It underlines the importance of marketing aspects.

The project consortium has 10 members from different countries and representing different disciplines and expertise. (See table in the end of the paper). The project is accepted and expected to start in the beginning of 1996 and last for 18 months. Expected costs: Approx. 600 kECU.

The project will, therefore, follow the marketing line, and include the main four aspects of marketing:

10.1 INFORMATION POLICY

Information policy is usually based *on technical market analyses and on surveys of the attitudes, wishes, needs and interests of the potential customers, in order* to bring in all pieces of information about the market situation and about the users that the institution that wants to "sell" a certain product needs.

In connection with the topic dealt with here, this means:

a) analyze the market situation (i.e., existing situation and solution

b) establish needs and interests of the relevant groups of people who potentially might be prepared to walk or cycle and

c) estimate what portions of car trips can be replaced (one important aspect will be to establish time and distance limits under different conditions and in different countries). Customers must be divided in different target groups (road users, employers, authorities and politicians), as each of these target groups have their own interests and they need specific information and encouragement

Information policy should give the ones who promote certain products information about the market situation in technical terms, and about the needs, interests and potentials on the users sides.

Much is known about the wishes, needs and interests of (potential) customers of walking and cycling, but often measures are just based on guesses, because it is rather difficult to find the wide-scattered existing material. Systematization and completion is needed, in order not to go on with the other steps of marketing (= product-, incentive-, and communication policy) without basing them on thorough and professional information policy.

10.2. PRODUCT AND DISTRIBUTION POLICY

Adequate and attractive technical solutions are looked for, based on what has been learnt about the users, in the frame of information policy (traffic planning and engineering level, clothes, shoes, cycles, transport aids like carts and bags, information help, parking facilities, etc.); styling and layout aspects have to be considered thoroughly. These aspects can also be discussed under the perspective of 4. Communication policy.

10.3. INCENTIVES/PRICING

Possibilities for society to give incentives on national levels (e.g., taxes) and on local levels (monthly tickets reduced in price, etc.) have to be found.

10.4. COMMUNICATION POLICY

This part of the marketing has the goal to demonstrate, for users and for potential users, that user needs and interests (see 1.) are taken into consideration on the product and distribution side and on the incentive side. The communication part has two goals: To give the product an image (or to display this image) and to inform the (potential) user about the technical product aspects[3].

The structure of the project is most easy to follow via a graph illustrating the various so called work packages, and how they are linked. (Figure below).

<table>
<tr><td>**WP 1**
Portions of short car trips, and trips by walking and cycling</td><td>**WP 2**
Existing products and efforts</td><td>**WP 3**
General problems - of pedestrians and cyclists</td><td>**WP 4**
Safety problems</td></tr>
<tr><td colspan="4">WP 5
Categorization of solutions</td></tr>
<tr><td colspan="4">WP 6
Interaction with road users; Attitude surveys, stated preferences</td></tr>
<tr><td colspan="4">WP 7
Identification of positive products and recommendations</td></tr>
<tr><td>WP 8
Incentive
strategies</td><td>WP 9
Communication strategies/
Campaigns</td><td>WP 10
Inoculation</td><td>WP 11
Outlining future lobbying</td></tr>
<tr><td colspan="4">WP 12
Project summary report</td></tr>
<tr><td colspan="4">Scheme for assessing measures on all levels from WP 8 to WP 11, to be displayed in its complete features in WP 12</td></tr>
<tr><td colspan="4">Model recommendations for influencing mode choice permanently and systematically - "The WALCYNG quality scheme"</td></tr>
</table>

Figure 1:
The WALCYNG work structure

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[3] It will be important to see and to demonstrate that communication policy alone (often mixed up with the concept of "marketing") without proper product and distribution policy bears the risk of boomerang effects (i.e., tests of the "product" by potential users and final decision to try it "never again").

The objectives of **Work Package 1** are to identify groups of potential users for walking and cycling and to evaluate their number, in order to adjust strategies and investments.

The main questions we try to answer in WP 1 are the following:

How many trips do people conduct on an average day, by different modes?

How long are the trips by different modes; on foot, bicycle, car?

What kind of transportation do people use on different trips, by purpose of the trip?

Which groups of the population do the different kinds of trips and to what extent?

WP1 will be based on data from all countries in the EU plus some more in Europe.

The main aim of **Work Package 2** is to make an inventory of existing products and efforts for pedestrians and cyclists. A secondary aim is to describe the purpose and important properties of the products and efforts.

The meaning of products and efforts will be extended; It should not only include what might traditionally be thought of in this connection, but in addition planning and engineering solutions as well as campaigns. It should also contain efforts to make car use less attractive.

The methods to be used are Focus Group Interviews (FGI) and literature studies. The FGI will be held by each partner in their country, respectively. Each partner will also search for relevant literature from all world from the 1980's onwards, but especially for literature from their own country or countries with similar languages.

The aim of **Work Package 3** is to describe the problems experienced by cyclists and pedestrians in traffic. In harmony with the marketing approach, emphasis is on the experience of these road user groups rather than an objective description of the problems.

All WP 3 partners will collect relevant literature from the 1980's onwards from their own countries and from other European countries.

For each recognized problem, we will try to answer three central questions:

1. Is the problem experienced mainly by some subgroup of users or is it rather general?
2. For which positive value does the problem pose a threat?
3. Which structural aspects of the traffic system generate the problem or can influence it?

In Work Package 4 we will identify and qualify the existing knowledge regarding solutions both in the area of passive safety (bicycle helmets, bicycle design, etc.) as well as in the area of active safety (intersection design, speed reducing devices, etc.). In the latter case the approach will be broad, covering all parts of the system "Man-Machine-Environment".

One important aspect is that a better consensus must be found in order to introduce common planning standards and to avoid an increase in the number of accidents caused by increasing cross national traffic (e.g., the legal duty to yield between motorized traffic vs. crossing pedestrians and bikes differs in European countries in a dangerous way).

In the frame of **Work Package 5,** results of the WPs 1 to 4 will be summarized and synthesized. The work package is preparing the information collected so far to answer the critical questions:

What wishes do the different target groups have?

What is making the products attractive in their eyes?

What is threatening to make them leave us as customers (not to buy our products, not to listen to us any more, etc.)?

Work package 5 (WP5) shall be the synthesis of WP 1 through 4. As a conclusion, it is intended to produce both a summary of activities carried out in previous work packages and a direction for WP 6 and subsequent WP:s. Gaps are to be identified which will be filled in by the further process within WALCYNG.

The material that is synthesized in WP 5 should then be qualified by the customers, in the frame of **Work Package 6.** The critical questions to be answered in WP 6 are:

What wishes do the different target groups have?

What is making the products attractive in their eyes?

What is threatening to make them to leave us as customers (not to buy our products, not to listen to us any more, etc.)?

The methods to be used in WP 6 will be Stated preference analyses (Norway) and semi-standardized interviews in several European countries (Austria, Finland, Italy, Spain) during the summer 1996.

The main objective of **Work Package 7** is to develop a quality-based scheme with important issues for pedestrians and cyclists as users and to relate qualities to user characteristics and user requirements.

It shall be outlined in WP 7 how the evaluation of products with respect to the criteria "user characteristics" and "user requirements" can be carried out systematically. Adapting product development and product modification with the users in mind should become a routine process (WALCYNG Quality Scheme).

The main method in WP 7 will be expert discussions, organized as a three day workshop including the whole consortium. Minutes of the workshop will be produced, and the findings, together with what has been achieved in the frame of WP 1 to 5, will be systematized and summarized in a way that fits the WALCYNG goals. Especially, a frame for a quality-evaluation scheme will be developed, in such a way that the results of the following WPs 8 to 11 fit in.

Work Package 8, Incentive strategies: In commercial marketing, incentive aspects are very important. Pricing policy is one central element. In non-profit marketing, however, one has to look for other incentives as well, positive or negative ones. In connection with WALCYNG it is planned to outline incentives that influence modal choice on several levels (= part of the

WALCYNG Quality Scheme). This can only be done on basis of a better understanding of the incentive background for today's modal choice situation.

This means that we differentiate between incentives for

road users

decision makers

politicians

industry managers

Incentives can be given both on a **national level** (e.g. taxes, ...), as well as on a **regional and local level** (e.g. monthly tickets reduced in price, etc.).

Types and combinations of incentives in today's modal choice situation have to be analyzed systematically. In the first step we will study written material. In the following we will carry out group discussions with experts and decision makers. On the basis of the collected information we will work out ideas and categories for incentives, which should be used more often.

Work package 9, Communication strategies - Campaigns: Based on facts collected in the frame of the Information-policy part a general outline for a potentially successful communication policy has to be developed. In addition, recommendations for the evaluation of communication activities will be given (part of the WALCYNG Quality Scheme).

We will use the results of WPs 1 to 7 in an analysis with respect to communication questions. Other literature on the topic, especially the one produced in connection with transport matters, will also be studied. In two or three group discussions with experts, incentives for WALCYNG will be introduced and discussed. Experts will present their experiences with various incentive strategies for different target groups. Furthermore, new ideas will be collected.

Work package 10, Inoculation: If somebody wants to promote the implementation of measures to the advantage of walcers (pedestrians and cyclists), he or she has to deal with many structural problems related to authorities, car-lobbies, politicians, etc. In order to encourage people - especially transport experts - to work for the enhancement of walcyng (walking and cycling), and not to give up too early, one has to prepare them regarding what problems they are going to meet, how these problems usually develop, and how problems can be overcome.

Usual difficulties to be expected, when working for walcyng, and how to prepare somebody both structurally and morally (= to inoculate somebody against difficulties to be met) will be systematically analyzed.

Even in this work package we will make literature studies (previous research on inoculation), as well as expert interviews about experienced difficulties and problems.

Work package 11, Outlining future Lobbying: Vulnerable road users have weak representation compared with motorists. Structural improvements (pressure groups, public departments that are responsible for pedestrians and cyclists, etc.) might help to change the modal split in favour of walcyng. Better information of the public about the situation of cyclists and pedestrians will in itself enhance structural improvements. The aim of this WP 11 is to collect information and ideas on how to achieve structural improvements, to develop recommendations how to initiate and institutionalize interest groups.

We will collect information about lobbying in general by studying sociological literature on this topic. We will concentrate on existing pressure groups, on politicians and decision makers and ask them for their experiences. We will also describe a lobbying-model-process based on cases, which should become a part of the WALCYNG Quality Scheme.

In order to get some practical information about lobbying we have to get in contact with different pressure groups in various European countries. In this way we are able to collect advises for the lobbying model-process, get an overview of existing pressure groups and make the WALCYNG-project more popular.

Besides we have to talk with politicians and decision makers, groups, who the pressure is put on. By this means we, e.g., get to know how politicians react, what they think about lobbying for walking and cycling, etc.

In **Work Package 12,** the results of the whole project will be summarised in a final report. The most important parts of the final report will be the summary of findings regarding a recommended strategy for

assessing measures on all levels from product assessment to future lobbying (WP 8 to WP 11), and to

produce model recommendations for controlling and influencing mode choice on short trips permanently and systematically - "The WALCYNG quality scheme"

10.5 THE WALCYNG CONSORTIUM

1.	DTPE	Dept. Traffic Planning & Engineering (Coordinator)	Sweden
2.	CTH	Chalmers Technical University	Sweden
3.	FAC	FACTUM Consulting	Austria
4.	FG	Franco Gnavi and Associates	Italy
5.	HKI	Helsinki's Department for Traffic Planning	Finland
6.	TØI	Institute for transport economy	Norway
7.	UH	University of Helsinki (Dept. Psychology)	Finland
8.	UVEG	University of Valencia (Dept. Psychology)	Spain
9.	VCK	Verkehrs-Consult Karlsruhe	Germany
10.	VV	Voetgangers vereniging	the Netherlands

11. Results of VRU-TOO

Oliver Carsten

11.1. OBJECTIVES

The work in DRIVE II Project VRU-TOO was targeted specifically at the reduction of risk and minimization of delay to vulnerable road users, namely pedestrians with as little inconvenience to motorized traffic as possible. To achieve this, the project linked practical implementations in three countries with behavioural studies of the micro-level interaction of pedestrians and vehicles and the development of computer simulation models. This paper concentrates on the implementations. These took the form of pilot projects to test the impact of applying advanced detector systems to improve conditions for pedestrians at signalized junctions and crossings on main roads. The overall objectives of the implementations conducted by VRU-TOO were to reduce waiting time for pedestrians, to obtain increased safety and comfort for pedestrians, and to do so without a negative effect on the efficiency of vehicle traffic in terms of queues, delays and capacity.

11.2 SYSTEM AND LOCATIONS

The generic VRU-TOO system is extremely simple in concept. It is illustrated in Figure 1.

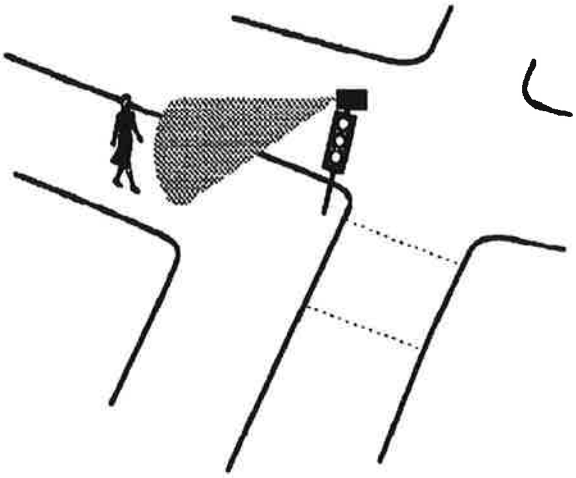


Figure 5:
The VRU-TOO “system“

Microwave detectors are mounted on traffic signals to register the approach of pedestrians. This detection can be applied to:

a) Replace the normal push-button on signalized pedestrian crossings;

b) Provide earlier activation of the pedestrian stage;

c) Provide an extension of the pedestrian stage for late arrivals;

d) Provide longer pedestrian stages when there are large numbers of detections.

The three locations for the trials were very different. The first set of crossings was in Leeds, England. Three crossings along one quadrant of the new one-way loop road that encircles the city centre were fitted with the VRU-TOO system. The second of these crossings links two large indoor shopping precincts as well as being on a major pedestrian radial route to and from the city centre. As a consequence flows of up to 6,000 pedestrians an hour can be observed. The other two carry lower flows of pedestrians.

In Porto, Portugal, the location was on a major east-west arterial, linking the city centre with the coastal industrial zone. The road is a dual carriageway, with a tram line running down the central reservation. The site was at a crossroads with a school on the north-west corner. As a consequence of the presence of the school, very large flows of children could be observed using the two pedestrian facilities across the carriageways of the arterial on the western arm of the junction.

The site in Greece was in the centre of Elefsina, an industrial suburb of Athens located along the coast to the west of Athens. The location was a crossroads in the town centre on what, prior to the building of a bypass, had been the main Athens to Corinth highway. This road runs east-west through Elefsina. The junction was not signalized at the start of the project.

Although there was a large common element in the manipulations at each of the sites, in particular the use of pre-arrival detection, there were also substantial differences. In Leeds, the signals were operated by an urban traffic control system (UTC), which used a set of fixed time plans for coordinating the signals. At Site 1 and 3, the push button was supplemented with automatic detection, and the normal pedestrian green man stage was extended by up to four seconds if pedestrians were detected approaching during the stage. Finally, pedestrians, whose approach was detected during the four seconds before the controller registered whether or not there was a pedestrian demand, now triggered the pedestrian stage. At site 2 in the after situation, the peak-hour situation was changed from a fixed pedestrian stage to a demand-based one. Demand could be registered either by the detectors or by the push-buttons. In the off-peak times, the pedestrian stage continued to be demand-based, but with demand now being registered either by the detectors or by the push-buttons. In addition, both for peak and off-peak times, the pedestrian green man was extended by four seconds if pedestrians were detected approaching the crossing in the last 10 seconds of the standard green man period.

The Porto signal was not tied into a UTC. The after configuration in Porto was more sophisticated than that in Leeds. It was designed both to take into account the size of pedestrian demand, i.e. to give more immediate response (up to 9 seconds sooner) and extra time (up to 4 seconds) when there were large groups (defined as at least 30% occupancy of relevant detectors), and to provide prolongation of the green on the second crossing for pedestrians who were slow walkers or late arrivals. The prolongation of green was intended to prevent pedestrians from becoming stranded in the central reservation or alternatively violating the red light and perhaps having conflicts with vehicles. As a result, the maximum time available for a pedestrian to cross the full width of the main road on green was now 18 seconds, in contrast with the previous normal time of 14 seconds, which was now the minimum. Late arrivals could result in a further 4-second extension. In addition there was still 3 seconds of flashing green and 3 seconds of all red.

The Elefsina configuration was more straightforward. The junction was signalized in November 1993. The signal staging was a very simple two-stage setup, with the vehicles on the main road having priority until either a vehicle was detected on the northern arm or button was pushed for one of the two pedestrian crossings. The pedestrian green man only came up if a button had been pushed. Vehicle movements from the side road were permitted simultaneously with the pedestrian green. The pedestrian stage was 7 seconds. The red time for vehicles on the main road could be extended by up to 5 seconds if a vehicle were detected on the northern arm, but the pedestrian signal would be red. There was a four-second inter-green period. This is the "before" situation.

Subsequently detectors were installed at the junction and the new system became operational in March 1994. On the western crossing, two detectors were positioned to detect approaching pedestrians and provide pre-arrival detection, supplementing the push-buttons. This was the "VRU-TOO" crossing for which a detailed evaluation was carried out. With regard to the pre-arrival detection, no change was made in the signal staging but the green time for pedestrians to cross was reduced to 6 seconds. The facility to extend the green for the side road traffic was eliminated. On the eastern crossing, no automatic pre-arrival detection was provided. Instead, at the request of the Greek Ministry of Transport, the microwave detectors were positioned pointing towards the centre of the main road, so as to detect pedestrians in the crossing and provide an extension of the green man.

11.3 RESULTS

A comprehensive evaluation of the sites was carried out, covering vehicle to pedestrian conflicts, pedestrian behaviour and effects on vehicle traffic. At all the sites, except Site 2 in Leeds, the system worked in direct sense: the proportion of pedestrians arriving on green increased. In Leeds, there was an 18% ($p<.10$) reduction in serious conflicts if the figures for the three sites are combined. This was accompanied by a reduction in the number of pedestrians who crossed the road whilst the signals were green for vehicles. Expected pedestrian delay (the time from arrival to the next green man) was substantially reduced, but actual delay, perhaps because of the large number of red light violators was hardly affected. In terms of vehicle behaviour, there was no increase in the number of vehicle red light violations. There was also no increase in any of the queue lengths but the survey showed some increase in total journey times.

In Porto, there was no statistically significant reduction in the number of serious conflicts. There was no overall change in the number of pedestrian red light violations when vehicle traffic had green, although there were variations in the effects on different sides of the dual carriageway. Expected delay was reduced on one crossing. Actual delay was reduced on the crossing nearer the school, but increased on the other crossing in line with the reduction in red light violations. In terms of the effects on vehicle traffic, there was no increase in the observed traffic queue lengths and also no significant increase in journey times.

In Elefsina, there was a 51% overall reduction ($p<.01$) in the number of serious conflicts on the "VRU-TOO" side. There was no change in pedestrian red light violation. Expected delay decreased, but actual delay was virtually unchanged. The proportion of pedestrians who had to wait for more than 30 seconds decreased from 28 percent to 18 percent. In terms of vehicle behaviour, there was a slight reduction in the number of vehicles who violated the red light on the main road from 7 to 5 vehicles per hour. There was no increase in the length of the vehicle queues.

11.3. CONCLUSIONS

The conclusions of the evaluation were as follows:

Pedestrian Safety: In two of the three locations there was an overall reduction in the number of serious conflicts between pedestrians and other vehicles. There were however considerable variations between the sites and even between different carriageways on the same site. There were no increases in the number of vehicles going through red lights.

Pedestrian Mobility: There was a reduction in the average length of time pedestrians had to wait at the kerb edge. There was an overall increase in the number of pedestrians who arrived at their crossing point to a green signal; this increase was greater than would have been expected from the actual increase in pedestrian green time on the signals.

Vehicle Effects: There was no significant increase in vehicle queue length at the individual sites although there was a slight increase in overall journey time over the length in Leeds.

11.4. REFERENCES

HYDÉN, C. (1987) The development of a method for traffic safety evaluation: The Swedish traffic conflicts technique. Bulletin 70. Department of Traffic Planning and Engineering, Lund Institute of Technology.

12. Exposure, safety and the use of rates

A.S. Hakkert

The aim of the presentation is to convey a methodological problem which is fairly well-known in the field of safety research, but which still lacks a proper solution. Accidents can be defined as the product of risk and exposure. Risk is generally expressed as a rate and a number of community used rates are given in Figure 1. What do we need and use rates for? (Figure 2). We require rates when making comparisons, because the absolute numbers of fatalities or casualties are meaningless, or for monitoring trends over time. Some examples appear in Figures 3, 4. The use of rates, especially the travel-risk rate -- defined as casualties or fatalities per unit distance travelled, is very widespread. The problems associated with the use of this rate are described in Figures 5 and 6.

12.1 WHAT IS THE SOLUTION TO THE PROBLEM DESCRIBED?

We need good models, relating accidents to flow (Figure 7). Preferably models should be disaggregated by conditions and accident types.

Three levels of aggregation can be defined:

Level I - relating accidents, or fatalities, to the total national amount of distance travelled (see work by Smeed, 1974, Figure 8);

Level II - relating accidents, or fatalities, to traffic volumes per road, or road category (i.e., AADT) - (see work by Hakkert et al., 1995, Figure 9);

Level III - relating accidents to hourly traffic volumes (see work by Persaud and Dzibik, 1993 or Maycock and Hall, 1984 (Figure 10).

It is hoped that additional research on the above-described problem can be initiated. This will shed further light on the issue, and may lead to results that will eventually enable the use of non-linear rates, thus enabling comparisons of travel-based rates in a meaningful context.

EXPOSURE, SAFETY AND THE USE OF RATES

ACCIDENTS = RISK x EXPOSURE

↓

RATE

COMMONLY USED RATES

ACCIDENTS PER UNIT POPULATION

ACCIDENTS PER UNIT VEHICLE-POPULATION
(i.e., NO. OF VEHICLES)

ACCIDENTS PER UNIT DISTANCE TRAVELLED
(i.e., VEHICLE-KILOMETRES)

ACCIDENTS, OR CASUALTIES, OR FATALITIES

Figure 1

WHAT DO WE NEED RATES FOR?

FOR COMPARISONS

FOR TREND MONITORING

GENERALLY:

1. **WHEN COMPARISONS OF ACCIDENT NUMBERS ARE NOT MEANINGFUL**

2. **WHEN WE LACK KNOWLEDGE OF DETAILED RELATIONSHIPS BETWEEN ACCIDENTS AND INDEPENDENT VARIABLES, i.e., THERE IS NO MODEL**

Figure 2

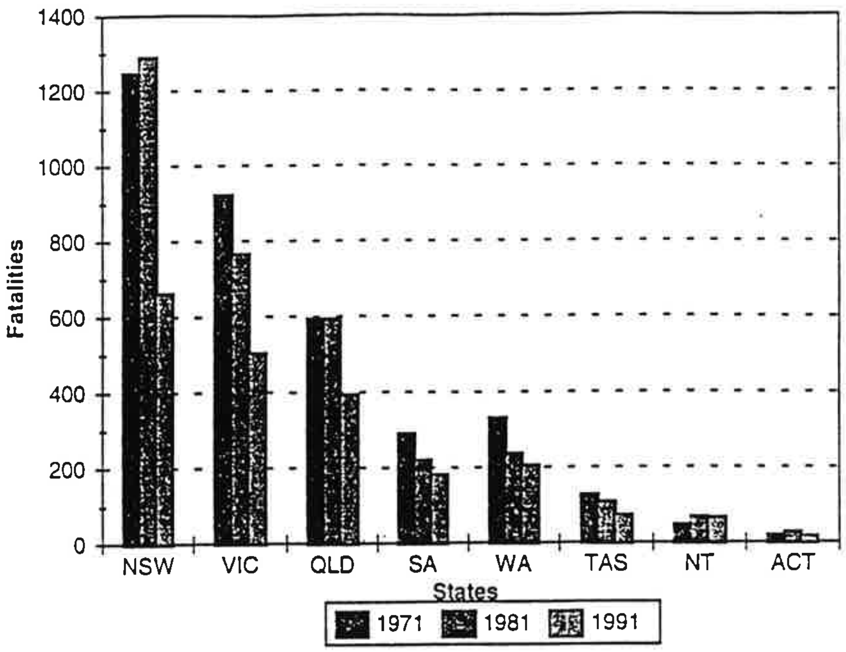


Figure3.1:
Fatalities in Australian States,1971-1991

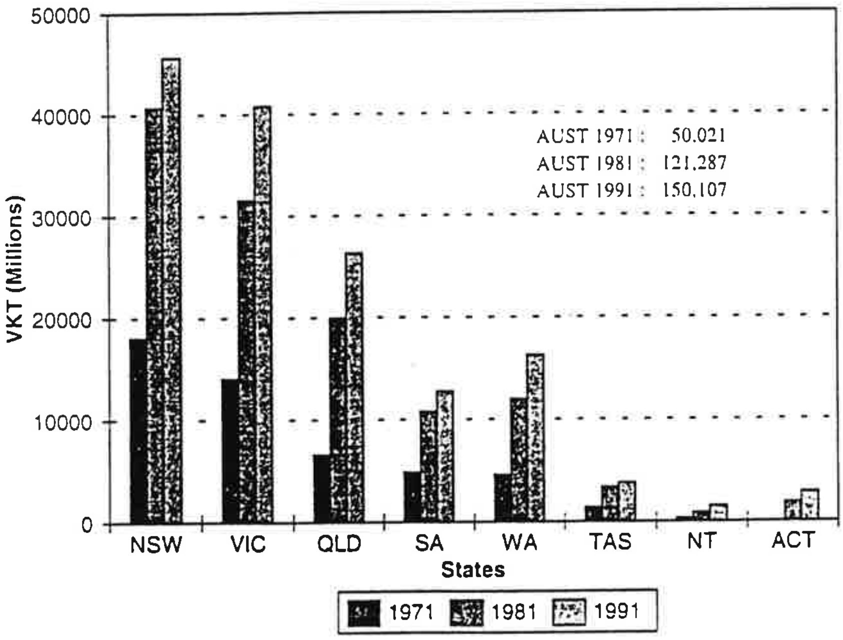


Figure 3.2:
Vehicle kilometers travelled (VKT) in millions, 1971-1991

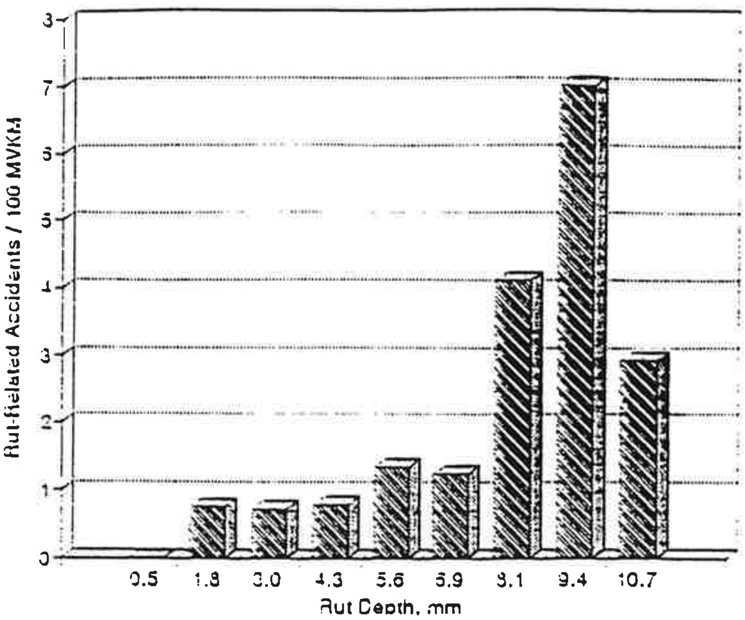


Figure 4:
Use of accident rates

WHAT IS THE PROBLEM?

IN USING RATES, WE ASSUME A LINEAR RELATIONSHIP

ALSO DISCUSSED HAUSER (1995)
ANDREASSEN (1991)

IF RELATIONSHIP IS NOT LINEAR -- WE HAVE A PROBLEM

- RELATIONSHIP IS GENERALLY NOT LINEAR

OTHER ASSOCIATED PROBLEMS

- **ACCURACY OF VEHICLE-MILEAGE SURVEYS**
- **ACCIDENT SEVERITY PROBLEMS -- WHAT ACCIDENTS GO INTO EQUATION -- PROBLEM NOT LIMITED TO RATES**
- **REGRESSION PROBLEMS WITH RATES**

Figure 5

12. 2. INDICATORS ASSOCIATED WITH CRASHES, INJURIES AND FATALITIES (FIG.6)

12.2.1 Raw data indicators

For the purpose of monitoring or evaluating safety within a State, other geographic entity or group, it may sometimes suffice to study the trends in the raw data. Suitable time periods should be selected as there is a tendency to look at changes over very small time intervals (a weekend, holidays, a week). The random fluctuations in the crash and injury data over short intervals generally make such fluctuations meaningless. Even a month of data on fatalities within one State is not meaningful without applying statistical trend analyses.

A study of changes in the number of crashes or casualties may lead to the identification of an issue in need of further study. For such further study, it will quickly become necessary to look at more complex indicators, such as rates, which enable comparisons to be made and can allow for changes in exposure.

12.2.2. Crash and casualty indicators

The most widely used indicator of safety performance is the number of crashes, casualties or fatalities associated with the issue under observation. Most countries limit analyses to accidents with personal injury although some countries, including Australia, also report on property damage accidents where the damage exceeds a certain value. Comparisons between States or countries are generally limited to fatalities, which are the most accurately and consistently reported, and in some cases serious casualties (ones admitted to hospital). The present study is also limited to the above two classes. It is generally beneficial to weigh the various types of accidents or injury according to cost indices if these have been developed, as is the case for Australia.

12.2.3. *Rates*

The most commonly used crash and casualty rates used for comparisons and evaluations are the crash or injury rates per unit population, per number of motor vehicles or per unit vehicle distance travelled. Using population in the denominator generally produces meaningful output indicators although it should be remembered that large differences in output can stem from differences in population, age group, mix or geographical location (urban vs. rural). Such differences should be taken into account as much as possible to produce rates broken down into the separate meaningful categories.

Rates per unit distance travelled are much more problematic. Such rates are in wide use and have also been used in this study. They generally overlook the difficulty raised in the following section (Hakkert, Livneh and Mahalel 1976, Andreassen 1991, Hauer 1995).

The number of accidents or fatalities per million vehicle kilometres travelled (Million VKT), which is a widely used index of comparison, is generally decreasing over time. Vehicle kilometres are generally defined as the distance travelled per vehicle multiplied by the number of vehicles. Each additional vehicle-km causes a smaller and smaller increase in the number of accidents. This situation is described in Figure 7. The decreasing slopes of curves OA and OB represent the fact that the number of accidents per vehicle-km decreases with increased travel. The ratio of accidents per vehicle-km is given by the angle a. The meaning of an improvement in the level of safety is that for each amount of travel the amount of accidents is reduced. Therefore, curve OB describes an improvement in safety compared with curve OA. For each amount of travel, the resulting number of accidents will be smaller.

It can be seen from Figure 7 that the number of accidents per vehicle-km by itself does not indicate a higher or lower level of safety, without further knowledge of the shape of the curves or our position along them. For a given amount of travel, curve OA produces a greater amount of accidents than OB and has therefore an inferior level of safety. For different amount of travel, wrong conclusions can be obtained from the use of the ratio accidents per vehicle-km. Point C, having a smaller slope than D (a < b) is worse than D from the overall safety point of view, but the fact that the number of accidents per vehicle-km travelled is less, is helpful. Each vehicle will be involved in fewer accidents, although the greater number of vehicles will mean more accidents. Only for the case of a linear relationship between travel and accidents, can the level of safety be described by this ratio. However, in such a case the absolute number of accidents can describe the situation as well.

It is, by now, fairly well established that over the whole range of practical traffic volumes, the shape of the curve is not linear (Hauer 1995).

A further problem with the use of vehicle-distance travelled is the basic accuracy of measurement. Vehicle distance travelled is generally assessed from relatively small surveys of odometer readings, from fuel consumption estimates or from traffic volume counts. These measures are prone to large errors.

Using the number of vehicles as denominator at first glance seems to circumvent the problem described above. It does, however, depend on the circumstances.

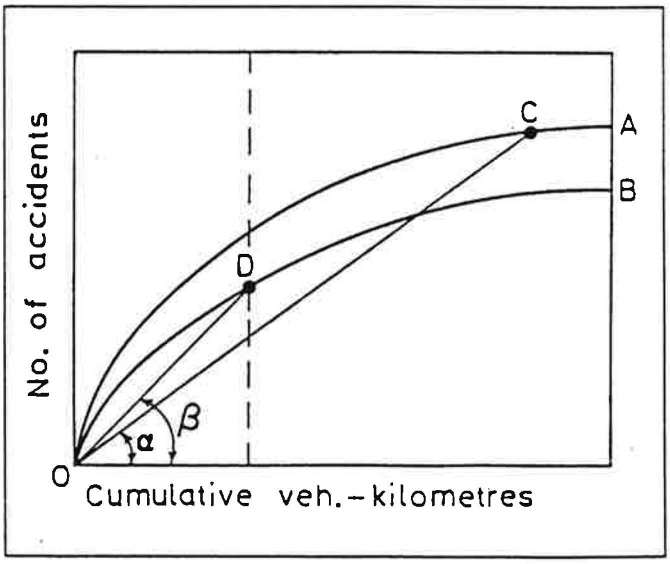


Figure 7:
The relationship between number of accidents and cumulative vehicle-kilometres travelled.(Source: Hakkert, Livneh and Mahalel 1976).

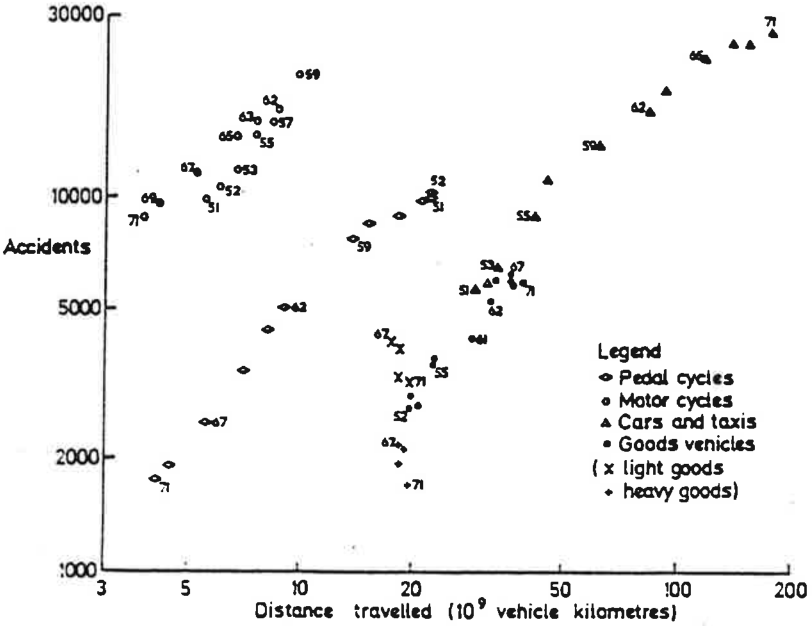


Figure 8:
Level I models (Smeed,1974)

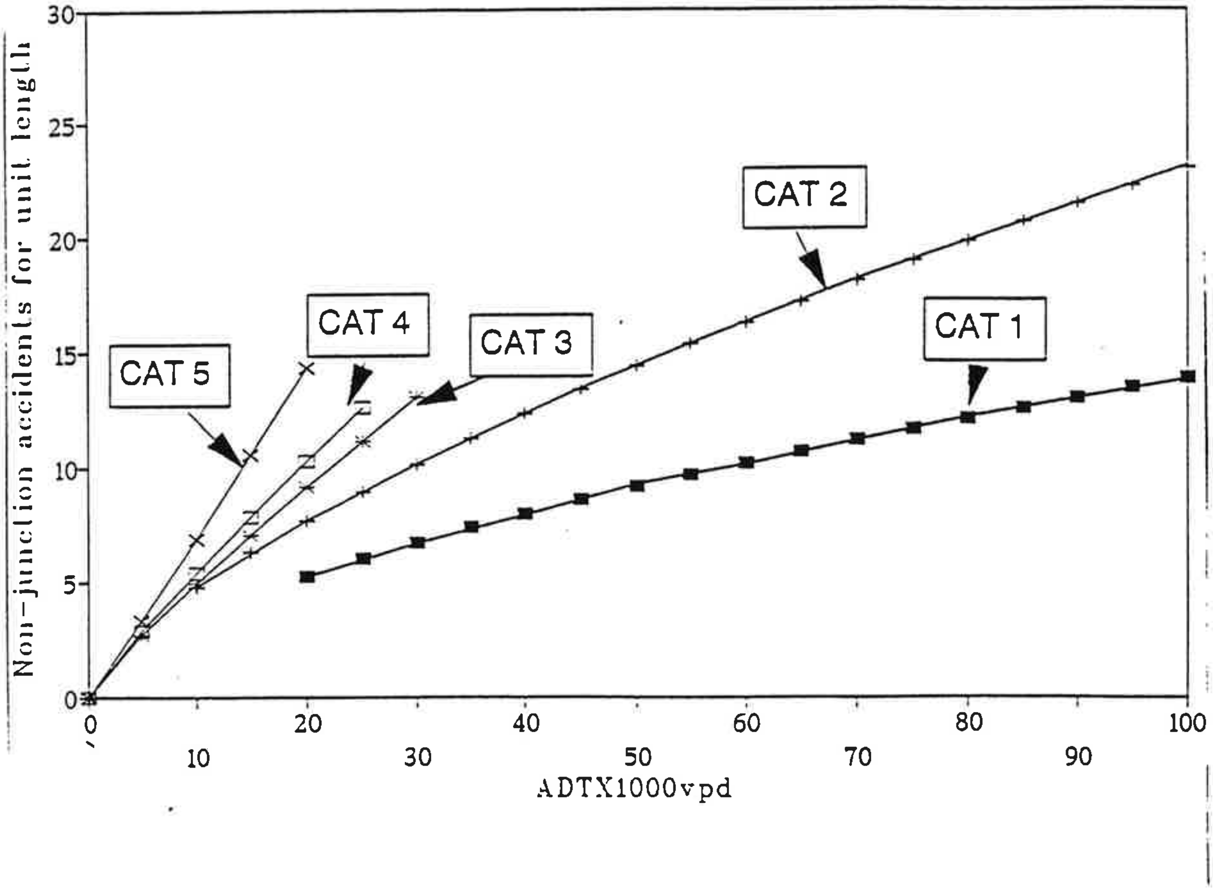


Figure 9:
Level II models (Hákkert et al. , 1995)

Level III models

Some recent flow models

Freeways

4-lane freeways (Canada) (Persaud, Dzbik, 1993)

m = 0.147 (AADT(1000)1.135

m = 0.00145 (hourly flow/1000)0.717

m = expected no. of accidents

Intersections

4-arm roundabouts

Level I - $\lambda_{total} = kQ^{0.68}$ (Maycock, Hall, 1984)

λ_{total} = exp. no. of acc. per year

Q = product of toatal entering flows

Level II

$\lambda_{e-c} = kQ\ 0.68 \times Q\ 0.36$

e - c = entering - ciculating

Level III

$\lambda_{e-c} = 0.046Q^{0}$

13. Viva

Christoph Hupfer

13.1. THE PROBLEM

The phenomenon of modern traffic is the product of countless individual decisions, which in turn affect man and the environment, quality of life, and resource usage in many ways.

Equally complex is the effective structure which affects traffic planning. The criteria traffic behaviour, traffic safety efficiency, minimal space usage, compatibility with the surroundings, etc. for all participants must be taken into consideration whereby the priority order of the aspects can of course be set quite differently by each one involved.

The development of traffic planning tools - mostly needed in inner-city areas for minimising the negative effects brought about by motorised traffic - is yet in an early stage. Successful introduction and distribution of innovative technology are dependent on the amount of evaluative data available, whereby the effects on traffic behaviour and traffic safety are the points of most concern.

However, there was until now in the areas of traffic behaviour and traffic safety a lack of suitable measuring methods by which the effects of innovative traffic planning could be adequately analysed within an appropriate time span.

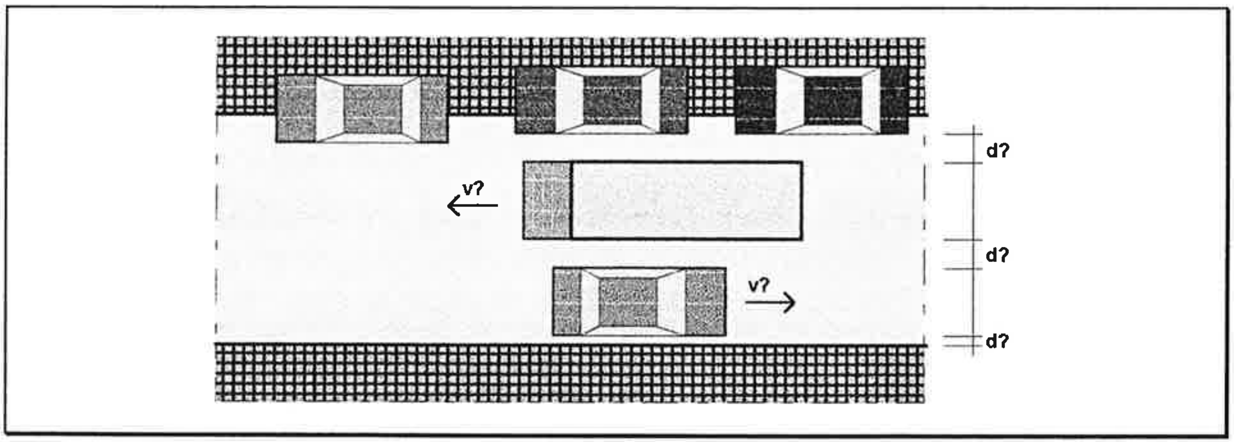


Figure 1:
Dimensions necessary for evaluating the traffic flow and safety of narrow main traffic roads (traffic behaviour - distances apart and speeds - in the case of encounter)

The effects of altered behaviour patterns in traffic, for example as regarding vehicular emissions, have until today had to be demonstrated by means of time-consuming as well as costly methods. It would be conceivable, however, to make use of the exact knowledge of the traffic motions (breaking, acceleration, speed, etc.) in order to calculate the needed data, thereby gaining quite adequate results.

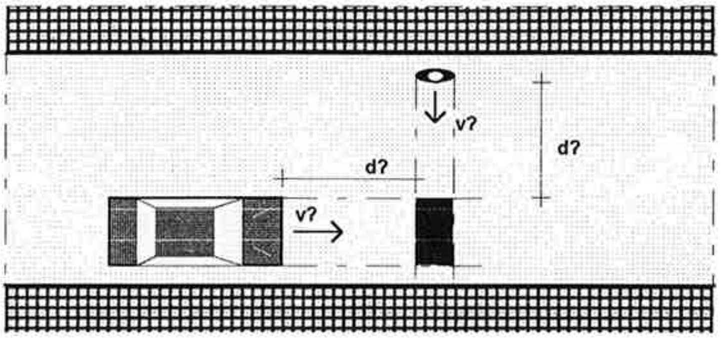


Figure 2:
Values for the evaluation of traffic safety at pedestrian crossings (speeds and directions of and distances between the participants)

In Germany the evaluation of traffic safety relies mostly on accident statistics. However, the quality of these statistics is controversial. Coincidences and unreported accidents, especially for accidents involving traffic participants on foot or bicycle, together with the inherently long periods of time (accidents are, statistically viewed, rare incidents), render this method more or less invalid. Moreover, the prerequisite to an accident statistics is the occurrence of accidents themselves, which is ethically seen as an objectionable practice.

Behaviour changes themselves were until now difficult to quantify. Although with the help of video filming these changes could be estimated, this type of method contained a high degree of subjectivity on the part of the reviewer, and the results were often not accepted by others.

The lack of traffic monitoring instruments is therefore one reason why innovative, space saving road design - which should also lead to more environment-oriented traffic behaviour and/or driving behaviour - is generally accompanied by a long acceptance period.

13.2. NEW TECHNOLOGY OFFERS NEW POSSIBILITIES

With these requirements in mind, the VideoVerkehrsAnalyse-System (Video Traffic Analysis System) ViVAtraffic was created, which makes it possible to measure distances, speeds and accelerations in video pictures, whereby the video film as such has proven to be an optimal and encompassing medium for recording traffic as it occurs.

The recent rapid development in computer hardware, especially as concerns efficiency and expenses as well as the development of image-processing algorithms, now facilitates the usage of computer supported digital image processing at reasonable prices. The traffic analysis system ViVAtraffic incorporates these new developments and emerges as a versatile traffic monitoring instrument. thereby appropriately filling in the above-mentioned gap, as well as supplying a much needed data basis for all areas of traffic planning and research.

13.3. THE SYSTEM VIVATRAFFIC

The system consists of an IBM-compatible PC, a special video card (frame grabber), a separate monitor, and the software. Since potential buyers already possess parts of this configuration, not many additional investments are needed.

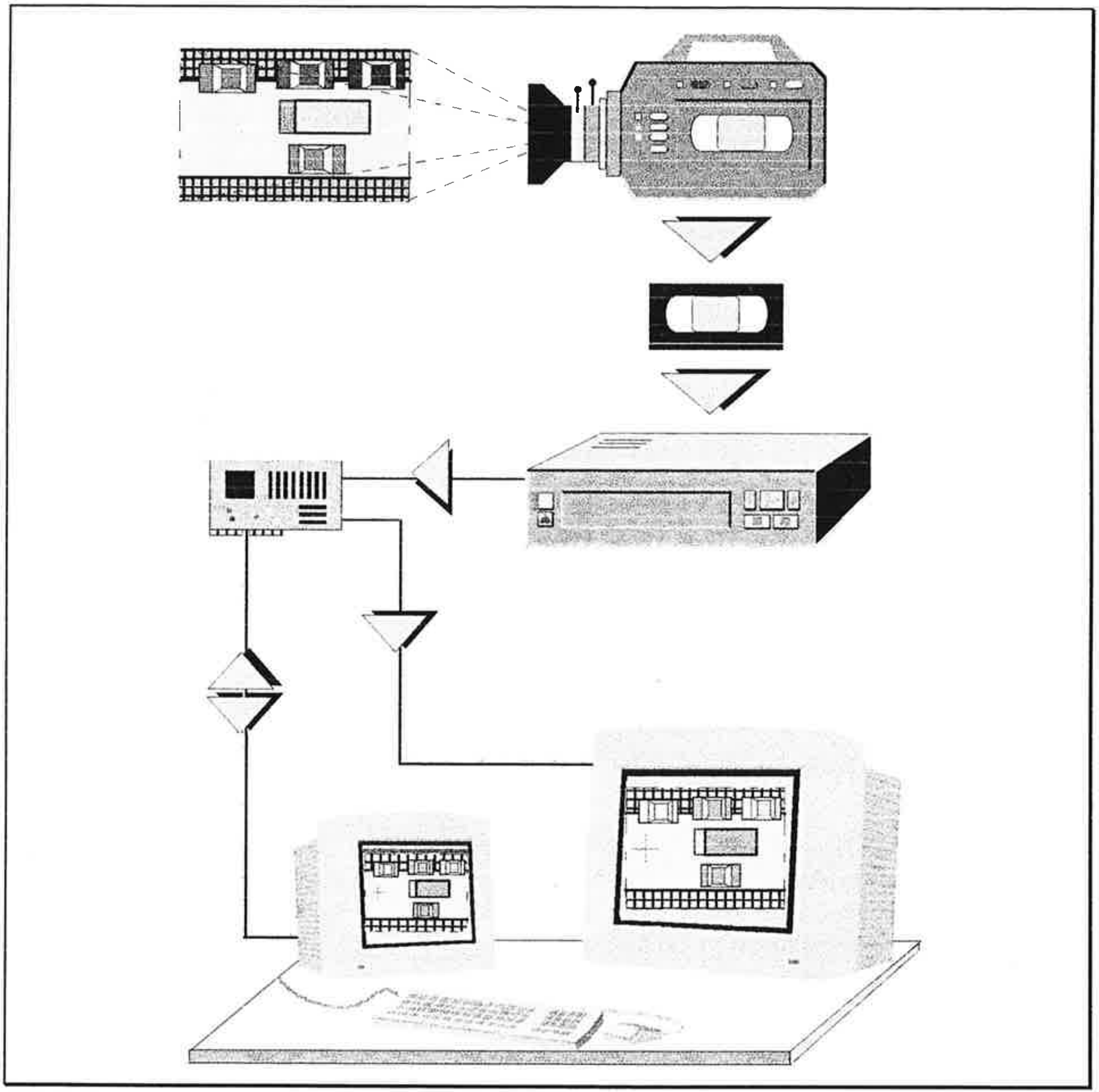
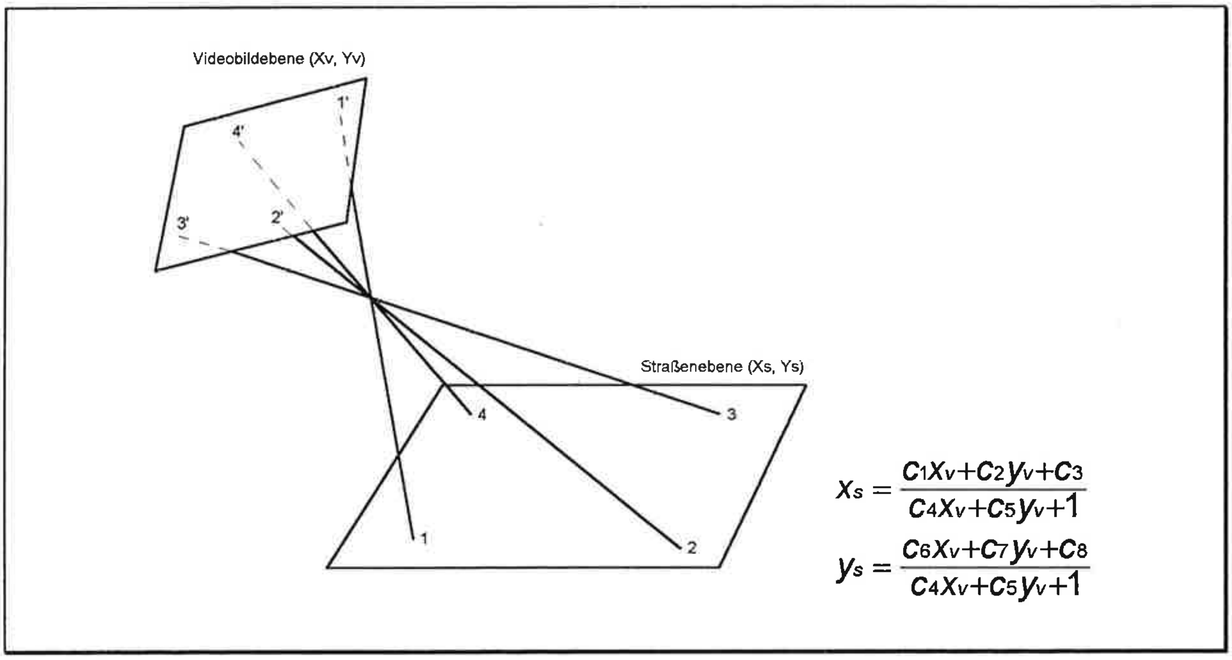


Figure 3:
System components of ViVAtraffic

During the conceptional phase of the system every effort was made toward designing a user-friendly instrument. It is used under the graphic user interface Microsoft Windows 3.xx / 95. No special system knowledge is necessary. The user has extensive on-line assistance at his disposal. Moreover, the system intercepts false applications with respective instructions, thus avoiding loss of data. ViVAtraffic can be installed in German or English.

13.3.1. Basis

The basis of the system is a projective model. By means of this model a point on the street can be related to a respective point on the screen. Thus, all points on the street plane, which can be seen in the video picture, are known.



$$X_s = \frac{C_1X_v+C_2y_v+C_3}{C_4X_v+C_5y_v+1}$$

$$y_s = \frac{C_6X_v+C_7y_v+C_8}{C_4X_v+C_5y_v+1}$$

Figure 4:
Projective model and determination equations for conversion between video picture co-ordinates (x_v, y_v) *and street co-ordinates* (x_s, y_s)

As a prerequisite for the usage of this model, only four points on the street must be known, and they must be recognizable on the screen. Of these four points, exactly two points must lie on one line. If these points are known, then the corresponding planes are also known (calibrated).

In practice, these points need to be visible for only a brief moment. Already existing videofilms can be subsequently evaluated by ViVAtraffic by measuring given fixed points.

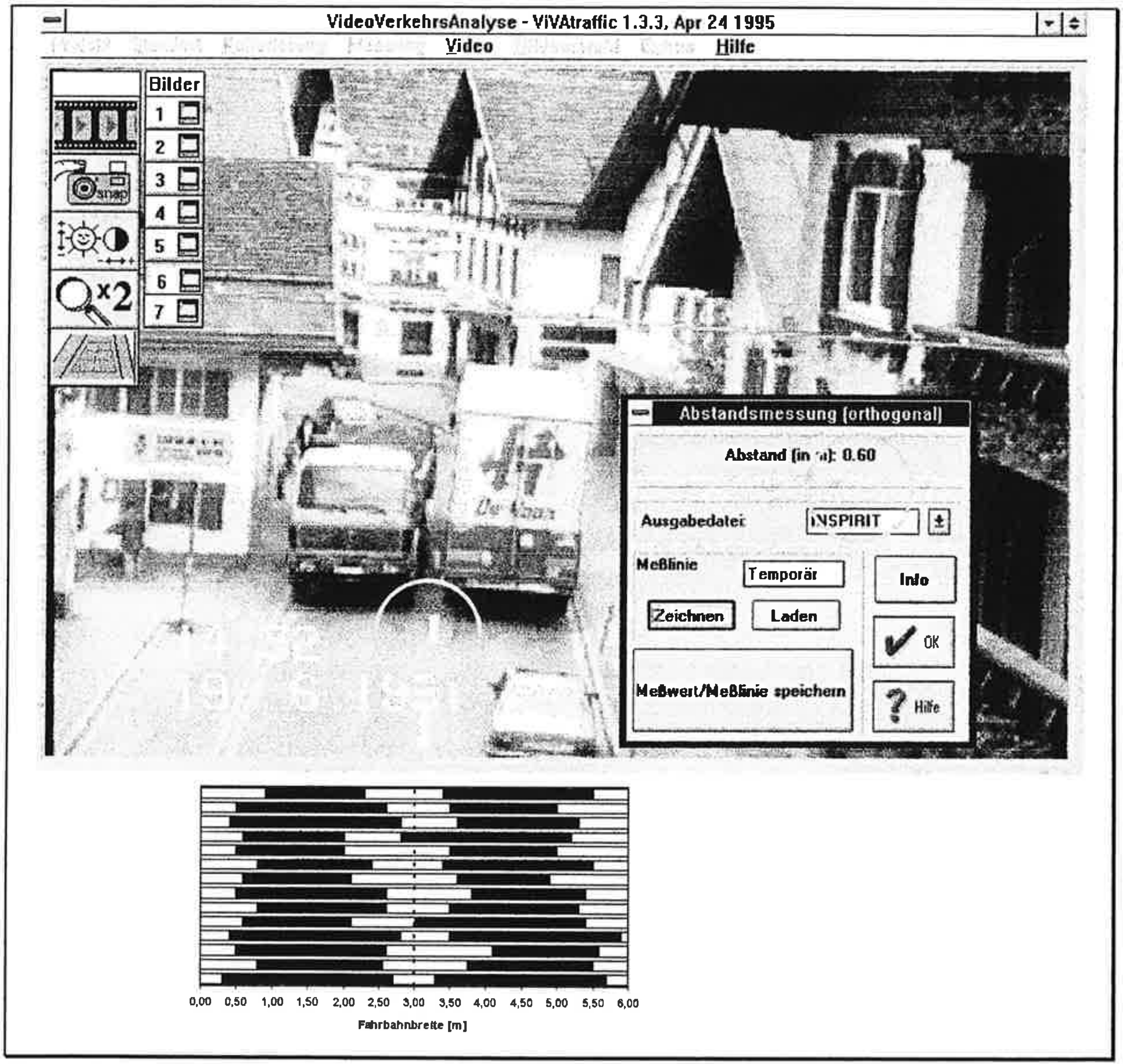
13.4. INTERACTIVE MEASURING WITH VIVATRAFFIC

Following successful calibration, the operator selects those pictures which describe the situation he or she wishes to investigate. By means of the mouse or use of keys then the relevant points are marked. The system converts the marked points on the screen into the real co-ordinates and then calculates the desired data (interactively).

The obtained data can be statistically evaluated with the help of table calculation programs and can be converted into expressive diagrams.

The example shown in Figure 5 was investigated during the research project „The Safety of Narrow Two-way Inner City Main Streets“ (Haag/Hupfer, 1992), sponsored by the Federal Ministry of Transport. One significant result of this study, computed with the help of

ViVAtraffic, was the fact that even heavily frequented main streets as narrow as 6.00 meters do not infer any safety deficits. „Altogether there were no relevant differences between the safety of narrow roadways and that of normally wide roadways. Narrow roadways do, however, offer more „shoulder“ space, which in turn can used for streetscaping, thus better integrating main traffic roads to their surroundings. This represents one step toward increased living quality in our cities and away from the dominance of motorised vehicles in main streets.“



Abstand (in m): 0.60

Ausgabedatei: INSPIRIT

Figure 5:
Right-angle proximity measurement in the case of an encounter between two trucks on the narrow main street of Nesselwang (above) and other various representative examples of encounter in a cross section diagram (black: vehicle, white: distances)

The traffic parameters speed and distance in cases of encounter constituted the basis of these results, whereby the proximity to the roadside borders or to parked automobiles as well as the distances between the passing vehicles were measured. By comparing these values on narrow and normally wide cross sections, the effects of narrow streets could be calculated.

This combination of data was applied in more cases. In particular ViVAtraffic was employed in bicycle traffic, which is hardly possible to monitor with any other existing instruments. In this case, „suggestive lanes“[4] as well as „not genuine one way streets“[5] were evaluated.

Situation oriented measurement of distances and speeds by ViVAtraffic also constituted the basis of the research project „Usage of various types of bus stops on inner city main streets“ (Hupfer/Haag, 1994). By means of the System it could be proven, that the bus accessibility and the safety of space saving lane stops („bus piers“) are generally better than halting bays.

In addition to evaluating individual measurements at individual cross sections, ViVAtraffic is also able to analyze the general traffic behaviour of a whole area.

Figure 6:
Sequential cut for evaluation traffic behaviour: speed observation and course of movement

This is done by recording numerous pictures which display the desired situation or movement. Then the traffic participants under examination are marked by means of a mouse piloted cross. Their calculated positions are then stored together as one set of data and can be evaluated by means of any suitable table calculation program.

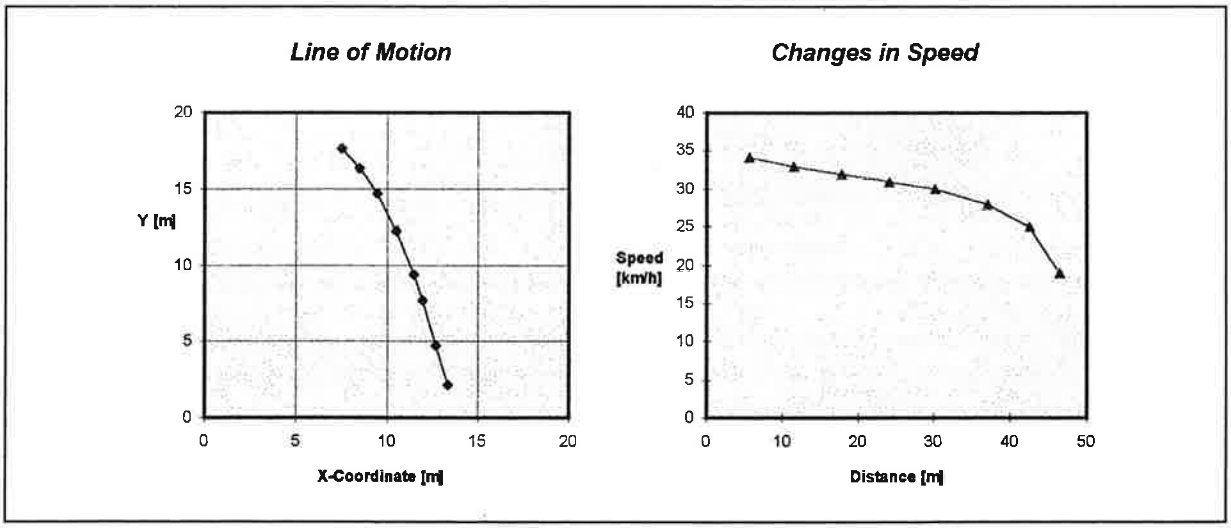


Figure 7: *Representation of the course of a delivery van in the sequence shown in Figure 6: line of motion and changes in speed.*

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[4] Suggestive lanes: Coloured lanes alongside a road, suggesting a restricted area for cyclists. They are not legally binding, but do however cause motorists to move more toward the centre of the street, thus causing them to reduce their speed.

[5] Not genuine one way streets: For motorised vehicles only one driving direction, for cyclists both directions allowed.

Thus, not only is it possible to collect data at certain locations, but additionally a complete survey of following traffic can be made and analyzed. Examples of application areas are: Traffic behaviour of motorists in approaching pedestrian crossings, crossing behaviour of pedestrians, effects of signalling speed reduction, acceleration behaviour. etc. From this data it is also possible to calculate the negative influence on the environment (pollution, noise, etc.)

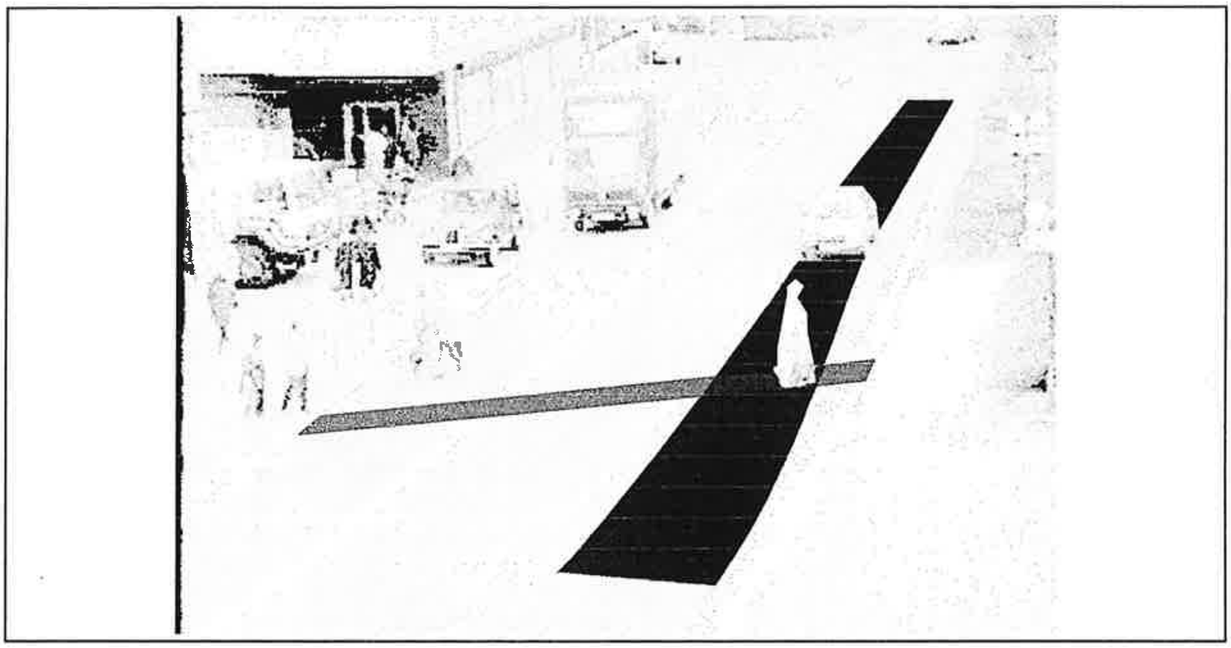
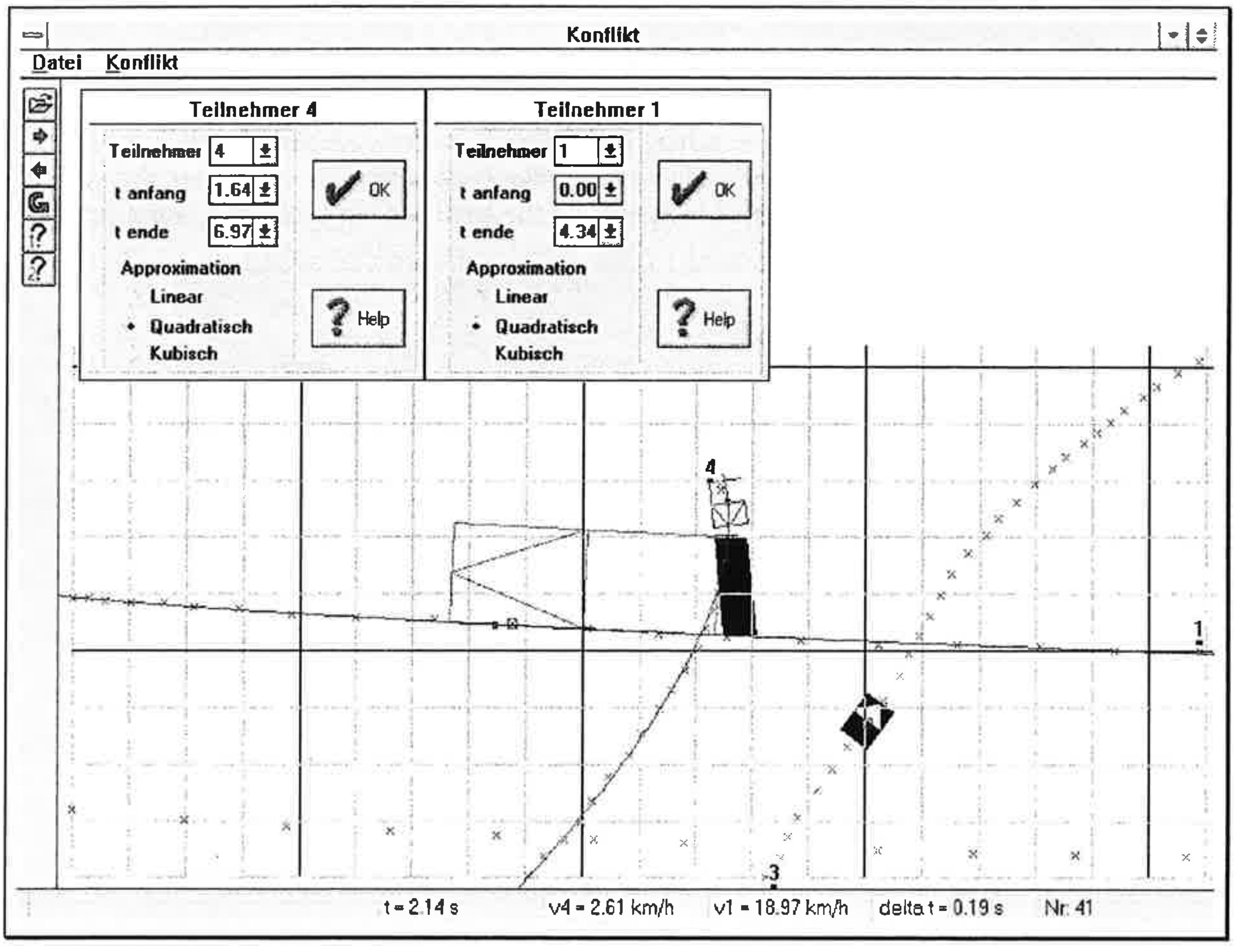


Figure 8:
Conflict situation vehicle/pedestrian. Vehicle speed 35 km/h; pedestrian speed 2.5 m/s. The pedestrian accelerate while crossing. The vehicle decelerates from 55 km/h to 35 km/h. Minimal time interval during the conflict situation until collision is 1.3 s.

At present, research work sponsored by the „Stiftung Rheinland-Pfalz für Innovation“ is being done on modifying traffic conflict technique especially for pedestrian crossings.

In the early 1980’s, the first efforts in establishing a traffic conflict technique as a supplement to accident quotas resulted in failure mainly due to the method’s lack of objectiveness. The modified traffic conflict technique based on ViVAtraffic will make an objective evaluation of traffic safety in traffic situations possible, on the bases of video recordings. Traffic parameters can be thereby determined objectively and exactly and used toward forming an evaluative basis.



Teilnehmer 4

Teilnehmer 4
t anfang 1.64
t ende 6.97
Approximation
Linear
• Quadratisch
Kubisch

Teilnehmer 1

Teilnehmer 1
t anfang 0.00
t ende 4.34
Approximation
Linear
• Quadratisch
Kubisch

t = 2.14 s v4 = 2.61 km/h v1 = 18.97 km/h delta t = 0.19 s Nr: 41

Figure 9:
Evaluation of a conflict between a vehicle (#1) and a pedestrian (#4). The measured movements are approximated in course and speed. The rhombus-shaped, black area represents the resulting potential area of conflict if the participants do not change their momentary direction. Out of the momentary speed of each participant, the time interval can be calculated, by which the two participants „miss" each other (here: 0.19 s). In the case of simultaneous presence of both traffic participants in the conflict area, the Time To Collision (TTC) can be determined.

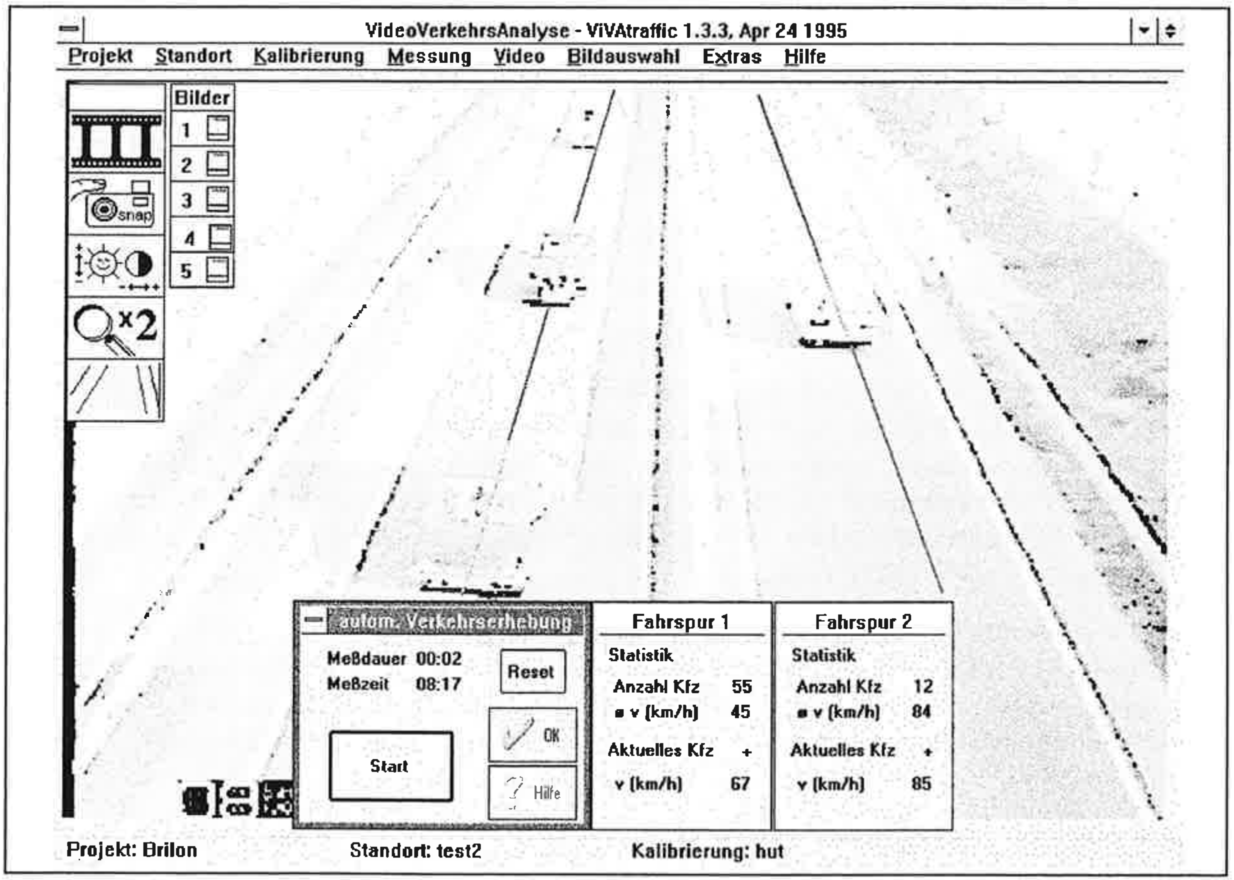
By means of the interactive possibilities of the system, the most various parameters of any given traffic situation, be they situation oriented or location oriented, can be determined. The effectiveness of traffic planning measures as regarding traffic safety, relevance to the surroundings as well as to the environment, etc. can thus be examined and optimized.

13.5. AUTOMATIC TRAFFIC-MONITORING

The previously discussed possibilities of the ViVAtraffic system require the ability of the operator to recognize a situation and to accordingly select the pictures which contain the situation. Automatic recognition and evaluation would require a type of hardware which would greatly multiply the costs of the whole system. Moreover, at present no satisfactorily dependable algorithms are known which can recognize and evaluate specific situations in a reasonable period of time.

Automatic recognition of a certain situation is not necessary for the determination of standard traffic data. In this case all motorized vehicles should be counted and distinguished according to their type and their speed should be determined. For the determination of this standard data, which is essential to almost every kind of traffic planning, an automatic tool was added to ViVAtraffic.

Basically, the automatic image processing is derived from the forming of differences between two pictures. A gray value is assigned to each point in a picture. By subtracting the pictures, unchanged spots have a sum of 0, spots with changes (=movement) have a value larger than 0. For the evaluation of a whole picture, 262,144 picture points must be compared within two pictures. This kind of performance is beyond the possibilities of a low-cost system, given the required real time.



Meßdauer 00:02
Meßzeit 08:17

	Fahrspur 1	Fahrspur 2
Anzahl Kfz	55	12
■ v (km/h)	45	84
Aktuelles Kfz	+	+
v (km/h)	67	85

Projekt: Brilon
Standort: test2
Kalibrierung: hut

Figure 10:
Automatic traffic monitoring with ViVAtraffic at the end of a state highway. Left lane (oncoming traffic): reduced speed caused by congestion; right lane: higher speed and acceleration at the beginning of the highway. (dark gray: measuring line; light gray: detected vehicle; dark gray, horizontal: determined edge of the vehicle for speed measurement)

The picture evaluation in ViVAtraffic is therefore restricted to a number of lines. The operator must secure two points as basis of a line, on which the system carries out the automatic analysis of the pictures. This line must lie on the road in such a position, so as to be „overrun“ by most of the vehicles. This way the system recognizes the vehicles, measures their lengths[6]

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[6] Hereby meaning the length of the vehicle in the picture which later is used for classifying the vehicles in the evaluation.

and speeds as well as the time gaps[7] between the vehicles, and then saves the data and the measured times.

Afterward, evaluative tables can be automatically produced with the assistance of a table calculation program. In this manner, the data can be collected as individual values with the most possible precision and can be subsequently combined as desired. A follow-up measurement at any later time is of course also possible. If initially only the amount of traffic and speeds were measure, then the video material could, for example, also supply the time intervals. Moreover, specific situations could be interactively analyzed.

The System ViVAtraffic is a video traffic analysis system which besides having the functions of conventional monitoring systems, additionally has the ability to analyze behaviour patterns in traffic. Thus it is possible for the first time ever to test the effectiveness of traffic planning measures. With this system, the effects on traffic safety and traffic behaviour of all traffic participants can be determined and evaluated so that traffic planning can be carried out accordingly.

13.6. REALIZATION

The development of ViVAtraffic began in 1986. The first version, developed for research projects, was named DiVA (Digitale VekehrsAnalyse = Digital Traffic Analysis). The second generation, with expanded functionality and the ability of automatic traffic survey, was named ViVA (VideoVerkehrsAnalyse = video traffic analysis). The name ViVAtraffic stands for the system now being introduced to the market. Each of these development stages represents a significant improvement of the system.

ViVA was presented in 1993 at the Hannover Messe Industrie (Industrial Fair at Hannover) and at the CeBIT (the world biggest computer fair in Hannover) in 1994. The developers of the system got a prize for outstanding scientific achievements, given by the Federation of German Automobile Industry (VDA - Verband der Deutschen Automobilindustrie e.V.).

13.7. THE VIVATRAFFIC-TEAM

ViVAtraffic was - and is still being - developed by an interdisciplinary team of computer specialists and traffic engineers from the Transportation Department of the University Kaiserslautern under the direction of Professor Hartmut H. Topp.

The theoretical foundations were laid by Karl-Heinz Schweig and Thilo Horstmann. They researched photogrammetrical relationships and made the first measurements of physical data from the video films with the PC. The results were published in the „Research Report on the Usage of the Model Principle 'Soft Separation' on Inner City Main Streets.“

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[7] The time gaps between vehicles. The measured time gaps are directly related to and provide information on traffic flow and traffic quality.

The modification of the system as well as the implementation of further analysis possibilities were accomplished under the direction of Christoph Hupfer, who improved and expanded the functions of ViVAtraffic, which in turn played an essential role as his monitoring instrument in two further research projects.

The transfer of the „Spaghetti Code“ into a sellable product under Microsoft Windows was performed by Thilo Horstmann. The theoretical foundations of the automatic traffic monitor were laid by Bernd Pollak, and the further development of these components was carried out by Markus Ebbecke.

At present ViVAtraffic is being supervised and modified by Volker Rudolph as well as Markus Ebbecke and Christoph Hupfer. All members of the ViVAtraffic Team are or were employees of the Transportation Department at the University Kaiserslautern.

13.5. APPLICATION

ViVAtraffic was developed for the purpose of testing the abilities of the various traffic planning and traffic regulation instruments. The system can be used for situation and infrastructure analysis, safety inspection, as well as the determination of basic data in traffic affairs.

The main publication domain is therefore the research of basic data in universities. The system is being used for most of their projects by the Universities of Hannover, Kassel, Dresden, Darmstadt and Kaiserslautern.

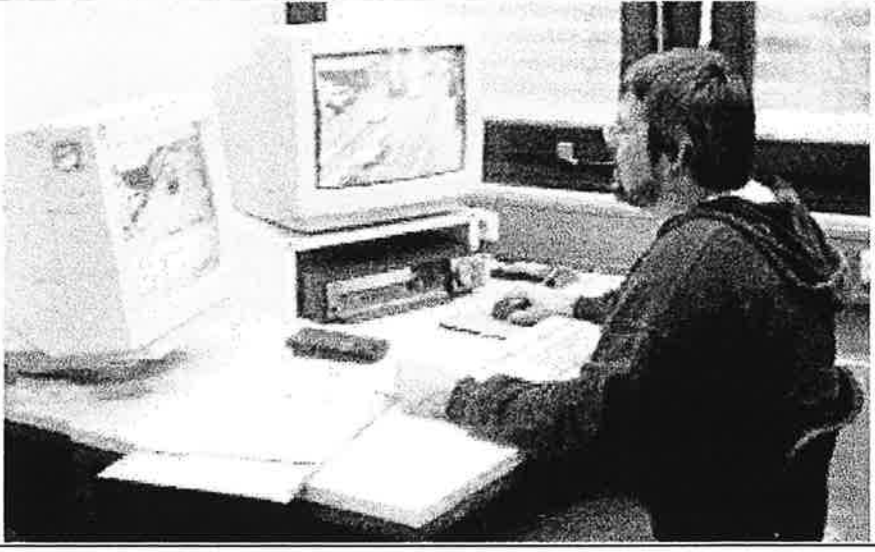

Figure 11:
ViVAtraffic working place with IBM-compatible PC with video card, 2 monitors and video recorder.

However, ViVAtraffic is, also an efficient system for use by planning offices and community planners as well as decision makers, who increasingly need more detailed and more complex traffic data in their situations related planning process. Users will welcome the fact, that no special preparations or skills are necessary in operating the system. The utilized components are inexpensive thanks to their mass production. The collected data can be graphically arranged. Furthermore, all situations can be documented in video pictures or picture sequences.

Up to now, there has been no intensive advertising about the system. Nevertheless, fact ViVAtraffic is already being used in various universities and planning offices. The distribution and the care of the system are managed by the GVA Gesellschaft für VerkehrsAnalyse mbH (Society for Traffic Analysis Limited) in Kaiserslautern which was founded for this purpose.

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14. Relationship between accidents and road user behaviour: an integral research programme

Piet Noordzij & Richard van der Horst

The analysis of accident statistics and the study of road user behaviour are the traditional methods of road safety research. Neither of these involve direct observation of accidents. A research programme has been designed to gain insight in the generation process of traffic accidents as well as to compare the traditional methods of road safety research. The first goal asks for long term day and night video recordings at a number of locations. In view of the second goal other methods of research have to be applied at the same locations. This kind of research has been called the integral approach.

The design of the programme will be presented and the value of video recordings will be illustrated by three recordings of actual accidents.

14.1. TRADITIONAL APPROACHES OF RESEARCH ON TRAFFIC SAFETY

Research on traffic safety takes the form of analyses of accident data or the study of road user behaviour. Both approaches have their advantages and disadvantages. The registration of accidents is limited in number as well as in the type of information. Many accidents (the less serious ones in particular) are not recorded. Circumstances, the sequence of events and the behaviour of road users in accidents are recorded in general terms only. Accident data can be complemented with observations at the spot or interviews with eye witnesses. This can only be done on a small scale and necessarily only some time after the facts. In summary, this approach is more concerned with the consequences of accidents than with the accidents themselves. The behaviour of road users can be studied in a number of ways. The most serious limitation lies in the fact that all this behaviour does not result in real accidents. The aim of research on traffic safety, however, is to gain insight in the occurrence of accidents as a result of the behaviour of road users in their actual traffic situation. This limitation is only partly resolved by choosing the conditions of behavioral studies in accordance with accident statistics. In summary, this second approach is directed at events that have at best a tendency to result in accidents. Knowledge about the generation of accidents is obtained by combining the results of both approaches, neither of which involves direct observation of accidents.

14.2. THE INTEGRAL APPROACH

In this situation there is a need for research in which accidents are studied in a direct way. Together with other institutes SWOV has elaborated the design of such a research programme. The goal of this research is to gain insight in the generation of traffic accidents as well as to compare the traditional methods of road safety research. The first goal asks for long-term video recordings during day and night at a number of locations. In view of the second goal other methods of research have to be applied at the same locations. This kind of research has been called the integral approach.

14.2.1. Selection of locations

The design of the proposed research programme has to meet a number of requirements, the first of which concerns the selection of locations. A number of locations is needed with a high number of accidents per time unit. Furthermore, these accidents should resemble each other in some ways and be different in other ways. Preferably, these accidents should represent a large proportion of all traffic accidents. Based on these considerations a choice has been made of urban intersections with high traffic volumes, partly with traffic lights, partly with priority signs. 20% of all serious traffic accidents occur at such locations. It has been estimated that in one year time ten of these intersections will have about hundred accidents, about thirty of which serious enough to be recorded by the police.

14.2.2. Selection of methods

The research methods to be applied in this programme have to be already proven in practice. They should also have a wide range of application. Finally they have to show essentially differing elements between them. Based on these criteria, a small number of methods has been selected. Traffic counts will be made from video tapes. Video recordings will also be analysed by measuring the Time-To-Collision (TTC): the time that is still available before two road users will meet at the same time at the same spot (provided neither of them takes evasive action). The length of this time period differentiates between encounters and conflicts. This method also measures the exact position, speed, change of speed, direction of movement and change of direction at successive moments in time (van der Horst, 1990). Additional video recordings will be made for the analysis of head movement data. Two other methods of conflict analysis will be applied based on human observations at the road side. One of these is DOCTOR (Dutch Objective Conflict Technique for Operation and Research), a method which can be seen as the 'subjective' counterpart of the video-based TTC method (Kraay, van der Horst & Oppe, 1986). The other method is a completely subjective judgement of the danger of an encounter in traffic (Kruysse, 1990). A totally different method is the reconstruction of accidents by means of road side inspections and interviews with eye witnesses some time after the accidents: the in-depth accident investigation (Stoop, 1991). Finally, all accidents and serious conflicts which are going to be recorded will be analysed by a team of traffic safety experts. This analysis includes an interpretation of the behaviour of the road users in terms of motivation, information seeking, decision-making and internal representation of the traffic situations. This, of course is not a standard method of safety research since such recordings have not been available before (with a few exceptions).

14.2.3. Selection of observation periods

Apart from the latter two methods, the application of all the other methods must be restricted in time to one or more relatively short periods of observation. These periods must have a high number of observable events per unit of time. This requirement has been translated as a high number of accidents per unit of time. Again, these accidents should preferably represent a large proportion of all traffic accidents (at this kind of locations). Accident statistics show that a first choice consists of the afternoon hours of weekdays during daylight. 40% of all serious accidents at urban intersections occur during these hours. To obtain a sufficient number of conflicts at each location, observations should last four days as a minimum.

14.3. ANALYSIS OF VIDEO-TAPED COLLISIONS

To demonstrate the approach of analysing the sequence of events that finally results in an accident directly from video, in this section three examples of video-taped collisions will be discussed. Collisions 1 and 2 were accidentally recorded during video-observations of road user behaviour in The Netherlands. The third collision was registered during an accident-recording study by the City of Helsinki with similar objectives as our proposed integral approach. In a period of 11 months they collected 9 accidents on tape. At another intersection 2 accidents were recorded within a one month period. The procedure in Helsinki to collect accidents required that there was made reference of an accident to the police. We anticipate a selection procedure that also enables the storing of minor collisions without the involvement by the police.

14.3.1. Rear-end collision at roundabout

The first example consists of a rear-end collision between two cars at a leg of a large-scale roundabout with roundabout traffic having right of way (Figure 1).

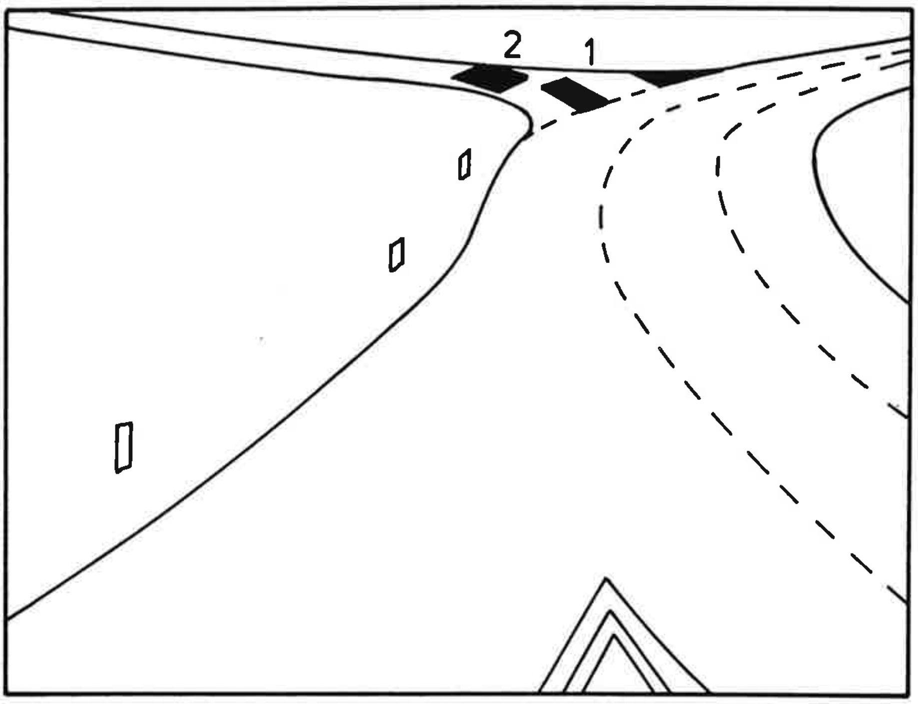

Figure 1:
Collision 1, rear-end car-car at a roundabout.

14.3.1.1. Accident registration

The information that most likely is available from the accident statistics (if registered at all!) is very limited and will probably only include: rear-end collision, car-car, at roundabout, some information on road and light conditions, damage-only accident.

14.3.1.2. Police report

If the original police report is accessible, some additional information may be available, such as a rough situational drawing, the direction the vehicles involved are coming from and going to, and as the reason why the accident occurred 'insufficient distance keeping'.

14.3.1.3. Event description from video

The vehicle in question (VEH1) is approaching the roundabout at a low speed, while the second vehicle (VEH2) is nearing VEH1. VEH1 is preceded by three vehicles that enter the roundabout in front of him. VEH1 stops (as does VEH2) for a vehicle at the roundabout, gives way to six other roundabout vehicles, accelerates for a very brief moment, but then waits for a seventh vehicle. VEH2 starts to accelerate at the moment VEH1 makes his small movement, and runs into VEH1 that stopped again. VEH2 pushes VEH1 several meters forward.

14.3.1.4. Subjective interpretation

VEH2 is nearing VEH1 with a relatively high speed. From the rather abrupt slowing down one may conclude that the driver of VEH2 is in a hurry (or is an aggressive type of driver). Apparently, VEH2 orientates himself towards the seventh vehicle on the roundabout, once he got the 'go' signal from the small movement of VEH1. VEH2 is missing the second stop by VEH1. The obtuse connection to the roundabout may well be contributing to the occurrence of this collision.

14.3.2. Right-angle collision at priority intersection

The second collision is of the right-angle type at a priority intersection (Figure 2).

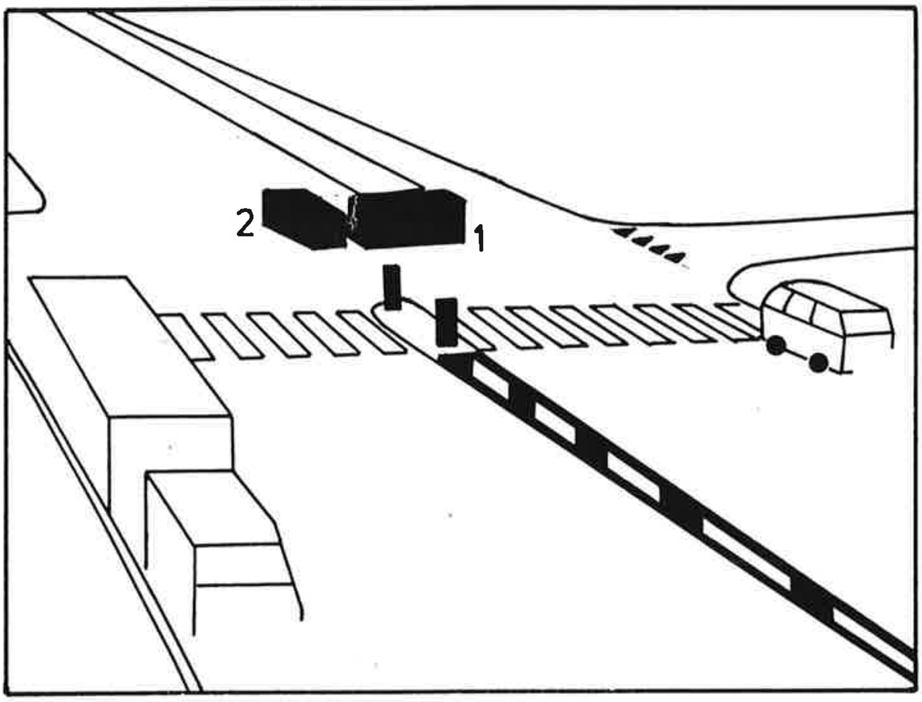

Figure 2:
Collision 2, right-angle accident at a priority intersection.

14.3.2.1. Accident registration

Information from the accident statistics on this accident comprises probably only the following items: car-car, right-angle collision, failure of giving right of way, damage only.

14.3.2.2. Police report

A raw situational sketch that is often included in the police report, may indicate the directions the vehicles involved are coming from, who was failing to give right of way, and sometimes the type of intersection is mentioned.

14.3.2.3. Event description from video

The vehicle from the minor road (VEH1) is approaching the intersection with a normal speed, comes almost to a full stop at a place beyond the yield markings on the road pavement. A vehicle from the left (VEH2) starts braking for about 1 s at 3 s away before the actual collision occurs, but accelerates again after VEH1 has reached a very low speed. At the moment VEH2 is just in front of VEH1 (and a third vehicle coming from the right is just entering VEH1's viewing area), VEH1 accelerates and runs into the right side of VEH2. VEH1's view to the left is restricted by a van that is parked at the corner for about 10 minutes.

14.3.2.4. Subjective interpretation

The reason why VEH2 starts braking may well be that he is probably anticipating a potential right of way error by VEH1. He concludes from the near stop by VEH1 that he has been noticed and decides it is safe to proceed. The driver of VEH1 is displaying behaviour that is rather typical for a normal right-hand-rule intersection, viz. that one only is looking to the right in search for other vehicles (Janssen et al., 1988). So he may have missed VEH2 completely either because he was not aware of the vigorous priority regime at this particular intersection, or because he looked at the left too early. It seems as if VEH1 decides that it is safe to accept the gap in front of the vehicle from the right, while completely overlooking VEH2. From this event it is clear that several measures for improving the intersection lay-out can be proposed.

14.3.3. Car-pedestrian collision at zebra crossing

The third example deals with a car-pedestrian accident at a signalised intersection (Figure 3).

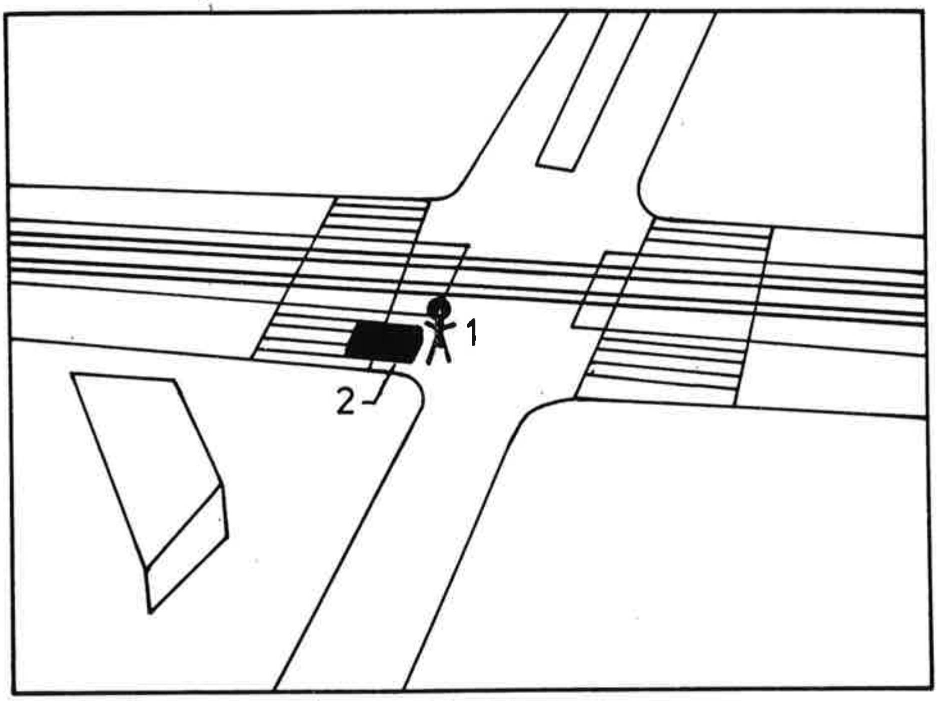

Figure 3:
Collision 3, car-pedestrian accident at zebra crossing of a signalised intersection.

14.3.3.1. Accident registration

Accident statistics would probably provide you with the following data: pedestrian-car collision, injury accident, zebra crossing involved, pedestrian from the left was running the red light, slippery road surface.

14.3.3.2. Police report

The police report would probably give some more details, such as at which zebra crossing the accident occurred, perhaps that the pedestrian started crossing all at a sudden, and, consequently, the car driver was not able to avoid a collision.

14.3.3.3. Event description from video

At a dual carriageway intersection with a wide median containing streetcar tracks, two pedestrians enter the first carriageway zebra near the end of green (that can be deducted from the behaviour of other road users). They also cross the median, but wait at the median curb of the second carriageway. A number of cars is waiting for making a left turn. For a relatively long time no straight-on traffic is present. All at a sudden one of the pedestrians starts running just at the moment a vehicle is approaching the zebra crossing on the left straight-on lane. The vehicle starts braking at a very late moment just before the frontal collision with the pedestrian occurs. A vehicle in the right lane is able to brake in time for the pedestrian lying on the road.

14.3.3.4. Subjective interpretation

While looking at this accident, one may wonder why the pedestrian starts running so suddenly. A plausible explanation is that he wants to catch the bus across the road. A careful inspection of the bus behaviour reveals that the bus moves forward a little bit just before the pedestrian starts running. Similar to collision 1, it seems as if relatively small movements in an expected direction people already trigger and focus on one particular sequence of actions that, once started, are difficult to interrupt. Moreover, the line of waiting left-turning cars together with the absence of straight-on traffic for a relatively long time may well have the pedestrian let come to the conclusion that the signal for the cars already had turned red.

14.4. CONCLUSIONS

The traditional approaches of traffic safety research (analysis of accident statistics, behavioural studies) do not involve direct observation of accidents. As a result the chain of events and the behaviour of road users resulting in an accident can only be hypothetically inferred. Long term video recordings open the possibility for direct observation of accidents. An integral research programme has been designed with long term video recordings, together with traditional methods.

The value of video recordings of accidents is illustrated with three cases, showing that the recordings:

- provide detailed information on circumstances and chain of events,
- can be analysed with quantitative measures (e.g. Time-To-Collision), and
- can be used for a detailed, subjective interpretation of the behaviour of road users.

The integral approach cannot be applied as a standard method, but will lead to a more appropriate application of traditional methods (such as conflict observations), based on a better theoretical understanding of the generation of accidents.

Acknowledgment

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