

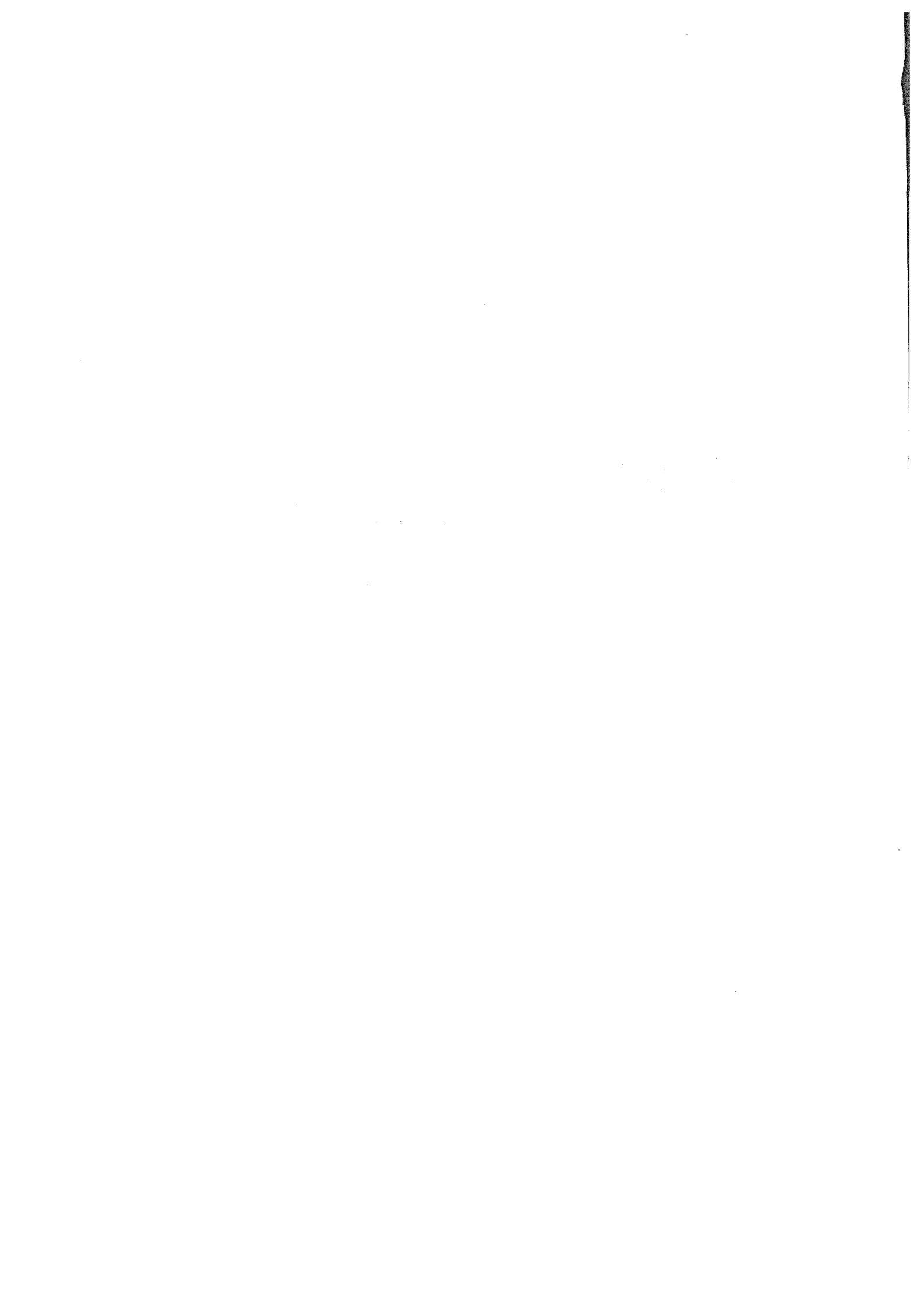
PROCEEDINGS OF THE THIRD INTERNATIONAL WORKSHOP ON TRAFFIC CONFLICTS  
TECHNIQUES, ORGANISED BY THE INTERNATIONAL COMMITTEE ON TRAFFIC  
CONFLICTS TECHNIQUES ICTCT, LEIDSCHENDAM, THE NETHERLANDS, APRIL 1982

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\* Papers also presented to the OECD Seminar on Short-term and Area-wide Evaluation of Safety Measures, Amsterdam, The Netherlands, April 19-21, 1982.

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FOREWORD

The primary purpose of the third international workshop was to discuss and finalise a research plan for the joint international study for the calibration of traffic conflicts techniques that is going to take place in Malmö, Sweden, May 30 to June 13, 1983. A preliminary plan of the study was presented by the Steering Group of the International Committee on Traffic Conflicts Techniques ICTCT. Different organisational and financing problems of the study were then discussed.

A secondary aim of the workshop was to present the state-of-the-art of different conflict techniques. The presentation included work of interest carried out since the second workshop in Paris 1979. Due to a relatively short time of notice the number of delegates was limited. The study in Sweden, however, will start up with state-of-the-art presentations as well as a presentation of actual definitions and working procedures. It is my hope that these presentations will give a complete picture of practice and actual use of traffic conflicts techniques around the world at present.

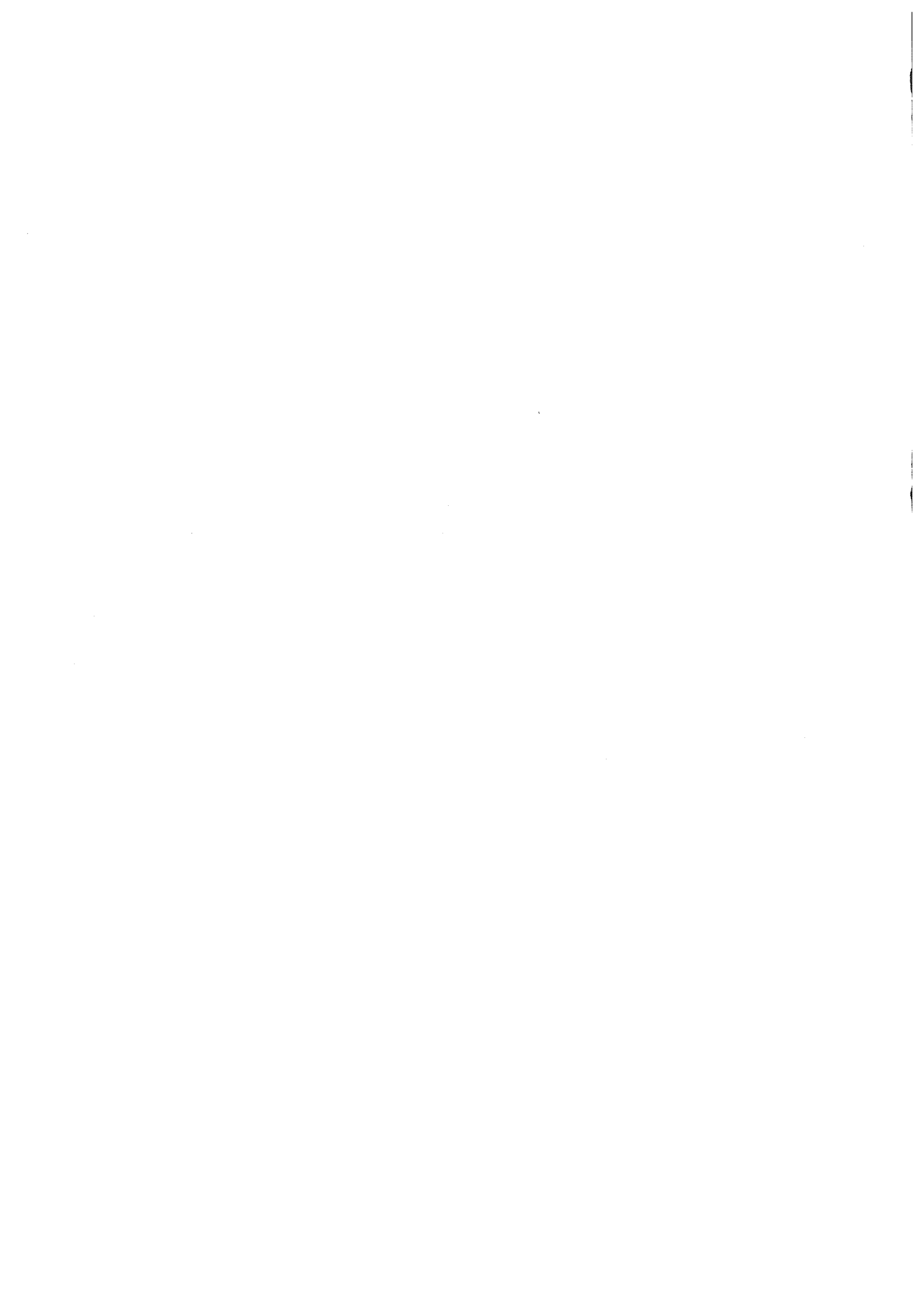
The workshop also included a film-show where the use of speed-reducing measures in The Netherlands was demonstrated. The potential interest among the delegates was great, but time restraints limited the following discussion.

The agenda of the meeting was completed with social events in the evenings.

The organisation of the meeting, carried out by SWOV, was great as usual. I want hereby to express the gratitudes of all the attendants.

Christer Hydén

Chairman of the Steering Group ICTCT



1. PRESENTATIONS BY THE DELEGATES

## THE BRITISH TRAFFIC CONFLICT TECHNIQUE: STATE OF THE ART REPORT

C.J. Baguley

Transport and Road Research Laboratory, Crowthorne, United Kingdom

### Introduction

This paper outlines developments in the method of traffic conflict data collection used by TRRL and describes research carried out since the last International Traffic Conflicts Technique Workshop (Paris, 1979).

### Developments in the Conflict Technique

In 1971 the traffic conflicts technique introduced by Perkins and Harris<sup>1</sup> was developed by Spicer<sup>2</sup> for use in the United Kingdom. Conflicts between vehicles at road junctions were subjectively awarded one of five grades according to the severity of the incident observed, as shown in Table 1.

The severity classification was revised in 1977<sup>3</sup> in order to overcome observers' difficulties in classifying many events which, although clearly more severe than Grade 2, did not appear to be sufficiently severe to fit easily into the definition of Grade 3. Although accepted as serious, this new Grade 2+ conflict has proved difficult to define in words but an attempt has been made in Table 1.

At the first International Traffic Conflicts Technique Workshop in Oslo in 1977 a general definition of a conflict was agreed<sup>4</sup> and it was apparent that the Grade 1 events did not satisfy this definition. Also, as the number of these observed events only showed a low correlation with the number of accidents that had occurred at the same junctions<sup>5</sup>, recording of Grade 1 events was discontinued after 1979. This enabled a re-scaling of the existing severity grades as shown in Table 1.

From detailed discussions between experienced conflict observers it was decided that four factors are considered when classifying the severity of a conflict.

- (i) The time before the possible collision that the evasive action commenced.
- (ii) The severity or rapidity of the evasive action.
- (iii) The complexity of the evasive action.
- (iv) Minimum distance apart of the vehicles involved when evasive action terminated.



TABLE 1  
Conflict severity classification

Conflict severity	Grade (1971)	Description	Modified grade label	
			1977	1979
SLIGHT	1	Precautionary braking or lane change or other anticipatory braking or lane change when risk of collision minimal	1	-
	2	Controlled braking or lane change to avoid collision but with ample time for manoeuvre	2	1
SERIOUS	-	Braking or lane change to avoid collision with less time for manoeuvre than for a slight conflict or requiring complex or more severe action	2+	2
	3	Rapid deceleration, lane change or stopping to avoid collision resulting in a near miss situation (no time for steady controlled manoeuvre)	3	3
	4	Emergency braking or violent swerve to avoid collision resulting in a very near miss situation or minor collision	4	4
	5	Emergency action followed by collision	5	5

In 1980, as an aid to the training of new observers, the experienced observers established a relationship between judgements of the levels of these factors and conflict grades. For each conflict, observers are now asked quickly to assess and record the level of each factor (as shown in Table 2) with the time of occurrence of the conflict. The combinations of the four factors can then be subsequently applied to Table 3 to obtain conflict grade.

The use of this factor rating approach has proved most helpful to observers and has resulted in a more consistent recording of conflict numbers and their severity grades<sup>6</sup>.

TABLE 2  
Four-factor level ratings

Factor	Level
1 TIME before possible collision when evasive action commences	i) Long time ii) Moderate time iii) Short time
2 SEVERITY of the evasive action	i) Light braking and/or swerving ii) Medium braking and/or swerving iii) Heavy braking and/or swerving iv) Emergency braking and/or swerving
3 TYPE Whether evasive action comprises one or more types	i) Simple - either braking or swerving alone ii) Complex - both braking and swerving
4 PROXIMITY Distance between conflicting vehicles when evasive action terminated	i) More than 2 car lengths ii) Between 1 and 2 car lengths iii) One car length or less iv) Minor collision v) Major collision

### Current Research

Following the long-term study at a single T-junction<sup>7</sup> reported at the 1979 Traffic Conflicts Technique Workshop<sup>8</sup>, it was decided to collect conflict and other traffic data at a fairly large number of junctions of different types so that the extent of the variation in conflict count numbers and the influence of such factors as type of site, vehicle manoeuvre flow, approach speed of priority road vehicles, vehicle type, and observer variation might be determined. A subsidiary objective was to provide further evidence of the relationship between accidents and conflicts.

A total of 17 sites has been used in the present study in a mix of urban and rural locations. These comprise 8 T-junctions and 9 crossroads and include both single and dual-carriageway priority roads with a fairly wide range of traffic flows and injury accident histories. Signalised junctions and junctions with roundabouts were not included in this study.

At all times during the study periods, two observers were present on site in cars parked in a convenient position off the main carriageway either side of the junction. Automatic counters using inductive loops were used at T-junctions (eg see Fig 1) and time-lapse film used at crossroads to log vehicle turning movements.

TABLE 3  
Conflict grades by factor ratings

	Time	Long		Moderate			Short				
	Severity	Light	Medium	Light		Medium	Heavy	Medium		Heavy	Emergency
	Type	Simple/ complex	Simple/ complex	Simple	Complex	Simple/ complex	Simple/ complex	Simple	Complex	Simple/ complex	Simple/ complex
PROXIMITY	>2 car lengths	1	1	1	1	1	1	1	1	2	3
	1 to 2 car lengths	1	2	1	2	2	3	2	3	3	3
	1 car length or less	2	3	2	3	3	3	3	3	4	4
	Minor collision	3	4	3	3	4	4	4	4	4	4
	Major collision	5	5	5	5	5	5	5	5	5	5

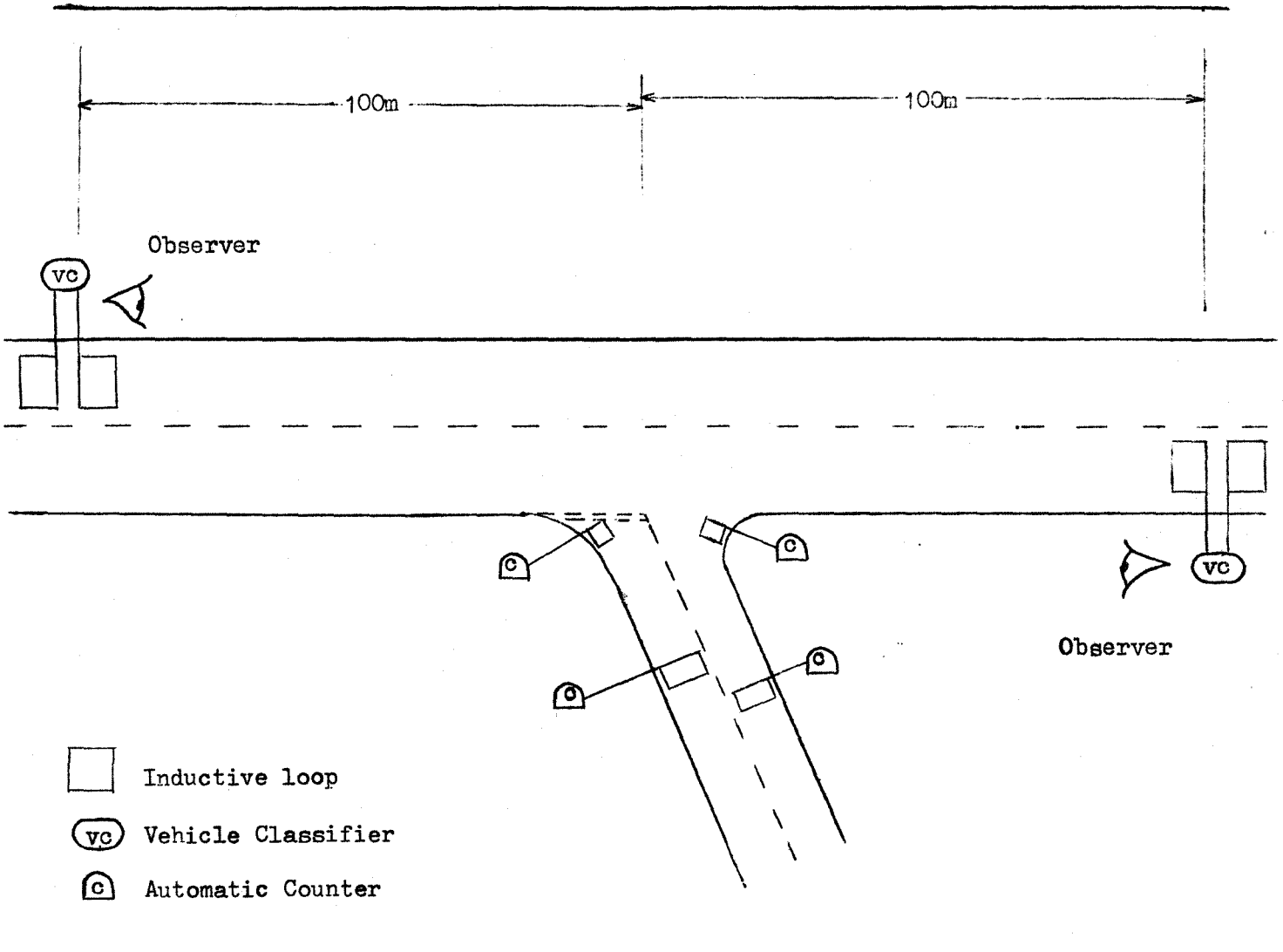


Fig 1. Example of Instrumentation Layout at T-junction

Two microprocessor based traffic classifiers were also used on site and were linked to pairs of loops installed on the priority road 100 m in advance of the junction on each side (see Fig 1). This equipment employed data cassettes to record the time of arrival (to 1/100th second), speed, and approximate length of each individual vehicle on the priority road. Observers recorded conflict times as accurately as possible using synchronised digital stopwatches. The classifier equipment, therefore, provided not only period summaries of priority road traffic flow, speed and vehicle type but also the facility to trace back vehicles actually involved in the observed conflicts to obtain an accurate measurement of their approach speed.

Field studies, extending over a total of 102 days have been made at the 17 sites (six 10-hour days per site). This stage of the work is now substantially complete and analysis of the data is in progress.

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FROM ACCIDENTS TO CONFLICTS: ALTERNATIVE SAFETY MEASUREMENT

V.A. Güttinger

Netherlands Institute for Preventive Health Care TNO, Leiden, The Netherlands

ABSTRACT

The danger of traffic is commonly determined by the occurrence of accidents. This paper presents some of the history of alternative measures for describing traffic unsafety (measurement of so-called conflicts). It also gives the results of a series of research projects aimed at the development of a conflicts observation technique for the estimation of the safety of child pedestrians in residential areas.

The reliability, practical applicability and validity of the developed technique prove to be satisfying.

It is concluded that the use of this technique seems to be justified for those situations in which accident rates are relatively low, e.g., in residential areas. This is not only because of the strong relationship between serious conflicts and accidents but also because other potential alternative indicators for the estimation of traffic unsafety often used in practice, such as traffic volumes and subjective estimation of risk by residents, had little success in predicting accidents.

Introduction

When speaking about the dangers of traffic, most of us think of accidents. The extent of traffic unsafeness is usually described by the occurrence of accidents.

However, recorded accidents are rather unsatisfactory indicators for traffic unsafety.

a) The registration of accidents is limited and not always reliable or complete. With respect to the first, the extent of limitation of the registration depends on the definition of accidents.

If one defines an accident as "a collision which results in the death of one (ore more) of the participants", all accidents in Holland are recorded. If one chooses, as we do, a definition of an accident as "a collision between an traffic participant and another participant or an object regardless of the results of that accident in terms of victims or material damage", only a small, unknown fraction of all accidents is recorded.

b) Although (even if one only speaks about recorded accidents) ac-

cidents happen frequently and qualifications such as "a modern epidemic" (1979) seem to be quite apt, they are still relatively rare events. It is, e.g., hardly possible to trace, within a short time, unsafe locations or to evaluate traffic safety measures.

- c) The fact that accidents must take place before one can determine the risk of locations is, from an ethical point of view, a basic disadvantage.

There is a need for a more frequently occurring and measurable phenomenon than the accident as a criterion for traffic safety.

### Conflict observation

To gain some insight into the effect of safety measures in a relatively small area, we decided to follow a trend in the research that concentrates on finding an alternative indicator for safety that, in its origin, started back in the nineteen forties. In aviation, "pilot errors" or "critical incidents" were then used as measures of safety performance (Fits & Jones, 1947; Flanagan, 1954).

The term "conflict" in traffic safety research was introduced by Perkins and Harris (1967). All research in this area originates from their work, although it must be mentioned that it was Spicer (1971) who, by means of introducing a new concept (severity grade), did much to promote the conflict observation technique.

There is agreement among the research workers in this area on the use of the term "conflict" and even on the main aspects of the operational definitions of conflicts (namely, evasive or avoidance actions).

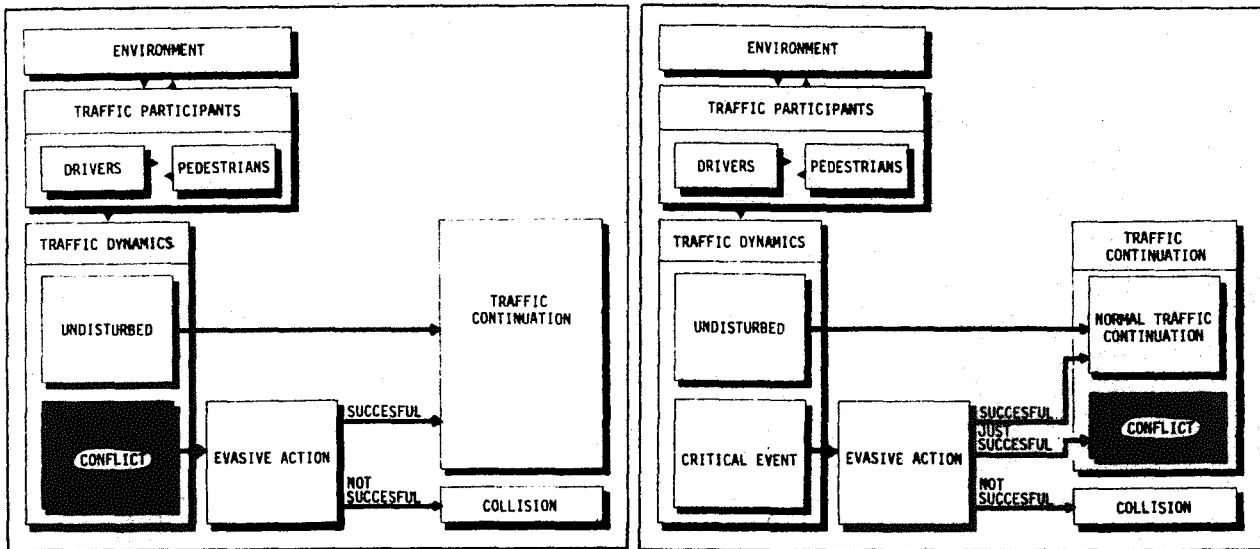
However, there seems to be some confusion regarding the place of the conflict in the traffic process, as illustrated in figure 1.

For some, the conflict is an event that precedes an evasive action that can be either successful or not successful (collision). For others, it is the same as a near-miss situation after an evasive action. In this last view, a conflict cannot lead to collision but is an event parallel with a collision.

At the time that we started our research in this area, three main conflict techniques existed, each with their advantages and shortcomings (table 1):

- a) the traffic conflicts technique of Perkins and Harris (1967, 1968, 1969);

Figure 1. Place of the conflict in the traffic process



a) Conflict as potential accident. Evasive action - sometimes combined with distance between participants - indicates previous conflict.

b) Conflict as near-miss situation. Just successful evasive action (see text) - sometimes combined with distance between participants - indicates conflict.

Table 1. Positive and negative aspects of the three conflicts techniques

technique	advantages	disadvantages
Perkins and Harris (1967, 1968, 1969)	<ul style="list-style-type: none"> <li>- objective definitions in terms of evasive actions and traffic violations</li> <li>- easy applicable (direct observation at spots)</li> </ul>	<ul style="list-style-type: none"> <li>- reliability not tested</li> <li>- no substantial and stable relationship with accidents (validity)</li> </ul>
Spicer (1971, 1972, 1973)	<ul style="list-style-type: none"> <li>- introduction of severity grade: distinction of serious and less serious conflicts (5 levels)</li> <li>- strong association between serious conflicts and accidents</li> </ul>	<ul style="list-style-type: none"> <li>- subjective operational definitions of conflicts</li> <li>- reliability not tested*</li> </ul>
Hayward (1972)	<ul style="list-style-type: none"> <li>- objective registration of the time-measured-to-collision by means of video- and computer equipment</li> </ul>	<ul style="list-style-type: none"> <li>- validity not tested</li> <li>- expensive equipment</li> <li>- practical application not always possible</li> </ul>

\* Given the established relationship between conflicts and accidents, a reasonable amount of reliability (in this case intra-rater-reliability) must exist.



- b) the traffic conflicts technique of Spicer (1971, 1972, 1973);
- c) the time - measured - to collision technique\* of Hayward (1972).

In terms of our interest - the safety of pedestrians, especially children - a general disadvantage was that none of the above-mentioned techniques took pedestrians into account.

#### The development of a conflict observation technique

Despite the mentioned disadvantages of the conflict techniques, this approach seemed to be the most promising with regard to the problem we faced: the estimation of the safety of (child) pedestrians in situations where accident data are very scarce. Especially the results of the work of Spicer (1971, 1972, 1973) seemed to be encouraging enough to justify attempts in this direction.

Our work which was aimed at developing a reliable and valid conflict observation technique that could be used for the prediction of the safety of children as pedestrians consisted of four steps:

- 1) operationalisation of the concept "conflict". Operational definitions of conflicts have to be objective. If strict objectivity is not possible, intersubjective agreement between expert observers can replace objectivity (de Groot, 1966);
- 2) a test of the reliability: do observers using the operational criteria for conflicts reach agreement in the judgement of situations (inter-rater-reliability) and are individual observers stable in their judgements (intra-rater-reliability);
- 3) a test of the practical applicability of the conflict observation technique in field situations;
- 4) a test of the validity of the conflict technique

#### Operationalisation

Following the work of others (particularly Spicer, 1971), we defined a serious conflict as: "a sudden motor reaction by a party or both of the parties involved in a traffic situation towards the other to avoid a collision, with a distance of about one metre or less between those involved".

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\* The time-measured-to-collision (TMTTC): "The time required for two vehicles to collide if they continue at their present speeds and on the same path" (Hayward, 1972, p. 9).

The criterion of "sudden" was determined empirically: observers had to judge reactions of participants in traffic situations to see whether they used certain common criteria in their judgements (the traffic situations were recorded on videotape). A discussion afterwards resulted in a detailed list of criteria that could be used to indentify four types of reactions (from "no reaction", scale value 0, up to "sudden reaction", scale value 3) of different kinds of road users.

### Reliability

With respect to the reliability, the following can be stated: even unselected, untrained observers were fairly capable (by using the developed list of criteria) of judging the reactions of traffic participants.

The mean coefficient for the intra-rater-reliability (10 observers jugded 54 evasive actions) varied from  $r = .85$  (judgement of the reactions of wheeled traffic) to  $r = .95$  (judgements of the reactions of pedestrians). The results of the test of the inter-rater-reliability were smaller:  $r = .75$  (reactions, wheeled traffic) and  $r = .87$  (reactions, pedestrians). Selection and training of observers yielded better results with respect to the inter-rater-reliability:  $r = .85$  and  $r = .94$  (a new team of 8 observers judged 54 reactions).

### Some definitions

Besides "serious conflicts" (characterized by "sudden evasive actions with a distance of about one metre or less between those involved"; popular: "just succesful evasive actions"), we distinguish "conflicts", "intensive contact-conflicts", "contact-conflicts" and "contacts". These distinctions are based on 6 different combinations of "sudden", "less sudden" and "nonsudden" reactions with "short distance" ( $\pm$  one metre or less) and "less small distance" ( $\pm 2 - \pm 20$  metres). The covering concept is called "an encounter", which is defined as "a motor action by a party or both of the parties involved in a traffic situation towards the other to avoid a collision, with a distance of 20 metres or less between those involved".

### Practical applicability

In two field studies (Güttinger, 1976; 1979) the practical applicability of the conflict observation technique by means of so-called sector and personal observation was found to be satisfactory.

The method of sector observation is especially suited for the determination of the risk of certain spots, e.g., an intersection or a part of a road.

In the case of personal observation, individual road users (in our situation, child pedestrians) are followed for a certain time. This method is suited for the comparison of larger environmental units (e.g., neighbourhoods), for the detection of high risk spots within large areas or to trace the relative risks for certain child pedestrians or groups of child pedestrians.

With both methods, an amount of information which gives a good idea of what happens between child pedestrians and wheeled traffic in residential areas can be collected within a fairly short time period.

If accident figures are used as criteria for road safety in the same situation, nothing can be said about traffic dangers for pedestrians in a comparable short time.

The possibility to use serious conflicts as an alternative measure of traffic safety, of course, depends on the relation between these serious conflicts and accidents.

### Validity

A study of the predictive validity of serious conflicts constituted the fourth step in our research.

Such a study has its limitations. Those factors that were the motivations for our attempts to find alternatives for accidents as indicators of traffic safety (the fact that accidents are relatively rare and the poor accident recording) interfere with the validation of the conflict observation technique.

Some remarks must be made with respect to the statistical testing of the relationship between conflicts and accidents.

If a correlational model is chosen, it is necessary to take a random sample of locations from the population of all locations.

Here, we are faced with two problems:

- 1) we do not know the population of locations;
- 2) to assure that the sample contains locations where accidents have taken place, it has to be of rather large size (because accidents per location are rare).

If one chooses a regression model for testing the relationship between conflicts and accidents, where random samples of locations with 0,1,2,3,4, etc., accidents must be taken, one is confronted with a comparable problem: we do not know the populations of locations with 0,1,2,3,4, etc., accidents.

What was our solution?

Based on the accident records of 4 municipalities of 1972 up to and including 1976, we selected a total of 25 road sections (max. length = 100 metres). The number of accidents (involving child pedestrians) per location varied from 0 to 5 (in five years). Each section was observed for 34 hours (after school hours and not during the weekend).

We will present the relations between conflicts as we observed them and accidents that happened in the previously chosen years in terms of product-moment correlations (but note that, because our sample was selected, estimation of the correlation coefficient of the population is not possible). If we find a relationship between conflicts and accidents, how strong must it be to indicate a certain validity of our method?

We formulated two demands.

- 1) The relation must be stronger than between exposure variables (traffic volume, volume of pedestrians, products of both) and accidents. In other conflict studies (Baker, 1972; Paddock, 1974; Glennon & Thorson, 1974), exposure seemed to be the explanatory variable of established relations between conflicts and accidents.
- 2) The relationship must be stronger than between subjective feelings of the residents regarding the safety of the locations under study and accidents. If this subjective safety is strongly correlated with accidents, the need for an instrument such as the conflict observation technique is doubtful.

Results: a) conflicts and accidents.

Of all types of encounters, serious conflicts correlated best with accidents:  $r = .51$ ,  $p < .01$  (see table 2).

It can be concluded from table 2 that the combination of the two variables distance and reaction is essential in defining the different types of encounters.

Encounters characterized by short distances do not correlate better with accidents than those characterized by greater distance, nor do encounters featuring sudden evasive actions show a better correlation with accidents than those characterized by nonsudden actions.

Although serious conflicts show the strongest relation with accidents (a confirmation of Spicer's findings (1971, 1972, 1973)), they explain only 25% ( $r^2 \times 100$ ) of the variance in recorded accidents.

Table 2. Matrix of correlations of the different types of encounters and reported accidents 1972 - 1976

	SC	C	ICC	CC	IC	C	E	A
serious conflict		.65 p<.001	.68 p<.001	.63 p<.001	.68 p<.001	.61 p<.001	.73 p<.001	.51 p<.01
conflict		1	.75 p<.001	.91 p<.001	.74 p<.001	.89 p<.001	.96 p<.001	.23 p>.05
intensive contact - conflict			1	.81 p<.001	.80 p<.001	.69 p<.001	.85 p<.001	.34 p<.05
contact - conflict				1	.65 p<.001	.90 p<.001	.96 p<.001	.37 p<.05
intensive contact					1	.64 p<.001	.80 p<.001	.15 p>.05
contact						1	.94 p<.001	.36 p<.05
total of encounters							1	.35 p<.05
accidents 1972 - 1976								1

This does not seem to be high enough to justify the use of serious conflicts as a criterion for traffic safety.

Addition of the other encounters as predictor variables (multiple correlation) yielded a correlation of  $r = .68$ ,  $p < .001$ , which explains about 50% of the variance.

It must be noted, however, that recorded accidents do not include collisions between pedestrians and cyclists, because these collisions seldom result in injury (criterion for recording). In our observations, we also recorded encounters between pedestrians and cyclists.

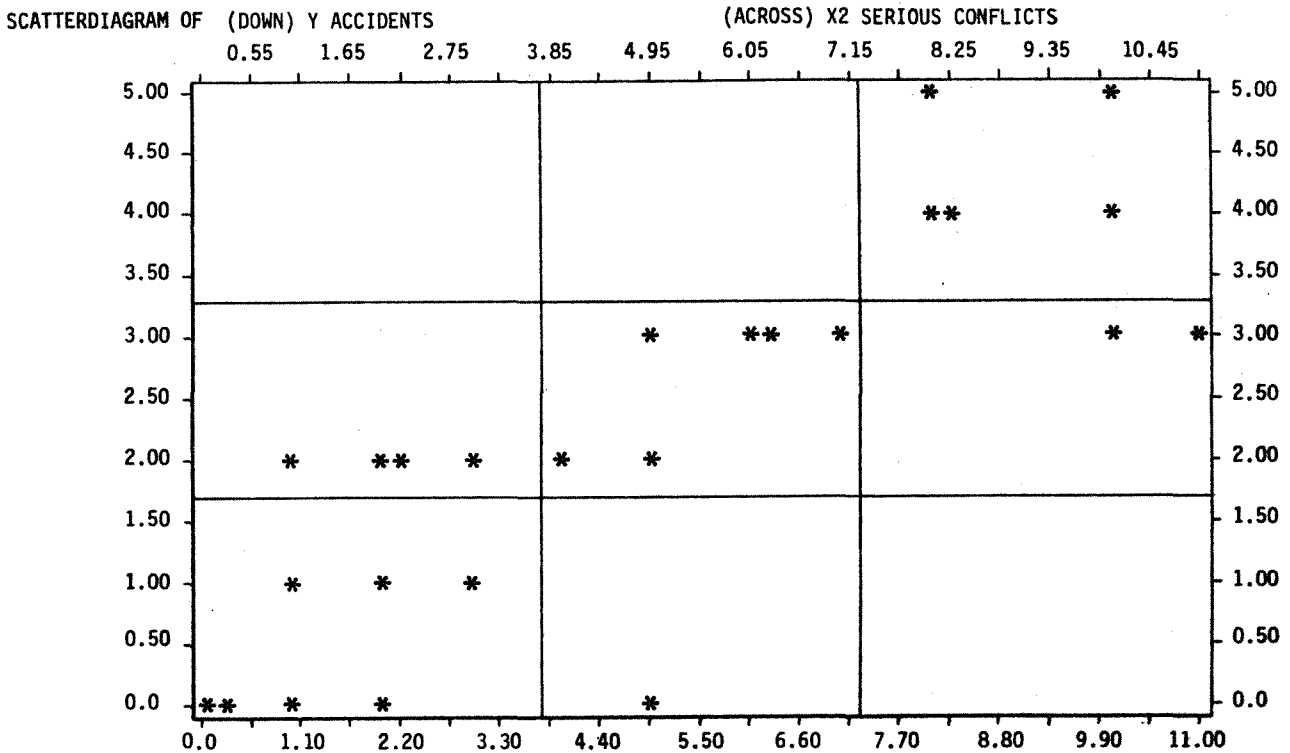
Leaving these kinds of encounters out of the calculations, we found a correlation of serious conflicts with accidents of  $r = .82$ ,  $p < .001$  (table 3). If all types of encounters are used as predictor variables, the multiple correlation is  $r = .88$ .

If we plot the relation between serious conflicts and accidents, the regression shows a strong linear component (fig. 2).

**Table 3.** Matrix of correlations between the different types of encounters (leaving cyclists out of the calculations) and reported accidents (1972 - 1976)

	SC	C	ICC	CC	IC	C	E	A
serious conflict		.57 p<.001	.55 p<.001	.62 p<.001	.66 p<.001	.62 p<.001	.68 p<.001	.82 p<.001
conflict		1	.73 p<.001	.91 p<.001	.79 p<.001	.90 p<.001	.95 p<.001	.26 p>.05
intensive contact - conflict			1	.82 p<.001	.85 p<.001	.66 p<.001	.82 p<.001	.31 p<.05
contact - conflict				1	.77 p<.001	.91 p<.001	.97 p<.001	.38 p<.05
intensive contact					1	.71 p<.001	.85 p<.001	.34 p<.05
contact						1	.95 p<.001	.41 p<.05
total of encounters							1	.41 p<.05
accidents 1972 - 1976								1

**Figure 2.** Serious conflicts (X) versus accidents (Y)



CORRELATION (R)-	0.81525	R SQUARED	-	0.66464	SIGNIFICANCE <	0.001
STD ERR OF EST -	0.91962	INTERCEPT (A) -		0.43776	SLOPE (B) -	0.36713
PLOTTED VALUES -	25	EXCLUDED VALUES -		0	MISSING VALUES -	0

b) exposure data and accidents.

Of all of the exposure variables we used, none yielded a better correlation with accidents, as can be seen in table 4.

If we add exposure variables to serious conflicts in our prediction of recorded accidents, we can see that they explain very little variance in addition (table 5).

Table 4. Matrix of correlations between exposure variables and recorded accidents (1972 - 1976)

exposure variable	r	p
traffic volume	.30	>.05
volume motor traffic*	.35	<.05
volume child pedestrians	.42	<.05
volume protected child pedestrians**	.31	>.05
volume unprotected child pedestrians	.44	<.01
product of 1 and 3 = exposure 1	.39	<.05
product of 2 and 3 = exposure 2	.40	<.05
product of 1 and 5 = exposure 3	.41	<.05
product of 2 and 5 = exposure 4	.41	<.05

Table 5.

	multiple correlation	partial correlation serious conflicts and accidents. Exposure constant	partial correlation exposure and accidents. Serious conflicts constant
serious conflicts + volume motor traffic	.82	.79	.14
serious conflicts + volume child pedestrians	.82	.77	-.12
serious conflicts + volume unaccompanied child pedestrians	.82	.77	.11
serious conflicts + vol.mot.traf. x vol. child pedestrians	.82	.78	.05
serious conflicts + vol.mot.traf. x vol. unacc. child pedestrians	.82	.77	.04

\* Because of aforementioned reasons (collisions between cyclists and pedestrians do not result in recorded accidents), cyclists are left out of the calculation.

\*\* Protection: presence of adults.

c) subjective safety and accidents.

Subjective feelings of the residents regarding the safety of the locations under study did not show much relation with the actual safety or hazards for children\*.

Conclusion

Considering these results and considering also that

- a) pedestrian accidents involving children in residential areas happen so infrequently that they cannot be used to arrive at statements about traffic safety; and
- b) if after years of data collection there are "enough" accidents to make statements about the traffic safety, these statements are of little value because too much has changed,

we feel that serious conflicts (as we defined them) between child pedestrians and wheeled traffic can be used to arrive at statements about traffic safety. However, the conflict observation technique is not yet suited to predict accident rates. It can be used for comparing situations (areas, roads, intersections, etc.) and for arriving at statements in terms of relative safety.

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The author wishes to thank Mr. M.L.I. Pokorny and Mr. C.H.J.M. Opmeer for their critical comments on earlier versions of the manuscript.

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\* Within a radius of 100 metres of each location, parents were asked questions like: "does your child play at that location"; "has your child to cross that location"; "if so, do you assist your child"; what is your opinion of the safety of that location", etc. Only one significant correlation was found: at locations where children of ages 0 - 4 years were allowed to play, more accidents had occurred ( $r = .40, p < .05$ )!



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## THE ANALYSIS OF TRAFFIC BEHAVIOUR BY VIDEO

A.R.A. van der Horst

Institute for Perception TNO, Soesterberg, The Netherlands

### 1. INTRODUCTION

At the Institute for Perception TNO, the study of human information processing is a main research area including the study of perception, decision making, and action. Road-user behaviour in particular is studied by using various methods ranging from mere observations in real traffic situations to highly controlled laboratory experiments, sometimes using advanced simulation techniques. The choice of methods depends on the questions to which the research is addressed.

In what follows an objective method, based on video, for observation and analysis of the behaviour of road-users in real traffic will be discussed. As an example a study will be reported in which new road design elements were evaluated in a demonstration project on cyclist routes through The Hague and Tilburg, two cities in The Netherlands. The study was carried out under contract with the Ministry of Transport. The questions were a.o. how the new elements are functioning, whether they are leading to the desired traffic behaviour and whether they have an effect on road safety. With respect to the last aspect accident figures do not form an efficient basis for studying the effects of road design elements on single spots. In this kind of situations serious interactions between road-users (conflicts) are thought to be an alternative to accidents as a criterion measure. A substitute measure as conflict counts might overcome some limitations in the use of accident figures; accident frequencies are unstable, necessary observation periods are too long in particular in evaluation studies and only a fraction of all accidents are reported with also differences with regard to types of accidents. These three limitations are the more severe, if the theoretical accident frequencies are already small, as is the case in studies at particular locations of the road network like neighbourhoods and intersections.

In the past various conflict-observation methods have been developed, mostly using individual observers. Although they may be highly trained and experienced, large differences between individual observers remain, sometimes due to inadequate definition of conflict, sometimes due to, for example, inaccurate time estimation in case of an interaction between road users. To reduce observer subjectivity, it was considered necessary to develop an observation technique which enables objective quantification of the severity of interactions between road users.

### 2. TRAFFIC CONFLICT METHODS

The Traffic-Conflicts Technique (TCT) was adopted as an operational tool in road safety research by a publication of Perkins and Harris (1967). They define a traffic conflict as any potential accident situation, leading to the occurrence of evasive actions like braking or swerving. Over twenty criteria for traffic-conflict situations are given. Evasive actions are counted simply by scoring brakelight indications or lane changes. During three 12 hour observation sessions an intersection can be evaluated completely. The observation team consists of two observers, one counting traffic conflicts and one counting traffic volumes. A detailed procedures manual has been published by Perkins (1969).

The strength of the General Motors TCT lies in its simplicity of application. Although the method was taken up enthusiastically, later studies showed some deficiencies of this method. The set of conflicts, as defined by Perkins, appears to be too large to have a close relationship with accidents or with collisions. Campbell and King (1970) used the General Motors TCT to measure the accident potential of two rural intersections. They found no significant association between conflicts and reported accidents. Omitting rear-end conflicts and rear-end accidents they observed a much higher degree of association. The reason for doing so was that while collecting the data it was noted that, although a large number of rear-end conflicts occurred, it appeared that some drivers were braking only for personal comfort or by way of precaution.

Furthermore, a need existed to classify the degree of severity of the evasive action. This was done by Older and Spicer (1976), who developed a severity grading in five categories, ranging from precautionary braking or lane change to an emergency action followed by a collision. In these conflict studies individual observers were used, complemented by time lapse film recordings (two frames per second). According to Older and Spicer, a combined observer and film study is necessary for research purposes. For a rapid assessment of number and location of conflicts, they conclude that the use of individual observers only is sufficient. This conclusion, however, is criticized by Hauer (1977) and Allen et al. (1977). Firstly, collisions may occur without evasive actions being taken. Therefore, a definition of conflicts including the occurrence of a collision, not preceded by evasive actions, is desirable. Secondly, the grading of severity of the evasive action by observers introduces a rather subjective aspect. This may be reduced by an intensive training programme. Older and Spicer (1976) found an agreement of 80% between gradings of the same traffic event by two groups of observers. However, effects over a longer time period were not investigated.

#### The time-to-collision concept (TTC)

To describe the danger of a conflict situation objectively, Hayward (1971, 1972) defined the *time-measured-to-collision* (TMTC or TTC). This measure is the time required for two vehicles to collide if they continue at their momentaneous speeds and on the same path. The measure is continuous with time. The theoretical shape of a TTC curve as a function of time is given in Fig. 1. If the vehicles are not on a collision course the value of TTC is infinite. However, a change in speed or path of one of the vehicles may lead to a collision course, implying that TTC is finite and will decrease with time. This will be linear as long as the speed and course of both vehicles are constant. If neither one would take action, it will result in a collision (TTC = 0). An evasive action (decelerating, swerving) may lead to a minimum value for TTC, which then increases to infinity again. It often happens that roadusers are on a collision course, but very rarely it will result in a real collision, because drivers are making continuously the necessary speed and heading changes. The minimum TTC value is a critical measure for the risk involved in an interaction between roadusers. Hayward (1972) suggests to use a minimum TTC value of 1.0 s as a good threshold. Interactions with a minimum TTC below this value would be defined as serious conflicts. The definition of a conflict then becomes: a conflict is each traffic situation with a minimum TTC less than 1.0 s. Hayward calculated TTC-curves by analysing film pictures quantitatively. Hyden (1975, 1977) tried to simplify this method with a lightly different definition. He proposes a larger critical value, namely 1.5 s instead of 1.0 s. Hyden had individual observers estimate minimal TTC values after an intensive training with help of video recordings of traffic situations with known TTC values. However, in doing so Hyden introduced again observers' subjectivity.

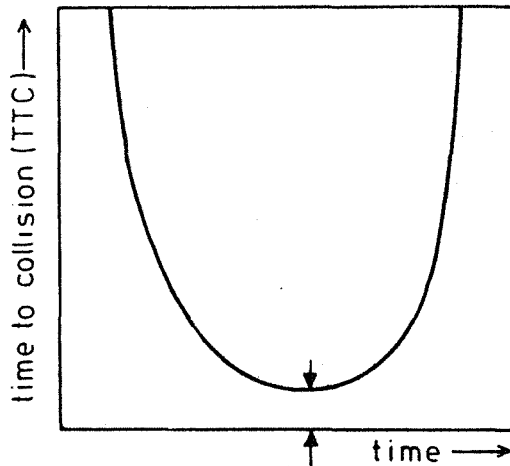


Fig. 1. Theoretical TTC curve as a function of time (Hayward, 1972).

### 3. RECORDING AND ANALYSIS METHOD

In order to measure motion and positional parameters involved in an interaction between road users, the use of film or video appears to be still necessary. Both techniques have their specific advantages and disadvantages, but with respect to costs and practical aspects the use of video is preferred (Van der Horst and Sijmonsma, 1978). In the near future the potential for automatic analysis of video seems to be rather high. At the Institute for Perception TNO a method has been developed for the quantitative analysis of video recordings in a semi-automatic way. A short description of this method will be given in this chapter.

#### Recordings

The behaviour of roadusers is recorded by means of video. A suitable place for mounting the camera has to be found in the neighbourhood of the location, preferably at a height of more than 4 m above the road surface, of course as unobtrusively as possible. In a study at 20 intersections on cyclist routes in an urban area (chapter 4) a good camera position could be found rather easily in adjacent buildings or in lampposts.

A block-diagram of the video recording equipment is shown in Fig. 2 up to now only one camera has been used. When the outlook over the location is too limited, the use of a second camera in combination with a video mixer is optional. The timer superimposes a numerical display of month, day, hour, minutes, seconds and 1/100 s onto the video picture. This is very helpful in selecting traf-

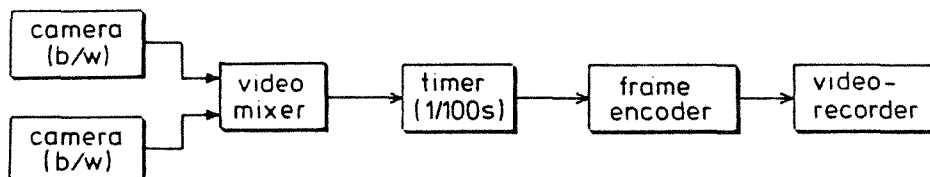


Fig. 2. Video recording equipment.

fic situations and relating these with other parameters like traffic volumes, densities, etc. Each frame is labeled uniquely by superimposing digital information at the beginning of each video line by the frame encoder, in order to search a particular video frame automatically, see Fig. 3. The digital label (24 bit) is repeated four times in each frame. So the information is always available independent of the position of the "noise bar" (the separation between two successive frames on stills). The video signal is recorded by a Sony Umatic video cassette-recorder (type V02850).



Fig. 3. Video still with digital label at the left, electronic cross-hairs, time and noise bar (at the bottom).

### Analysis

The vehicle movements, recorded on video-cassette, are analysed quantitatively to describe their behaviour in terms of course, course changes, speed, speed changes and measures for the interaction with other roadusers, for example time-to-collision (TTC). The quantitative analysis consists of selecting the positions of some points of the vehicle on a video still. By means of transformation rules, positions in the plane of the picture can be translated to positions in the plane of the street. By differentiating successive positions in time, the speed of the vehicle can be obtained. The selection of one picture from every twelve (one picture/0.24 s) appeared to be a reasonable compromise between accuracy and length of analysis time.

### Video analysis equipment

To ensure a flexible use of the analysis equipment a great part of the system has been realised in software. The central part of the system consists of a small minicomputer (a PDP 11/03 with 28K memory), see Fig. 4. A 8-channel digital interface (24 bits per channel) interconnects the computer with the other elements. A small modification of a standard joy-stick remote control unit makes computer control of the video recorder possible (operational control and control of the tape speed). The tape speed can be adjusted continuously from zero to plus and minus three times the normal video tape speed. The digital labels

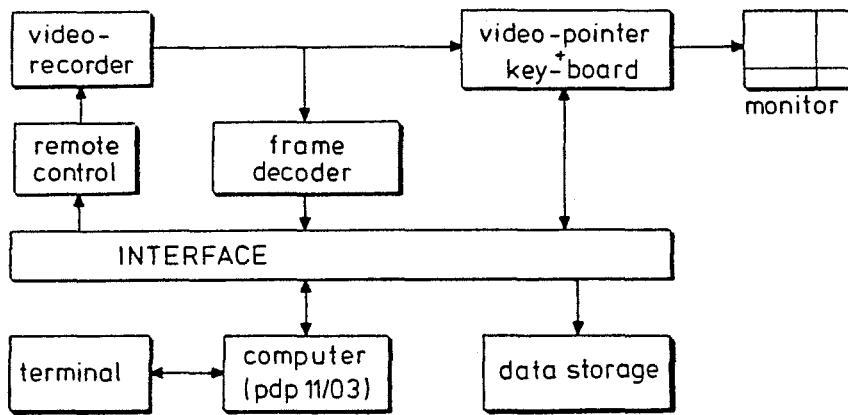


Fig. 4. Block-diagram of the video-analysis equipment.

(stored in each frame four times) are read by the frame decoder continuously and passed at a command of the computer. This enables the computer to search the desired frame and then to shift down the noise bar to the bottom of the monitorscreen.

The operator is communicating with the system in two ways, by means of a terminal for normal input and output of the programme and by means of a special keyboard (Fig. 5) consisting a.o. of 16 push buttons, to which a function may be related in software, for example "point ready", "picture ready", "manoeuvre ready", "other point", etc. The operator is indicating a point on the screen of the video monitor by positioning two crosshairs, continuously by a joystick or step-by-step by four push buttons. The crosshairs are mixed electronically



Fig. 5. Monitor, remote-control of the video recorder (at the right) and the special keyboard (black) with 16 programmable push buttons and the control of the electronic crosshairs: a joystick and at the left four pushbuttons.

in the video, so parallax errors have been avoided. On command of the operator, the computer reads out the x- and y-coordinates, and then positions the cross-hairs on predicted x- and y-coordinates of the next point to be measured. The prediction is based on previous selected positions of the point. In this way the operator has only to correct these coordinates with a few steps. After finishing the manoeuvre a datafile is submitted to a data storage device for further analysis, in the current system to a disc of a PDP 11/40 computer.

Transformation from video coordinates to street coordinates

The known coordinates  $(X_v, Y_v)$  of a given point in the video plane have to be transformed to coordinates  $(X_s, Y_s)$  in the plane of the street; see Fig. 6. Assuming that all points of the street are lying in one flat plane and that no reproduction errors occur (neither by the camera nor the monitor) the following transformation rules can be derived (Hallert, 1960):

$$\left. \begin{aligned} X_s &= \frac{C_1 X_v + C_2 Y_v + C_3}{C_4 X_v + C_5 Y_v + 1} \\ Y_s &= \frac{C_6 X_v + C_7 Y_v + C_8}{C_4 X_v + C_5 Y_v + 1} \end{aligned} \right\} \quad (1)$$

The coefficients  $C_1$  to  $C_8$  can be calculated from (1) if the coordinates of at least four points are known in both planes. Substituting the  $X_v, Y_v, X_s$  and  $Y_s$  of four points in (1) gives a system of eight linear equations with  $C_1$  to  $C_8$  as the unknown elements. This system can be resolved if none combination of three points in both planes is lying on a straight line.

This transformation offers the great practical advantage that nothing has to be known about the position and orientation of the camera. All information is in-

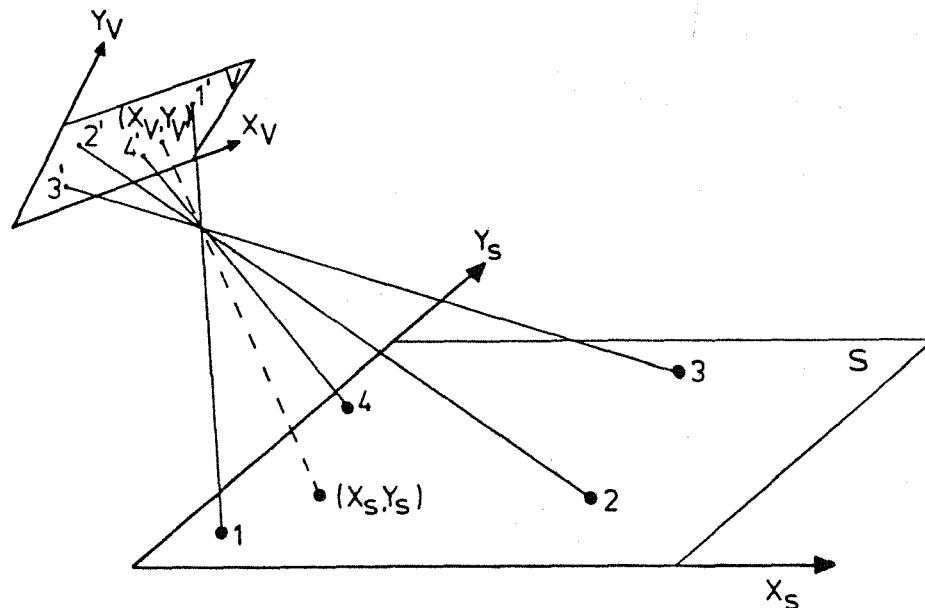


Fig. 6. Schematic representation of the projection of points in the plane of the street (plane S) on the video plane (plane V).

cluded in the way in which the four points on the street are projected on the video plane. On the street, only the distances between the points have to be measured. The accuracy of the transformation depends strongly on the selection of the four reference points. So it is advisable to measure some more points to have a check on the transformation and to make an optimization possible.

### Data analysis

A datafile, generated by the video-analysis equipment, contains the x- and y-coordinates in the video plane of successive positions of points of the vehicle involved. This datafile is stored on a disc of a PDP 11/40 computer. Software has been developed for further analysis, namely for the transformation to street coordinates, a smoothing routine to minimize sampling inaccuracies, the calculation of motion parameters like speed and acceleration and the computation of interaction measures (like time-to-collision (TTC) curves and minimum passing distances). For the last measures accurate vehicle dimensions are required, for which a data base of current types of motorcars is available. For the calculation of the TTC measure, see the Appendix. The outcome of the procedure is illustrated in the example of Fig. 7. In a situational map of an intersection the courses of a car coming from the minor road and two cyclists on a cycle track are plotted. Each point gives the position of a given point of a vehicle at successive time intervals, here 0.24 s. The car driver did not give right of way to the cyclists. Cyclist 1 had to stop (points close together), while cyclist 2 rode behind the car. The plot in the bottom corner gives the time-to-collision (TTC) curve for the interaction between the car and cyclist 1.

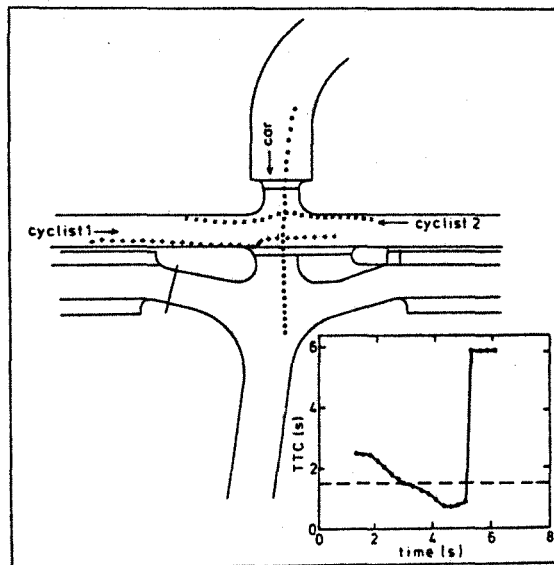


Fig. 7. Example of a serious conflict between a car from the minor road and cyclist 1. Bottom right: time-to-collision (TTC) curve.



#### 4. BEHAVIOURAL STUDY CONCERNING PRIORITY INTERSECTIONS OF THE DEMONSTRATION CYCLEROUTES AT THE HAGUE AND TILBURG

##### Background

The increasing number of cars on the road leads to an increasing demand on the available space. Therefore, the government's policy aims at a restricted car use, especially in urban areas and during peak hours, and to promote the use of the bicycle and/or public transport instead. A safe and highly comfortable system of cycletracks might promote the use of the bicycle. To stimulate the construction of cycleroutes in urban areas, the national government had designed and constructed the two aforementioned demonstration cycleroutes in The Hague and in Tilburg.

These cycleroutes have their own tracks on the road, separated from motorised traffic, traced through areas with rather low traffic volumes, crossing other traffic streams as less as possible, giving right-of-way to bicyclists at non-signalised intersections, special priority measures at signalised intersections and, if necessary, even a viaduct or tunnel over/under heavy traffic streams.

Especially at non-signalised intersections, where the cyclists on the cycle-track have the right-of-way over crossing traffic, the road design elements play an important part in supporting the traffic behaviour, as intended by the designers. The experimental character of the project made it possible to try out some different solutions for the same kind of problems at a priority intersection.

##### Procedure

The evaluation of the functioning of new road design elements at a number of priority intersections, with respect to roaduser behaviour, consisted a.o. of:

- a. A comparison between the actual behaviour and the behaviour as intended by the designers for each aspect and location,
- b. a comparison of the actual behaviour between experimental locations and
- c. as far as possible, a comparison between the actual behaviour at the experimental locations and the behaviour at some control locations, without special provisions.

At fifteen locations of the cycleroutes and at five separate control locations video recordings were made, at each location for six hours during one day. The video recorder was started by hand when a vehicle arrived and stopped when the manoeuvre had occurred. For each location the relevant road-user behaviour to be recorded had been discussed with municipal authorities.

From the video recordings a number of behavioural aspects, including path chosen, speed, speed changes, place of stopping and, of course, interactions with cyclists on the cycletracks (conflicts), were studied in detail, as influenced by specific design elements (humps, hobbles, constrictions, curves, etc.), in particular for crossing traffic. Whenever clear behavioural alternatives could be distinguished, registrations were done by individual observers directly from the video recordings. Otherwise a quantitative analysis was carried out with the video analysis equipment, as described in chapter 3.

##### Results

In this session only some aspects of speed control and the interactions with cyclists will be discussed, just for demonstrating the usefulness of the observation- and analysis method. For more detailed information it is referred to Van der Horst (1980).

Speed curves

A number of the road design elements has the function of reducing the speed of crossing cars. By analysing the video recordings quantitatively, speed curves were determined for cars, crossing the cycletrack without the presence of other traffic. For four locations Fig. 8 gives an example of speed profiles of crossing cars as a function of the distance to the cycle track. Each point gives

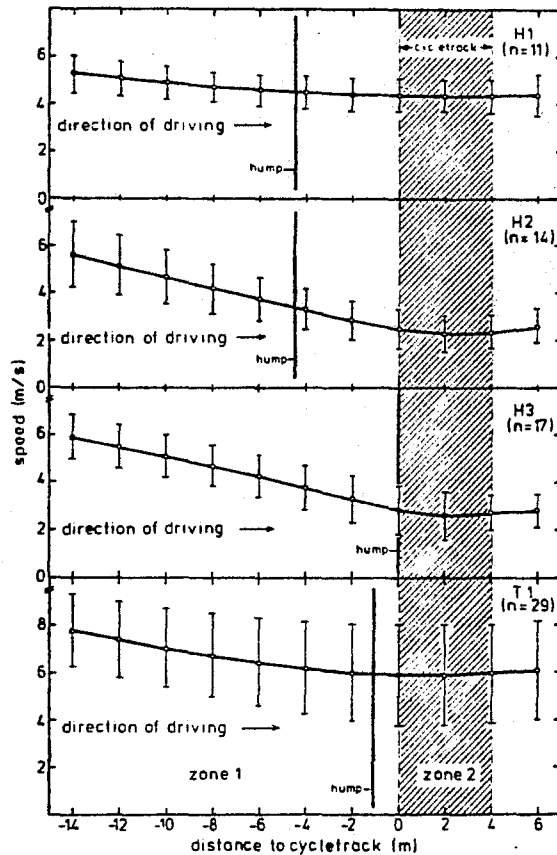


Fig. 8. Speed profiles of freeriding cars from the minor street at four locations (H1, H2, H3 en T1).

the mean value of  $n$  vehicles, together with the standard deviation. The most important characteristics of such profiles are a.o., the speed on the boundary of the cycletrack ( $\bar{v}$ ), the minimum speed ( $\bar{v}_{\min}$ ) and the place where this minimum is reached ( $\bar{d}_{\min}$ ). The front axis of the vehicles is taken as the measuring point. In Table I these characteristics are given as a mean for each group of locations.  $\bar{d}_{\min}$  Gives an indication of the place where car drivers have taken the decision to go through. Although the speed curves differ between locations,

Table I. Mean speed on the boundary of the cycletrack ( $\bar{v}$ ), mean minimum speed ( $\bar{v}_{\min}$ ) and the mean distance to the cycletrack where this minimum is reached ( $\bar{d}_{\min}$ ), for freeriding cars from the minor street;  $n$  is the number of locations in each group.

group of locations	$n$	$\bar{v}$ (m/s)	$\bar{v}_{\min}$ (m/s)	$\bar{d}_{\min}$ (m)
The Hague	8	2.7	2.5	-0.5
Tilburg	6	3.6	3.4	0
control	5	4.3	3.7	+4

in general the speed control elements (humps for instance) at the experimental locations are functioning according to the expectations. The speeds are lower than at the control locations and the place where the minimum speed is reached ( $d_{\min}$ ) appears to be prior to or on the cycletracks instead of a few metres after the cycletrack for the control locations. With the special elements more attention is paid by car drivers to the cycletrack.

In case of interactions with cyclists, the minimum speed was reached on or after the cycletrack for control locations, while for the experimental locations it was reached a few metres prior to the cycletrack, an example of which is given in Fig. 9.

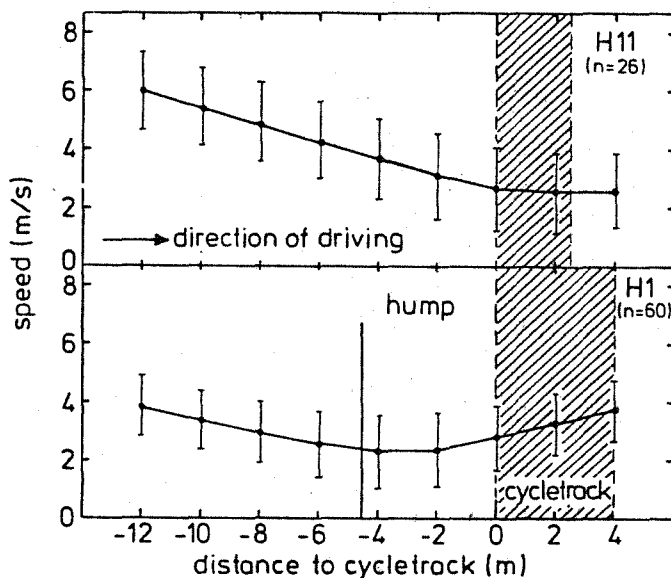


Fig. 9. Example of two speed profiles of crossing cars with cyclists on the cycletrack, H1 is an experimental location with a speed control hump at a distance of 4.5 m from the cycletrack, H11 is a control location without hump in front of the cycletrack.

An experimental parameter in applying a speed control hump is the distance between the hump and the element it is intended for (here the cycletrack). A comparison of locations where this distance was different (between 0 and 5 m), resulted in a preference for a hump as the beginning of a plateau at a distance of about 4.5 m from the cycletrack.

A raised intersection plane, consisting of humps + plateau of brick pavement, reduced the speed of through-going cars on the main road significantly with 4 m/s, a reduction of about 40%.

#### Interactions between crossing cars and cyclists at the cycletrack

An important aspect in evaluating intersections is road safety, in this study, especially in relation to cyclists. The number of accidents at a single location cannot be used as a evaluation criterion for reasons given before. Conflicts seem to have an alternative to accidents as a criterion measure for road safety. In the following the time-to-collision (TTC) will be given as a possible measure for describing serious interactions between road users.

By means of the video-analysis equipment a large number of manoeuvre combinations were analysed. On the basis of the x and y positions of the vehicles at successive moments TTC curves can be calculated with the help of a computer programme. Fig. 7 illustrated already the output of a given manoeuvre combination: a serious conflict between a crossing motorist and two cyclists on the cycletrack.

The number of conflicts (for example defined as the number of interactions with a minimum TTC less than 1.5 s), related to an exposure measure E might give a risk index (RI) for two intersecting traffic streams. On the basis of these risk indices, intersections might be compared relatively. From the literature it is not quite clear which kind of exposure measure has to be used. Often the exposure E of two traffic streams i and j has been defined as:

$$E = \sqrt{I_i * I_j}$$

where  $I_i$  and  $I_j$  are the number of vehicles in stream i and j during a given period. In the following this E will be used.

In Fig. 10 the number of conflicts is given as a function of the exposure E for two types of manoeuvre combinations at the intersections under study. In Fig. 10a it concerns the conflicts between car drivers from the minor street ( $car_1$ ) and cyclists coming from the left (the first bicycle stream B1), while in Fig. 10b between stream  $car_1$  and cyclists coming from the right (the second stream B2). Each point represents the relevant type of manoeuvre at the intersection. The quotient of the number of conflicts and E gives the risk index RI. The solid line in both figures represents RI, averaged over all points ( $car_1 - B1$  and  $car_1 - B2$  combined). Interactions between  $car_1$  and B1 at an average are scoring above this line, while those between  $car_1$  and B2 are below. Cyclists B1 are involved more frequently in a serious conflict with cars from  $car_1$  than cyclists from B2. The width of the cycletrack gives some extra space between a car from  $car_1$  and a cyclist from B2. The reversed situation

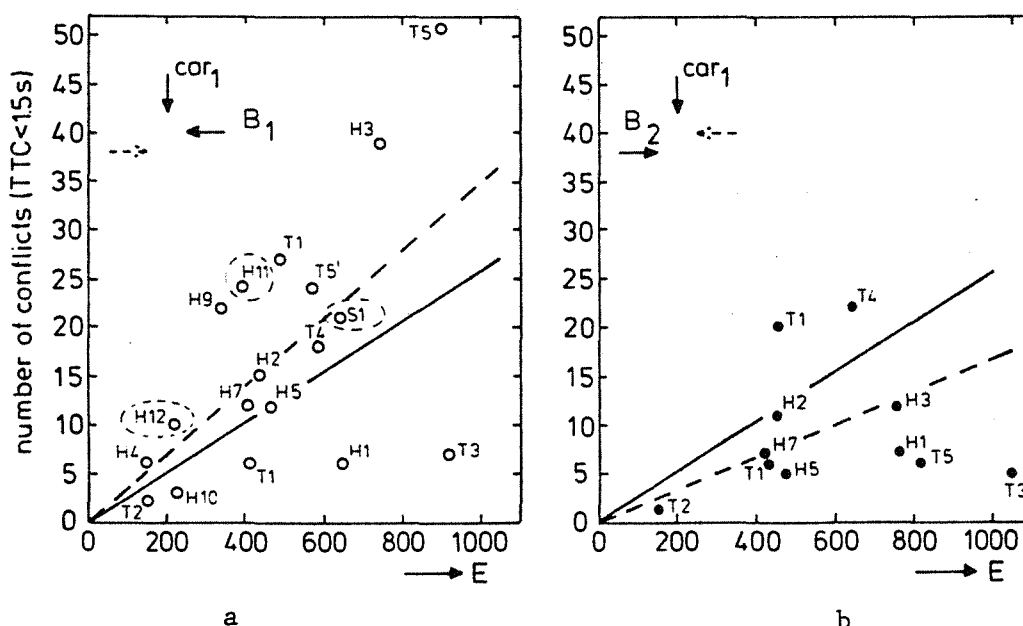


Fig. 10. The number of conflicts (TTC < 1.5 s) as a function of exposure E ( $E = \sqrt{car_1 \cdot B_1}$ ) for two types of manoeuvre combinations. The control locations are marked with ( ) .

holds for cyclists from B2 and cars coming from the opposite direction (data not presented here). The mean RI per type of manoeuvre combination in Fig. 10 is given by the dashed lines. Intersections above this line are relatively more unsafe (in terms of conflicts) than intersections below the line, that is for the particular type of manoeuvre combination.

Initially, it was not obvious which minimum TTC value has to be used. However, it appears from this study that interactions with a minimum TTC value greater than 1.5 s do not contribute an essential part to figures based on  $TTC < 1.5$  s. So 1.5 s is used as an upper limit. In Fig. 11 a distinction has been made for pairs of locations which are comparable for a number of aspects. Three different types of riskindices are given, based on interactions with a minimum TTC of less than 1.5, 1.25 and 1.0 s, respectively. For example at the cycleroote location H3 the number of serious interactions between cars from the minor road ( $car_1$ ) and cyclists on the cycletrack was higher than at cycleroote location H1, independent on the type of riskindex that is used (left topfigure). In this case the distance from hump to cycletrack was largely responsible for the difference; at location H1 this distance amounts 5 m and at location H3 it is 0 m. Another indication that humps at a distance of about 5 m are functioning better than humps bordering the cycletrack.

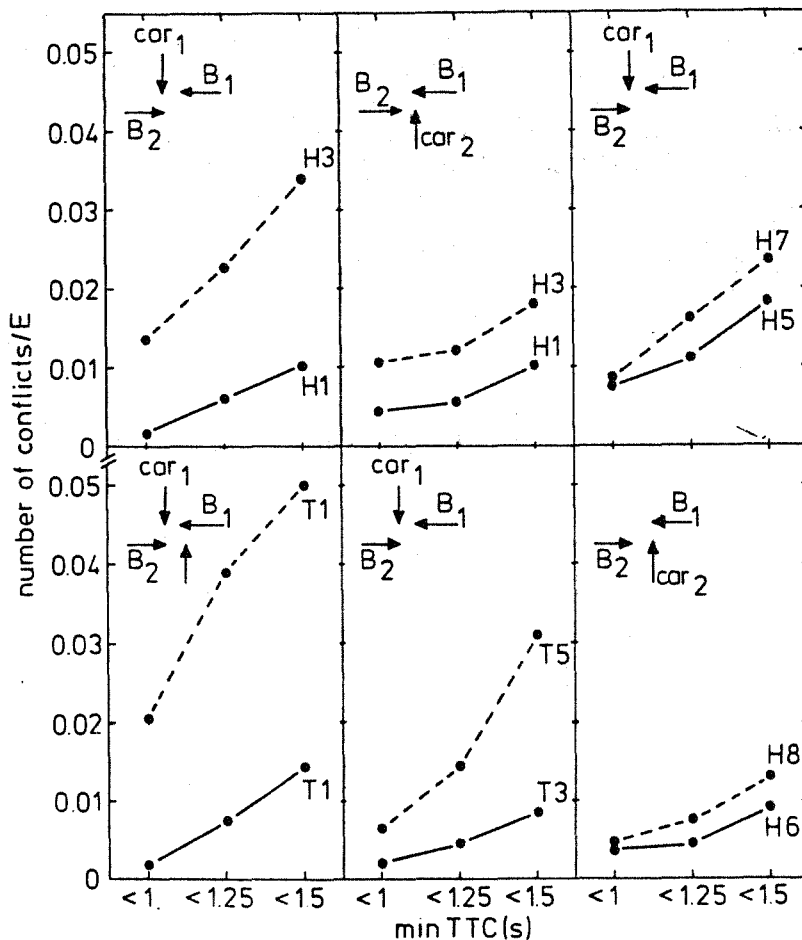


Fig. 11. Riskindices (number of conflicts/E) based on different minimum TTC values (< 1., < 1.25 and < 1.5 s) for pairs of comparable intersections. The type of manoeuvre-combinations is given in the left top corner.

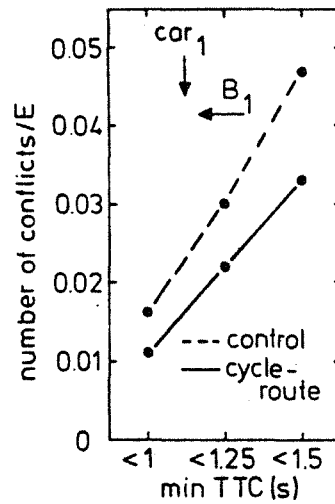


Fig. 12. Riskindices of the control locations (H11, H12 and S1) in comparison with the cycle-route locations, for the manoeuvre-combination car<sub>1</sub> - B<sub>1</sub>, i.e. cars from the minor road and the bicycle flow, which is intersected firstly.

In general the three control locations (H11, H12 and S1) produce more conflicts, than locations at the cycle-routes, for one type of manoeuvre combinations see Fig. 12.

### 5. CONCLUSIONS

- Recording and analysing the traffic behaviour in detail may give a lot of information about the functioning of several road design elements.
- The method as described in chapter 3, based on video, enables a process oriented analysis of interacting behaviour between roadusers, not necessarily restricted only to the time-to-collision concept.
- However, in spite of a semi-automatic analysis procedure by the use of a mini-computer, the quantitative analysis remains time consuming. Further automation of the procedure seems necessary.

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APPENDIX

The computation of the time-to-collision measure (TTC)

Let Fig. A give the simplified situation at time  $t$ . Vehicle 1 and vehicle 2 are approaching each other. Assuming that from the moment  $t$  no changes in speed and heading occur, for each vehicle a straight line is estimated through the current point (P) and three preceding points. The intersection of the two lines, point S, is determined. Then, the decision is made whether the vehicles are on a col-

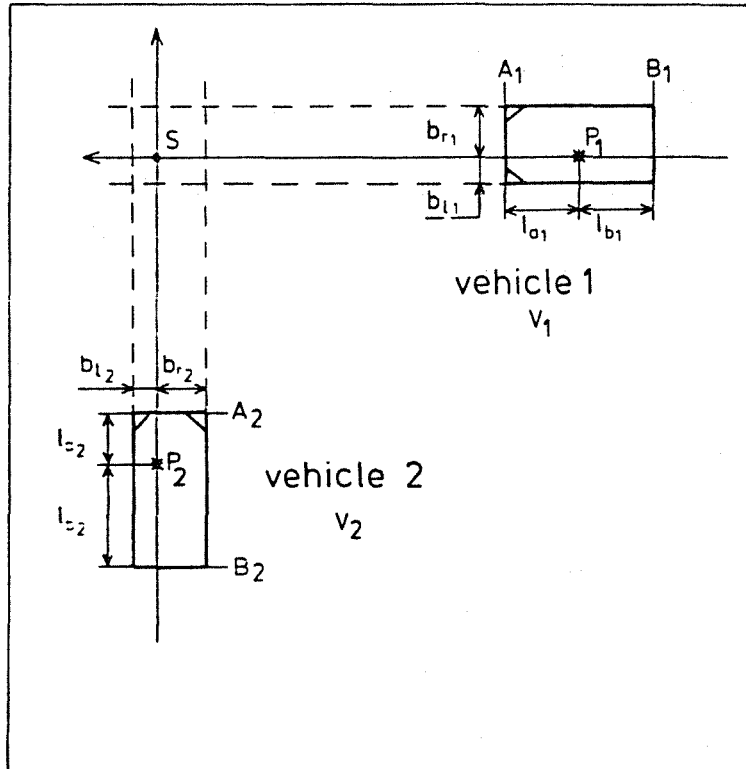


Fig. A. Some vehicle characteristics used in calculating TTC curves.

lision course or not, taking into account the dimensions and speeds of both vehicles. They are in fact on a collision course at time  $t$  if either of the following two conditions is satisfied:

$$t_{A1} < t_{A2} < t_{B1} \tag{A1}$$

$$t_{A2} < t_{A1} < t_{B2} \tag{A2}$$

in which:

$$t_{A1} = t_{P1} - \frac{l_{a1} + b_{r2}}{v_1} \tag{A3}$$

(time vehicle 1 reaches the intersection plane)



$$t_{B1} = t_{P1} + \frac{l_{b1} + b_{12}}{V_1} \quad (A4)$$

(time vehicle 1 has left the intersection plane)

$$t_{A2} = t_{P2} - \frac{l_{a2} + b_{11}}{V_2} \quad (A5)$$

(time vehicle 2 reaches the intersection plane)

$$t_{B2} = t_{P2} + \frac{l_{b2} + b_{r1}}{V_2} \quad (A6)$$

(time vehicle 2 has left the intersection plane)

$t_{P1}$  = moment point P1 passes intersection point S;  
 $t_{P2}$  = moment point P2 passes intersection point S;  
 $V_1$  = speed of vehicle 1 at moment t;  
 $V_2$  = speed of vehicle 2 at moment t.

Then, TTC will be for (A1):  $TTC = t_{A2} - t$  (A7)

and for (A2):  $TTC = t_{A1} - t$  (A8)

Determination of the TTC for successive times (e.g. each 0.24 s) allows it to be plotted as a function of time, but only if (A1) or (A2) is satisfied.

The above applies to a  $90^\circ$  angle of intersection. Adjustments can be made for other angles. Special computations have to be done if one of the vehicles has a speed of 0 km/h ( $V_1$  or  $V_s \approx 0$ ). The continuation of movement is based on a constant speed in one direction at moment t. In the next step, let us say after  $\Delta t$  s, the computation of TTC is made with the speeds and courses at moment  $t + \Delta t$ , which of course may be different from those at the previous moment t. Balasha et al. (1978) suggest that other assumptions for the continuation of movements, like a constant angular velocity and a constant acceleration or deceleration might give improvements for the computation of TTC values.

AN UPDATING OF THE USE AND FURTHER DEVELOPMENT OF THE TRAFFIC CONFLICTS  
TECHNIQUE

C. Hydén, P. Gärder, L. Linderholm  
Department of Traffic Planning and Engineering, Lund Institute of  
Technology, Lund, Sweden

1 BACKGROUND

It is of obvious interest to be able to estimate risks for different road-users at various locations e.g. when prioritising safety-measures between different sites, when choosing counter-measures, and when evaluating their effects. The lack of an effective method to evaluate these effects makes traffic safety planning on local and federal levels ineffective. This means that the most cost-beneficial solutions rarely are chosen and sometimes even that supposedly safety-beneficial solutions have a negative effect on the safety without so being found out until many years after the implementation of the countermeasure.

Traditionally the only method of estimating risks has been by analysing accidents. This is however very time-consuming and there are often interfering changes in the variables that preferably should be kept constant during the period of analysis (i.e. traffic intensity). Furthermore, information of how and why the accidents have occurred is lacking. These facts combined with the low percentage of occurred accidents that ever get reported naturally make accident analysis far from perfect.

Many of the problems related to the analysis of accidents could be solved by estimating the risks indirectly by a "Conflict-Technique". Work with developing such a technique started at our department in 1973 and a technique for operational use was specified in 1974. Since then the technique has been modified and is still under further development, but many of the bases are unchanged.

The basic hypothesis, unchanged since 1974, says that there is a distinct relation between conflicts with a certain degree of seriousness and accidents. When these relationships have been determined the technique is practically useful. This means that after a conflict study has been undertaken actual accident risk can be calculated with a known degree of uncertainty.

Below the different phases of the development of the Swedish technique will be described.

## 2 THE ORIGINAL TECHNIQUE

The following definition was used: A serious conflict occurs when two road-users are involved in a conflict-situation where a collision would have occurred within 1,5 seconds if both road-users involved had continued with unchanged speed and direction. The time is calculated from the moment one of the road-users starts braking or swerving to avoid the collision.

The recording of conflicts was and still is made by observers at the traffic site. Tests show that observers, after approximately four days of training, are able to recognise serious conflicts with a large degree of certainty.

To analyze the relations between accidents and serious conflicts, studies were made in a total of 115 intersections in three stages:

1. Malmö 1974-75, 50 intersections
2. Malmö 1976, 15 intersections
3. Stockholm 1976, 50 intersections

At each intersection, conflict registration was made during approximately seven hours and then compared with previous accidents of personal injury during seven to eight years.

Analysis showed that two factors had a definite influence upon the relations between police reported accidents with injuries and serious conflicts, namely the kind of road-user involved and the general speed level at the intersection. The following average connections were obtained between the number of police reported accidents with injuries and the number of serious conflicts during the same period of time.

TABLE 1: ORIGINAL CONVERSION FACTORS BETWEEN SERIOUS CONFLICTS AND INJURY ACCIDENTS.

SPEED LEVEL	ROAD-USERS	
	CAR-CAR <sup>1)</sup>	CAR-PEDESTRIAN CAR-BICYCLE
LOW-SPEED SITUATIONS, i.e. situations with turning motorvehicles involved, and situations with straight-on driving motorvehicles in low-speed intersections (non-signalized, mean speed < 30 km/h from all accesses)	3,2 (2,2-5,1) <sup>2)</sup>	14,5 (12,2-17,4) <sup>2)</sup>
HIGH-SPEED SITUATIONS, i.e. situations with straight-on driving motor-vehicles in signalized- and highspeed intersections (non signalized with a mean speed ≥ 30 km/h from at least one access)	13,2 (11,2-15,1) <sup>2)</sup>	77,2 (64,8-91,9) <sup>2)</sup>

Attention! All values in the table should be multiplied by the factor  $10^{-5}$

1) The concept "car" includes lorries and buses.

2) Confidence interval with 90 % degree of confidence.

The results obtained in the project shows that the developed conflict-technique offers practical application, mainly within the following areas:

- Description of present state of situations involving risk in urban traffic. This description includes causes likely to arise situations involving risk, suitable countermeasures for increasing traffic safety and their probable effect.
- Pilot and follow-up studies to establish the effect on traffic safety of countermeasures implemented. The conflict-technique offers possibilities to study both the immediate and long-range effect of countermeasures.

The only preparation needed, is a few days training of conflict-observers.

### 3 NEW CALCULATION OF CONVERSION RATES

The original technique, as described above, proved to work fairly well in operation but had some weaknesses. Therefore the technique was slightly changed in order to give better accident-risk-predictions.

The most important weaknesses of the original technique were:

- 1) that the method did not give satisfying results for predicting accident risks in car-car situations, when dividing these into different types of accidents
- 2) that the predicted risk of accident for two identical conflicts could be different in different types of intersections.

To solve weakness 1) analyses were made that showed that car to car situations should be divided into at least two groups, considering the risk of injury, namely

- A) situations where the angle between the directions of the involved cars is under  $90^{\circ}$ . These situations are symbolized with "Car-Car //".
- B) situations where the angle is over or equal to  $90^{\circ}$ . These situations are symbolized with "Car-Car  $\perp$ ".

Conflicts of type A turned out to be approximately four times as frequent as type B per reported accident with injury of the same type.

Weakness 2) that two identical conflicts lead to injury accidents with various probability depending on where they occur have been solved by developing a new model for calculation of risk. The new model is built on the assumption that serious conflicts can lead to personal injuries with different probabilities, depending on their degrees of seriousness. Because of the basic structure of the data a division of conflicts has only been made into two classes of seriousness. A new method of calculation has also been used to determine the connection between police-reported accidents with injuries and serious conflicts.

The following average conversion rates were received between the number of serious conflicts and the number of accidents with injuries.

TABLE 2: NEW CONVERSION FACTORS BETWEEN SERIOUS CONFLICTS AND INJURY ACCIDENTS.

SITUATION CONFLICT	CAR-CAR //	CAR-CAR ⊥	CAR-PEDESTRIAN CAR-BICYCLE
<u>Class 1</u> Speed < 35 km/h $1,0 \leq TTC \leq 1,5$ sec	0	2,4	9,6
<u>Class 2</u> Other conflicts with $TTC \leq 1,5$ sec	2,8	11,9	33,9

Attention! All values in the table should be multiplied by the factor  $10^{-5}$ .

4 PRESENT WORK

The conversion rates between conflicts and injury-accidents will in the continuing work be determined in two stages:

1. to determine the probability of each conflict leading to an accident

2. to determine the probability of each accident leading to personal injury

It should be possible to describe the probability of a conflict leading to an accident by the degree of seriousness of the conflict, which mainly depends on speeds, time-margins and possibilities of avoiding the accident.

The factors determining the probability of an accident leading to personal injuries are mainly type of road-users involved, speed at collision and angle of collision.

The conclusion of this theoretical discussion is that a threshold-level depending on the actual speed should be used instead of the fixed 1,5 seconds.

A number of smaller studies in rural areas at intersections with varying speed-limits led us to set up the following tentative definition of a serious conflict:

A conflict is serious if the time-margin that remains when the evasive action is started is not more than the braking-time at hard breaking on slightly wet pavement plus half a second. The half of a second can be regarded as the remaining reaction margin.

The relationship is illustrated in the figure below.

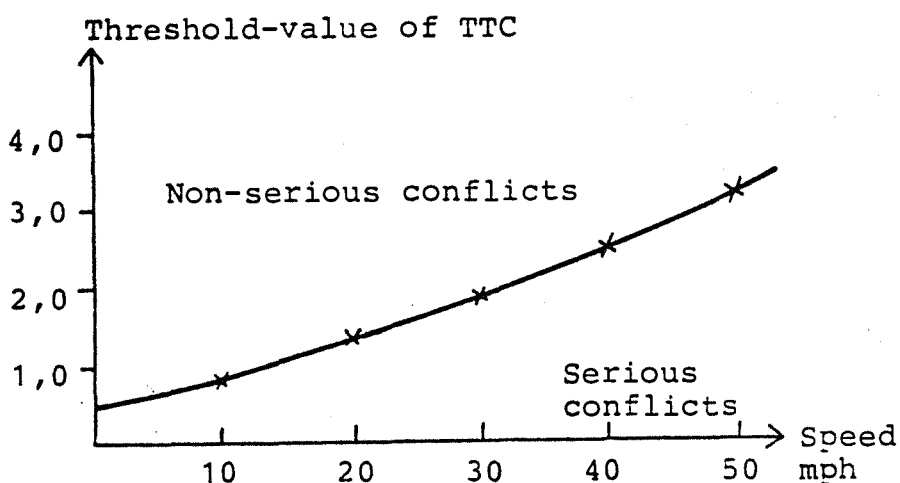


FIGURE 1 A TENTATIVE DEFINITION OF A SERIOUS CONFLICT BASED ON TIME TO COLLISION AND THE ACTUAL SPEED OF ROAD-USERS INVOLVED

During the years 1980 to 1983 a 0,7 million kronor (US \$ 130 000) project is carried out sponsored by state funds. This project aims at finding the most relevant definition of a serious conflict. The definition mentioned above is one that is going to be tested. When the optimal definition has been chosen the technique will be validated. To be able to test as many definitions as possible the conflicts are recorded with extended information in comparison to what the final recording-procedure probably will include.





## TRAFFIC CONFLICT STUDIES IN FINLAND

R. Kulmala

Technical Research Centre of Finland VTT/TIE/AUR, Espoo, Finland

### 1. THE EVALUATION OF TRAFFIC SAFETY WITH THE TRAFFIC CONFLICT METHOD

#### Accidents vs. conflicts

Usually traffic safety has been measured either by the number or the risk of traffic accidents. In many cases this evaluation based on traffic accidents has not been sufficient.

Traffic accidents are very rare and random events. Because of this reliable conclusions about the effects of different safety measures and devices can be drawn only after a sufficiently large material has been gathered. This usually means a wait of 3 to 10 years after the implementation of the studied measure if the measure was applied on just a few locations. In addition, many, if not most, accidents are not even reported to accident statistics. This causes systematic errors and bias in the statistics, which can result in false conclusions about the effects of the studied devices.

Because of the rareness and randomness of accidents researchers should study traffic situations, which are a) sufficiently close to accidents to describe traffic safety in a valid way and b) statistically frequent enough events. This is portrayed in Fig 1.

The most suitable traffic situation for research purposes can be found at the maximum of the product between severity and frequency  $p \times n$ . Conflict situations are presumably very close to such optimal situations. It is often reasonable to classify conflict situations according to their seriousness (see Fig. 2).

#### Conflict risks

Conflict and accidents are, as seen before, closely related. This is why it can be assumed that the probability for a conflict to

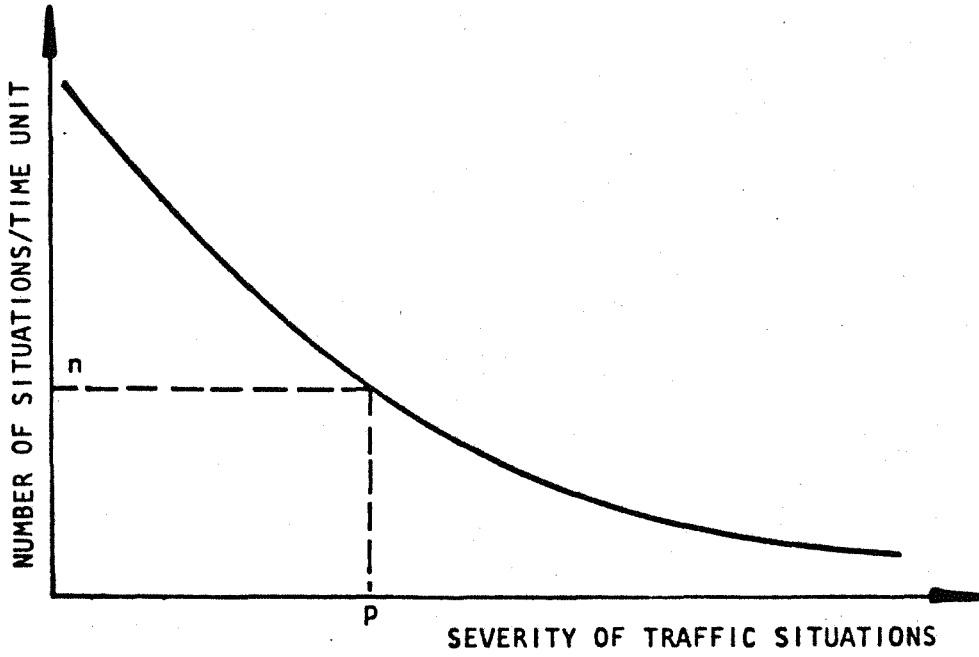


Fig. 1. The frequency of traffic situations in regard to their severity.

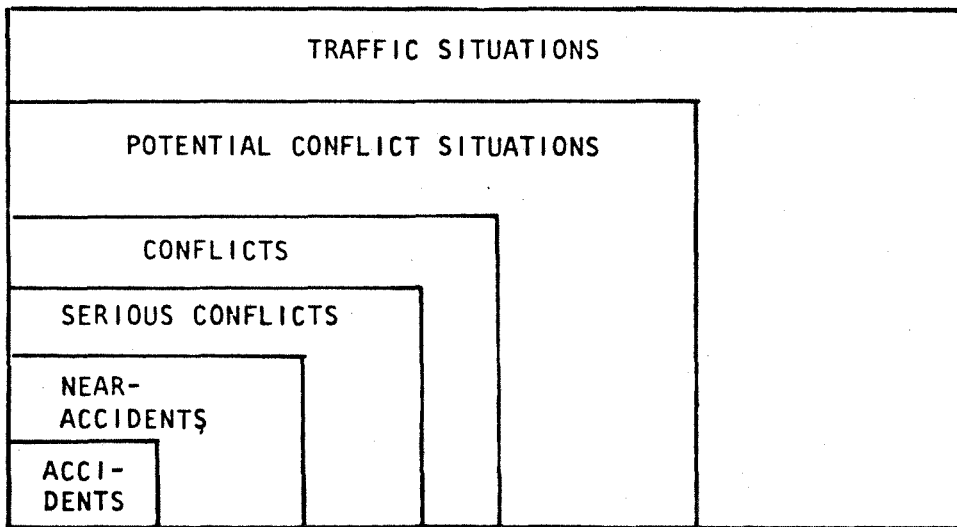


Fig. 2. Traffic situation classification.

result in an accident is approximately constant in regard to road and traffic conditions. In such case traffic safety can be measured with conflict risks instead of accident risks. This can be written:

$$R = \frac{A}{E} = \frac{A}{C} \times \frac{C}{E} \quad ,$$

where A is the number of accidents in time T,  
E is exposure to accidents (or conflicts) of the studied type in time T and  
C is the number of conflicts in time T.

When the accident risk of conflicts  $\left(\frac{A}{C}\right)$  is constant, accident risk is proportional to the conflict risk  $\left(\frac{C}{E}\right)$ . The use of conflict risks  $\left(\frac{C}{E}\right)$  as quantities describing traffic safety is very practical as these risks can be estimated directly by observing traffic on location or by simulation.

## 2. STUDIES BASED ON CONFLICT OBSERVATIONS

### Observations on location

Conflicts (serious and mild) and potential conflict situations are registered by type at the field studies made by the Technical Research Centre of Finland. In addition, traffic flows are registered to determine conflict exposure.

Situations, where braking or weaving begins 1,5 sec or less before a potential collision, are defined to be conflicts. The definition is based on the experiences gained in Sweden /1/. If braking or weaving is uncontrolled the conflict is defined serious. Potential conflict situations are situations, where the participants adjust their speeds well enough before the potential collision. All participants don't, however, behave in a way required and the situation nearly ends up in a conflict. Traffic violations are also classified as potential conflicts.

At the field studies the observers take such positions, where they can observe traffic at the studied location without disturbing

drivers and pedestrians. Video equipment is usually situated on a roof, bridge or a balcony nearby. In this way people moving on the road very seldom notice the video camera and the camera view isn't obstructed. Sometimes the camera has to be installed on a roof of a van. Traffic radar has also been used at some field studies.

The reliability of the observers is quite good. Only about 15 % of all observations are in error /3/. Still, all observations are checked at laboratory from the video tape afterwards.

### Applications

The conflict method is especially suitable when the effects of safety devices and measures are to be investigated quickly. Conflict studies must only be made before the implementation of the device and a couple of months after it. The effects of the device can then be estimated as the observed changes in conflict risks. These changes can be tested i.e. by  $\chi^2$ -test /3/. In all, a conflict study may last 6 to 8 months from planning to reporting. Same amount of data could well require 5 years just waiting for sufficiently large accident material.

The method has also been used in studying "black spots" and junctions. In addition to conflict risks and frequencies the Technical Research Centre of Finland usually reports the results with the help of conflict charts, such as in Fig 3.

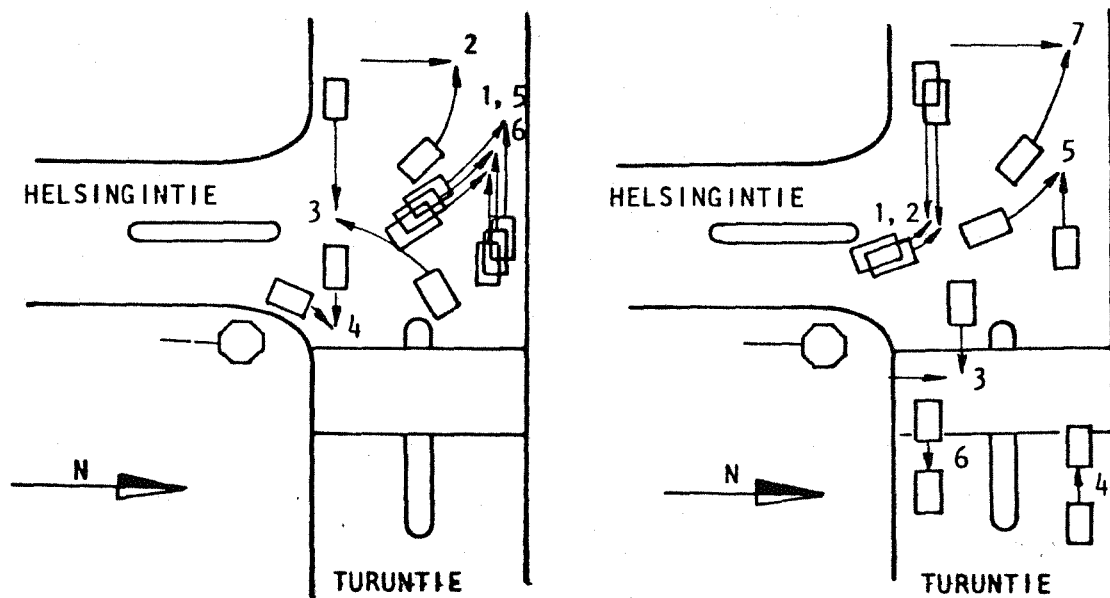


Fig. 3. Conflict chart.

Next some applications are presented, where the conflict method was used in evaluating the effects of road safety measures and devices.

The effects of pedestrian refuges was studied in Helsinki /3/. Pedestrian conflict and potential conflict situation risks before and after the building of refuges are presented in Fig. 4. The exposure E was for all studied pedestrian crossings the square root of the product between pedestrian and vehicle flows.

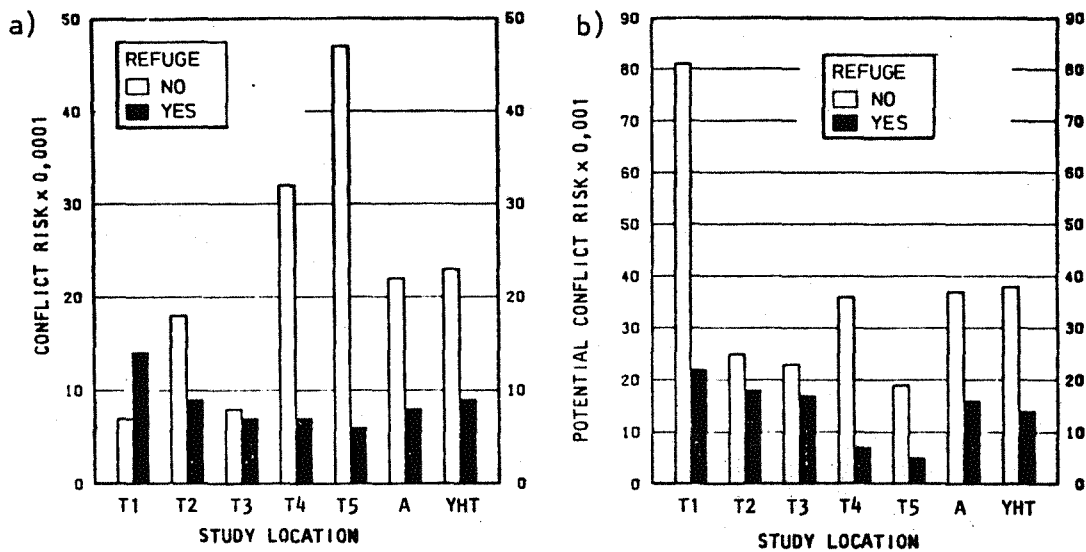


Fig. 4. Pedestrian conflict risks (a) and potential conflict situation risks (b) at different pedestrian crossings (T1-T5,A), and in total (YHT) before and after the building of pedestrian refuges.

The risks for conflicts and potential conflict situations between pedestrians and vehicles were about 60 % lower at the after-studies than at the before-studies on an average. The decrease was statistically significant.

Another study dealt with the effects of different pedestrian crossing arrangements on pedestrian safety /4/. Research material consisted of police reported traffic accidents from 6 years at 16 crossings and 6 hours' conflict observations at 13 of the 16 crossings. Some results are presented in table 1.

Table 1. The risk differences (%) between pedestrian crossing groups that differ from each other in only one crossing arrangement (refuge/junction/signal control).

Differing arrangement	Compared crossing groups	Risk difference between crossing groups (%)			
		All accidents	Non-alcohol accidents	Conflicts	Potential conflicts
Refuge (R)	- R	-30 (-)	+7 (-)	-9 (-)	-77 (xxx)
	JS - RJS	+111 (-)	+180 (-)	+332 (-)	+532 (xxx)
Junction (J)	RS - RJS	+6 (-)	-7 (-)	-28 (-)	-2 (-)
Signal control (S)	R - RS	-57 (xx)	-53 (-)	+20 (-)	-66 (xxx)
	RJ - RJS	-30 (-)	-22 (-)	-49 (-)	-75 (xxx)

The significance of the risk difference:

- (-) when the difference is not significant,
- (x) when the difference is significant at the 0,05 significance level
- (xx) when the difference is significant at the 0,01 significance level
- (xxx) when the difference is significant at the 0,001 significance level.

The method has also been applied to highways outside built-up areas. On study dealt with the effects of acceleration lanes on traffic flows at grade-separated intersections on a four-lane divided highway /2/. The study material was obtained at four intersections so that the total observation time was 22 hours. The exposure measure was the square root of the product between vehicle flows entering from the ramp and driving on the right-side lane. Only 4 conflicts were observed during the after-studies, when the number of conflicts during the before-studies was 14. The conflict and potential conflict risks were significantly lower after the building of acceleration lanes than before. The decrease took place at the three busiest intersections and mainly when the pavement was slippery.

In another study the effects of the replacement of crawling lanes by overtaking lanes were investigated /5/. The exposure used was the vehicle flow in the studied direction. The results are presented in Fig 5.

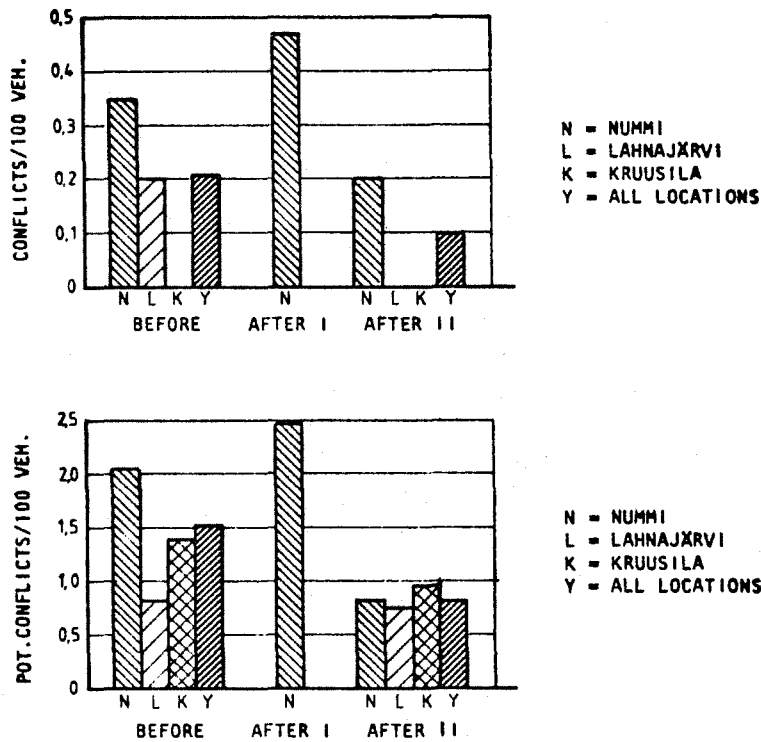


Fig. 5. The risks of conflicts and potential conflict situations before and after the lane change at different study locations.

The risks were lower three months after the change (After II-phase) but not significantly due to too short observation period (12 hours during before and after phases). As an experiment observations were made at one location, Nummi, just two weeks after the change (After I-phase). The risks were at these studies significantly higher than three months after the change. This was probably due to drivers' unfamiliarity with the new regulation or insufficient information in mass media.

A major conflict study is going on concerning the effects of the total change in Finnish traffic legislation. The safety effects of different pedestrian-bicycle-way characteristics and arrangements is also under study.



### 3. CONFLICT SIMULATION

The development of a model for simulating traffic conflicts began at the Technical Research Centre of Finland in 1973. The model was first completed in 1974, but it has been improved continuously.

The input information needed by the model consists of the geometry of the road environment i.e. a map of a junction, the amount of traffic (the number of pedestrians or vehicles in different flows), the speed distribution of different vehicle flows and the phasing scheme of the possible signal control.

The model generates vehicle into the system according to the input information. The moving of the vehicles is based on six different movement rules. Another factor affecting vehicle movements is the behaviour of the driver, which is described in mathematical functions derived in behavioural studies abroad. Because most conflicts are due to some shortage in the ability of the driver to observe everything going on in the traffic system a number of random variables has been used to describe the observation ability. The occurrence on a conflict and also the severity of the conflict are judged by braking decelerations.

The output of the model consists of the number of conflicts in the time given classified by the severity and the type of the conflict in different parts of the road environment studied. The model also gives the types of the vehicles in conflict situations and the platoon length maximums in the in-coming lanes of the junctions and some variables describing the fuel consumption in the road network studied. In addition, the function of the model can be visualised on a graphic terminal.

The validation of the model after the recent improvements and changes is to be carried out in 1982. Even before these improvements the simulated conflicts correlated highly significantly with the observed accidents and conflicts at the locations tested.

The simulation model can be used both for one junction and also for a part of network. The only practical restriction in the road network size is the capacity of the used computer.

The model is especially useful in evaluating the effects of safety improvement measures and devices already in the planning stage, even for completely new road projects.

#### 4. CONCLUSIONS

The advantages of the traffic conflict method can be summed up as follows:

- effects of safety measures can be evaluated quickly,
- good reliability especially when used with video,
- visual demonstrations of the observed conflicts and potential conflict situations on video tape (or charts) can easily be made and are also interesting and useful for traffic planners and decision makers,
- conflict simulation enables effect evaluation of safety measures even in the planning phase,
- measurements on location give also lots of information about traffic conditions in addition to safety aspects.

The disadvantages are as follows:

- conflict observers must be effectively trained in order to gain sufficient reliability,
- studies with video tend to have larger costs than conventional statistical studies, but the amount of additional information and the savings in accident costs due to shorter research periods compensate well for this disadvantage,
- the connection between conflicts and accidents is not known for all accident types or road environments,
- the connection and the ratio between conflicts and accident varies for different accident types and the reasons behind this variation are not yet known,
- the validity of the conflict simulation model isn't sufficiently thoroughly tested.

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RECENT WORK IN CANADA ON THE DEVELOPMENT OF TRAFFIC CONFLICTS TECHNIQUES

J. Lawson  
Transport Canada, Ottawa, Canada

The Road Safety Branch of Transport Canada undertook studies in 1977/78 which developed the concept of "Post-Encroachment Time" as a measurement of traffic conflicts(1). Work was undertaken then in 1978/79 to validate the technique at seven signallized intersections, reported in (2). Correlations found between PET's and accidents were not very encouraging, though the frequencies of the events were too low for very confident assessments. Furthermore, restricting the study to signallized intersections meant that certain types of conflicts could not be analysed using the PET measure. Another small study was therefore undertaken in 1980/81 to apply the methods to unsignallized urban intersections. That study is reported in (3), but has not previously been reported to ICTCT.

The study was of five unsignallized intersections in Ottawa. A team of four observers examined traffic at each intersection for eight hours in one day, during the periods 7 a.m. - 10 a.m.; 11 a.m. - 1 p.m.; and 3 p.m. - 6 p.m. The teams recorded PET's and "critical encroachments" (generally abrupt stops which make "post-encroachment time" inappropriate as a measure of conflict), for six conflict types: left-turn; right-turn; crossing; weaving; rear-end; and left-turn-cross-traffic.

Conflict measurements were then compared to the accident history of the intersections over the previous six years. The intersections had between them experienced a total of 231 accidents during that period. Analysis of correlations between conflicts of each type and accidents of the same type gave the following main results:

- (i) for "weave" conflicts, some high positive correlations were found, but numbers of relevant accidents were very small;
- (ii) for "left-turn-cross-traffic" conflicts, some high positive correlations were also found, but the numbers of relevant accidents were again very small;
- (iii) for "rear-end" conflicts, no meaningful positive correlations were found, despite relatively large numbers of relevant accidents.
- (iv) for "opposed left-turn" conflicts, high positive and statistically-significant correlations were found;
- (v) for "crossing" conflicts the perverse result of negative correlations was found.

Also in general it was found that correlations were maximised when the criterion for a conflict was a PET of  $\leq 2$  secs.

### Conclusions to date

Based on the work described above and the previous studies of PET, the Department does not have much confidence that PET would prove to be a useful tool, either for diagnosis of accident problems or evaluation of countermeasures. Further application of the PET measurement techniques to larger samples of locations would be required to verify this; but the Department does not at present intend to pursue them. The Department has not found there to be any concrete interest amongst the traffic engineering community in Canada in developing and using the techniques. It appears that formal measurement and analysis of conflicts is still not used at all in Canada.

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THE FRENCH TRAFFIC CONFLICT TECHNIQUE: A STATE OF THE ART REPORT

N. Muhlrad

National Organisation for Road Safety (ONSER), Arcueil, France

BRIEF DESCRIPTION OF THE TECHNIQUE AND SUMMARY OF THE WORK DONE BEFORE  
THE LAST ICTCT MEETING (Paris, May 1979).

Work on a traffic conflict technique was undertaken at ONSER in 1973, with the primary aim to provide an instrument for measuring danger suitable for evaluation studies in urban areas. Possible use of conflict data in safety diagnoses on hazardous locations was also tested.

The ONSER conflict technique has been termed a "subjective" one as data is collected directly by a team of field-observers, trained to detect conflicts and assess their severity according to a five-point scale. A conflict is defined as "a situation where the interaction of several road-users (or of a vehicle and the environment) would result in a collision unless at least one of those involved takes evasive action". The severity scale is linked to an appreciation of the suddenness and strength of the evasive action and of the proximity of an actual collision (injury-producing or not) after this action has been performed. Successfully avoided collisions are rated as light, medium or serious conflicts (1 to 3), while the last two points on the scale describe observed accidents, producing either damage (4) or injury (5).

Severity of conflicts, as rated by the observers, is not directly linked to possible casualties. A risk-matrix was therefore established, based on severity values and on complementary data also collected by the observers, such as speed-level, type of road-users involved, angle of the would-be collision. By application of this matrix, a risk-value assumed to be proportional to the probability of an injury-accident occurring in similar conditions, is attributed to each conflict. The total risk on a given location is then obtained by summing these individual values for all the conflicts recorded during a standard time-period (17 hours between 7 a.m. and midnight).

A training manual for observers was issued in 1977. A proper training

period, including indoor teaching, guided observations and group-discussions was shown to lead to a satisfying level of reliability. However, it was suspected that observers tend to "wear out" and should not therefore be kept on the job for too long. Also it was thought that video-films showing conflicts would improve training, even though this kind of tool is not actually used for data-collection.

Validity of the technique was checked on fourteen intersections in 1976-1977 and again on six new locations in 1978, after some modifications to the risk-matrix (mainly, the replacement of "angle of the would-be collision" by "type of manoeuvres performed by the road-users" at the beginning of the conflict-process). The risk-matrix was shown to greatly improve the correspondance between conflict and accident data, but a clear relation between conflicts and injury-accidents could not be quite established. It was assumed that this relation was different according to various types of road-junctions, and that a risk-matrix should be calibrated on a wider sample of locations - or several matrices produced for different groups of situations.

Informative value of conflicts in safety diagnoses was checked on six accident black-spots. The conclusion was that analysis of the police accident-reports, when possible, was best suited to detect precise accident factors, but that conflicts were a valuable complement for planning countermeasures as they are indicative of various traffic malfunctions, including minor collisions. However, conflicts appeared to be the most useful in short-term before-and-after studies on given locations, provided (for validity requirements) that the countermeasure to evaluate didn't alter too radically the local road lay-out or traffic pattern.

The French traffic conflict technique team took part in the first international calibration study, held in Rouen in April 1979. Comparison with data collected through different techniques was very valuable for subsequent work.

NEW DEVELOPMENTS IN THE FRENCH TECHNIQUE.

The results of the validation and calibration studies led us to modify our technique in several respects :

1- The observers.

The Rouen experiment confirmed our suspicions that observers do "wear out" and no longer collect sufficient data after they have been performing the task for some time (several years for the ONSER team). Also the use of two teams of two observers on each location investigated, designed to ensure that successively occurring conflicts could all be recorded, proved in fact a cause for lack of attention, each team relying too much on the other.

It was therefore decided that new observers would be trained regularly according to the need for conflict data, and that only a team of two would be responsible for the data collection on each location. In order to make the recording of each conflict easier and faster, the original data-sheet was simplified and the variables which were the most difficult to appreciate (speeds of the road-users involved for instance) weren't noted any more. Maximum emphasis was placed on the type of conflict according to the manoeuvres performed (turning movement, right-angle course and so on).

2- The length of the data collection period.

One of our former conclusions being that conflicts should be used mostly in short-term evaluation studies, there was a need to provide a technique which could be used easily and at relatively low cost by the local authorities. The highest cost factor being the length of data collection, we investigated the possibility of reducing it without further reducing the validity of the technique.

Influence of the day of the week and the hour of the day was analysed. While no significant difference in risk-data appeared between weekdays (Monday to Friday), important variations appeared between hours: conflicts were, in general, more frequent between 2 p.m. and 7.30 p.m. (54 % of the data was recorded during 32 % of the seventeen-hour observation period) ; they were particularly frequent during evening peak-hour (5.30 to 7.30 p.m.), but showed then a low risk-level ; on the contrary, risk-values were parti-



cularly high between 7.30 p.m. and midnight, but conflicts were fairly rare during that time.

These general results, obtained from a sample of 28 road-junctions where over a thousand conflicts were recorded, are not in themselves surprising ; however, they show important variations when each particular location is considered, and so does accident-data : on some black-spots, danger is the highest at peak-hour, while on some others it is during the low-traffic parts of day or night that the accidents occur. As a consequence, the validity of the conflict technique, measured as a relation between risk calculated from conflicts and numbers of accidents over a period of 18 months (all hours included) became lower when the data collection period was reduced from 17 hours to 5 1/2 (from 2 p.m to 7.30 p.m.).

It is therefore better, in general, to stick to the long period of observation. However, when a particular before-and-after evaluation study is undertaken, it may be possible to shorten data-collection by taking into account the local accident characteristics : a balance must be struck between a good representation of the accident hours and the total numbers of conflicts collected (afternoon and evening peak-hour). When conflict-data is used as a complement to accident-data for designing countermeasures, it is then the number and most frequent types of conflicts that are the most important factors, and there is no objection to reducing the period of observation to our 5 1/2 hours.

### 3-The risk-matrix.

Our risk-matrix was fairly complex and required the use of a computer-program as soon as any significant numbers of conflicts had to be treated. Again with the aim of making the technique easier to manipulate by non-researchers, we found that it was necessary to simplify risk-calculation in a way that would not affect validity too much. Other arguments pointed towards a change :

- the assumption that the relationship between conflicts and accidents varied according to the type of junction required the introduction of some junction characteristics in the matrix.
- the Rouen experiment showed that nearly all conflicts recorded by the ONSER technique were considered as "serious" by other teams, even when they were rated as "light" or "medium" by our observers. There didn't seem to be a real need for keeping our three-point scale in risk-calculation, and it

could be, in fact, a welcome improvement to leave it out, as some observers apparently found it difficult to distinguish between severity levels 1 and 2.

The new risk-matrix is now based on three variables : the type of conflict according to the manoeuvres performed by the road-users involved, the type of road users, and whether the junction investigated is light - controlled or not. The coefficients have been simplified to make it possible to calculate individual risk values on the spot, and the conflict-situations that corresponded to a very low probability of injury-accidents have been attributed zero as risk-value.

Calculated from data on 11 locations, the correlation between risk-values obtained with the new matrix and the old one reaches 0.91. Validity with respect to injury-accidents appears unchanged. The new matrix is definitely more practicable than the old one.

It is to be noted that all conflicts keep being recorded, even those that show a zero risk-value. Comprehensive conflict-diagrams remain necessary, for evaluation studies (for instance, to detect the appearance of a new problem) as much as for safety diagnoses (to detect minor problems and malfunctions of the traffic system). This is an important point if conflict techniques are to remain an analytic tool as well as a quantitative one.

FURTHER USE OF THE CONFLICT TECHNIQUE

Our simplified technique was used for research purpose in a study carried out in Orléans in 1980 ; the aim of this study was to provide new instruments to help local authorities design countermeasures, and to find out whether "subjective safety" could be of any use in this respect.

Interviews were carried out at residents' homes and a sample of 11 urban junctions was selected, including both "objectively" dangerous locations and others that were only felt as such by road-users. Accident-data was collected over a two year period, conflicts were recorded on all eleven junctions, and road-users were interviewed in the street. Although the numbers of accidents were low, we were able to draw a few tentative conclusions :

- it is past accident-data that seems to give the best prediction of future accidents...
- the subjective feeling of safety of the road-users appears linked with conflicts themselves rather than with risk : light conflicts which are very frequent are more noticed and felt more important than serious conflicts or accidents. A possible assumption is that light conflicts are related to damage-only collisions, but this couldn't be verified for lack of data.
- frequency and severity of conflicts do not seem to have any direct connection with intensity of traffic-flows and occurrence of traffic-jams.

Apart from this particular piece of research, conflicts were quite left aside in France in the last two years. The main reason for it seems to be a general lack of interest for evaluation studies, which is mostly due to the French administrative system : local authorities had, so far, a small budget and little power of decision, and, in order to get countermeasures partly financed by the State, were required to make an a priori assessment of their effects ; this didn't of course encourage a subsequent evaluation of real effects once the money had been used...

We can only hope that this situation will change in the near future and that experimental safety action will become possible, which will make conflicts an indispensable monitoring tool.

Risk-matrix for a non-controlled intersection

	V L	P L	2 R	P	Total
11 →→	1	1	2		
12 →→					
13 →→					
14 →→					
15 →←	3	3	6		
16 →↑	3	3	6		
21 →→					
22 ↑					
23 ↑	2	2	4		
24 ↑←	3	3	6		
31 ↑←					
32 ↑					
33 ↑	2	2	4		
34 ↑	3	3	6		
35 ↑	3	3	6		
36 ↑					
37 ↑←					
41 ↑←					
42 ↑←					
43 ↑←					
44 ↑←					
45 ↑←					
51 →↓				1	
52 ↑↓					
53 ↓				2	
54 →					
61 à 69 others					
Total					

Risk-matrix for a light-controlled intersection

	V L	P L	2 R	P	Total
11 →→	5	5	10		
12 ↘↘					
13 ↘↘					
14 ↘↘					
15 →→	5	5	10		
16 ↘↘	5	5	10		
21 →→					
22 ↓	1	1	2		
23 ↓	1	1	2		
24 ↘↘	5	5	10		
31 ↘↘					
32 ↘↘	1	1	2		
33 ↘↘	1	1	2		
34 ↘↘	5	5	10		
35 ↘↘	5	5	10		
36 ↘↘					
37 ↘↘					
41 ↘↘					
42 ↘↘					
43 ↘↘					
44 ↘↘					
45 ↘↘					
51 ↓	1			1	
52 ↓					
53 ↓	2			2	
54 →→					
61 à 69 others					
Total					

## STATISTICAL TOOLS FOR THE CALIBRATION OF TRAFFIC CONFLICTS TECHNIQUES

S. Oppe

Institute for Road Safety Research SWOV, Leidschendam, The Netherlands

### 1. INTRODUCTION

Just before the Second International Workshop on Traffic Conflicts Techniques, held in Paris, May 1979, an international experiment took place in Rouen. The purpose of this experiment was to compare the results of various conflict techniques from different countries. This experiment showed that, in general, from each technique the same conclusions were reached with regard to the problems of safety at two intersections in Rouen. However, it was not always clear how the observations led to these conclusions. From the discussions at the Workshop in Paris and extended discussions that took place afterwards, it was concluded that an international calibration study would be very informative. This calibration study should be concerned with a detailed comparison of conflict scores. From such a detailed comparison conclusions can be drawn about the extent to which different techniques lead to different results. In order to improve existing techniques, a comparison of one's own results with the results of other techniques is of value for each conflict technique. Furthermore, it is important to know the similarities and dissimilarities of techniques in order to evaluate validation studies of other techniques and the consequences of these validation studies for one's own results.

Efforts are made to realise such a calibration study.

This note describes a data-analysis technique that, in the author's opinion, is an efficient tool for the analysis of the data that will be collected in such an experiment. An example will be given from which it is clear that the analysis, which is in fact much more general and not restricted to the narrow context of the calibration experiment, will give all the relevant information in this case.

### 2. GENERAL DESCRIPTION OF DATA AND ANALYSIS

We will not give here a detailed description of the planning of a calibration study, but comment only on the fundamental structure of the data and the analysis of this data that should result from such an experiment. Essentially, the problem is to measure the same objects (conflict situations) with different measurement techniques (conflict observation teams). Each team has to decide whether or not a number of traffic situations are conflicts, and if so, how serious these conflicts are. Each team may use its own scale to measure this seriousness (e.g. a three-point scale or a five-point scale, or even a continuous scale). Cues that are used by different teams, in order to evaluate the seriousness of a conflict, may differ from team to team.

A further complication is the lack of an objective norm for the seriousness of conflicts such as there is in e.g. experiments concerning the estimation of velocities.

Furthermore, in almost all cases where techniques are used in practical situations, the classification system is more or less subjective and depends on judgements of observers. Here it is assumed that all teams measure the seriousness of conflict situations.

Technically speaking each of m teams measures each of n objects (some values may be missing). This results in a m times n matrix of scores. We want to investigate to what extent it is possible to scale all n conflicts on one dimension and at the same time to rescale the response classes of each team on the same dimension such that maximum homogeneity is reached between the scores for different teams. This "common" dimension will be interpreted as the severity dimension of conflicts. The rescaling of the response classes for each team makes it possible to compare categories of different techniques with regard to the seriousness of conflict observations. If the data will not be described sufficiently by this one-dimensional representation, then a two-dimensional description may tell us whether or not severity is judged in a more complicated way.

As mentioned before, a score results from this analysis for each conflict. As a second step one can relate these scores to various cues of the conflicts to find out which cues (that are used explicitly or implicitly) are relevant and/or redundant. This last step is not necessary to calibrate techniques. However, it will be useful to explain agreement and disagreement about the scores of different teams. We can think of cues such as traffic volume, type of vehicles involved, velocities, decelerations, manoeuvres, time to collision, post-encroachment time etc.

### 3. THE ANALYTICAL TECHNIQUES

#### 3.1. Introduction

As has been described before, the analysis consists of two steps. First it will be investigated to what extent conflict measurement of teams can be compared to each other with regard to the severity of conflicts. The technique that is proposed for this step is a principal components analysis for classified data. The computer programme is called HOMALS (homogeneity analysis by means of an alternating least-squares solution). The analysis results in severity scores for all situations that are investigated and rescaled values for the severity classes of each team on the same dimension. The second analysis relates the severity scores to objective measures of the situation that will be based on the data collected by means of video recording and other registration techniques. In this case multiple regression techniques seem to be useful. If classified data are related to the severity scores or if we want to relate the objective measures directly to the classified conflict data of the teams, then the use of CANALS is proposed. CANALS is a computer programme in which canonical regression analysis (and multiple regression as a special case) is generalised to classified data in the same way as HOMALS is a generalisation of principal components.

#### HOMALS and CANALS

Technically speaking, HOMALS is a principal components analysis for classified data. If one applies principal components analysis directly to classified data, one violates the condition that all variables must be measured on an interval scale. To solve this scaling problem one uses the fact that this condition is always satisfied for binary data: any rescaling of two classes into other ones is possible by a linear transformation. If we use classes of characteristics as if these are themselves characteristics and rescore the objects on these new "characteristics" with one if they are and zero if they are not in that class of the prior characteristic, then a new data matrix results with

only one's and zero's containing the same information. E.g. if 25 objects are classified according to two characteristics having 3 and 4 classes respectively, then the previous 25x2 data matrix can be rewritten in a 25x(3+4) matrix of one's and zero's. This matrix is singular: the scores in the last class of each characteristic can be deduced from those of the previous classes. Therefore from this matrix a 25x5 matrix of binary scores can be derived that contains all the relevant information. The principal components analysis applied to this matrix results in the intended solution. The weights for the classes can be regarded as scaling factors.

Therefore, HOMALS may also be regarded as a multi-dimensional scaling technique.

This generalisation can also be applied to the problem of canonical regression analysis.

CANALS delivers such a solution for the canonical analysis of classified data. HOMALS is a technique that is related to "Analyse des correspondences", a similar kind of technique developed in France by Benzécri (1973).

A detailed description of these kinds of data-analysis techniques can be found in De Leeuw (1979) and Gifi (1981).

### Example

In order to demonstrate the use of HOMALS we applied this technique to data from an investigation of Güttinger (1980). He trained observers to use his conflict technique. Ten observers were asked to score 27 traffic situations on a four point scale. During the training they got knowledge of results in order to improve their scoring procedure.

We analysed one of the resulting matrices of scores. The data are taken from Güttinger (1980, Bijlage 12a). The analysis is given in Appendix 1. We assumed that the observers scored the objects in the same way and on one simple dimension.

The discrimination measure (a measure of squared correlation, between the object scores and the rescaled scores for each observer) is highest for observer 5 ( $dm = .983$ ) and lowest for observer 9 ( $dm = .793$ ).

From this analysis we conclude that the agreement between observers is rather high. The eigen value  $\lambda$ , the mean discrimination measure representing the degree of homogeneity between observers, is equal to .89. A more-dimensional solution did not add information to this one-dimensional description.

The object scores of the 27 situations with regard to the solution show that situation 4 and 18 are the conflicts which are the least severe and situation 9, 13 and 15 those that are the most severe. The category scores for each variable show the rescaling for each observer such that the agreement with the common solution is maximal.

A plot of the object scores together with the category scores of observer 5 and 9 is given in Figure 1. The original scores for observer 5 and 9 are also included.

From this plot we see that the scores of observer 5 are in complete agreement with the ordering derived from the solution. The categories of observer 9 (especially the categories 2 and 3) show inconsistencies with this order.

From this analysis we conclude that all observers agree to a large extent. Furthermore, special scoring problems of observers, such as observer 9, also become clear from this analysis.

As a second step we could have related the observation scores to characteristics of the traffic situations in order to investigate with CANALS why the response behaviour of observer 9 differs from the other observers.



observation nr	4,18 2,11 14 20 24,25	6,12,26,27 3 8	17	19 5	22	1	12 7,21 10,16 9,13,15
observation scores	22112	411	1	11	1	1	12 2 3
cat. scores for subject 5	1	2		3			4
cat. scores for subject 9	1	2	3				4
original scores for subject 5	1,1 1,1 1,1 1,1	2,2,2,2 2 2	2	3 3	3	4	4 4,4 4,4
original scores for subject 9	1,1 1,1 1,1 3,3	3,2,3,2 3	3	3 3	1	4	4 4,3 4,4 4,4,4

Figure 1. Plot of the 27 traffic situations from Güttinger (1980) on one conflict dimension together with the scoring of observer 5 and 9.

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\*  
\* VARIABLES  
\*

	*	1	2	3	4	5	6	7	8	9	10
OBJECTS	*****										
1 *	4	4	4	3	4	4	4	4	3	3	3
2 *	1	1	1	1	1	1	1	1	1	1	2
3 *	2	3	3	2	2	2	2	2	2	2	2
4 *	1	1	1	1	1	1	1	1	1	1	1
5 *	3	3	3	3	3	2	3	3	3	3	3
6 *	2	2	2	3	2	2	2	2	2	2	2
7 *	4	4	3	4	4	4	4	3	4	4	4
8 *	3	2	3	2	2	2	2	2	2	3	2
9 *	4	4	4	4	4	4	4	4	4	4	4
10 *	4	4	4	4	4	4	4	4	3	4	4
11 *	1	1	1	1	1	1	1	1	1	1	2
12 *	2	3	3	2	2	1	2	2	2	3	2
13 *	4	4	4	4	4	4	4	4	4	4	4
14 *	1	2	1	1	1	1	1	2	1	1	1
15 *	4	4	4	4	4	4	4	4	4	4	4
16 *	4	4	4	4	4	4	4	4	3	4	4
17 *	2	3	3	2	2	3	2	2	2	3	3
18 *	1	1	1	1	1	1	1	1	1	1	1
19 *	3	3	3	3	3	3	3	2	3	3	3
20 *	1	1	1	1	1	1	2	1	1	1	2
21 *	4	4	4	4	4	4	4	4	4	3	4
22 *	4	1	2	4	3	3	4	4	3	4	4
23 *	4	4	3	4	4	4	4	3	3	4	4
24 *	2	1	1	1	1	1	1	1	1	3	1
25 *	2	1	1	1	1	1	1	1	1	3	1
26 *	2	1	2	1	2	4	1	2	2	3	2
27 *	2	3	2	2	2	2	2	2	2	2	2

MARGINAL FREQUENCIES:

\*  
\* CATEGORIES  
\*

	*	MISSING	1	2	3	4
VARIABLES	*****					
1 *	0	6	8	3	10	
2 *	0	9	3	6	9	
3 *	0	8	4	8	7	
4 *	0	9	5	4	9	
5 *	0	8	7	3	9	
6 *	0	8	6	3	10	
7 *	0	8	8	3	8	
8 *	0	8	7	7	5	
9 *	0	6	3	10	8	
10 *	0	5	9	4	9	

DIMENSION	EIGENVALUE
1	0.8933

DISCRIMINATION MEASURES PER VARIABLE PER DIMENSION

```

*
* DIMENSION
*
*
*      1
VARIABLES *****
1 *   0.953
2 *   0.842
3 *   0.829
4 *   0.932
5 *   0.983
6 *   0.826
7 *   0.913
8 *   0.940
9 *   0.793
10 *  0.922

```

THE OBJECT SCORES ARE:

```

*
* DIMENSIONS
*
*
*      1
OBJECTS *****
1 *   0.94
2 *  -1.19
3 *  -0.46
4 *  -1.24
5 *   0.20
6 *  -0.47
7 *   1.21
8 *  -0.40
9 *   1.37
10 *  1.32
11 *  -1.19
12 *  -0.49
13 *   1.37
14 *  -1.15
15 *   1.37
16 *   1.32
17 *  -0.23
18 *  -1.24
19 *   0.13
20 *  -1.13
21 *   1.22
22 *   0.72
23 *  -1.15
24 *  -1.06
25 *  -1.06
26 *  -0.50
27 *  -0.49

```

Category	Category quantifications									
	Observer									
	1	2	3	4	5	6	7	8	9	10
1	-1.19	-0.88	-1.16	-1.09	-1.16	-1.08	-1.08	-1.16	-1.19	-1.15
2	-0.59	-0.68	-0.19	-0.41	-0.43	-0.46	-0.45	-0.43	-0.47	-0.70
3	-0.03	-0.22	0.14	0.20	0.35	0.20	0.85	0.82	-0.13	0.26
4	1.20	1.25	1.27	1.23	1.25	1.08	1.20	1.31	1.23	1.23

## ERHEBUNG VON KONFLIKTEN IM RAHMEN DER ENTWICKLUNG EINER MITFAHRENDEN BEOBACHTUNGSMETHODE

R. Risser

Kuratorium für Verkehrssicherheit, Wien, Austria

Im Rahmen einer Fahrprobe mit 250 Vpn führen wir Konfliktbeobachtungen durch. Der Kontext besteht in einer Fehlerregistrierung. Die Frage ist, inwieweit bestimmte Fehlerarten eines Probanden mit Konflikten Hand in Hand gehen.

Die einfachste Konfliktdefinition wurde dem Registriervorgang lapidar zugrundegelegt :

Ein Verkehrskonflikt ist eine beobachtbare Situation, in der Verkehrsteilnehmer einander zeitlich oder räumlich so nahe kommen, daß eine erhöhte Kollisionsgefahr besteht, wenn sich ihre Annäherung nicht rasch ändert.

Kriterien für die Konfliktregistrierung sind also :

- Nähe der Begegnung relativiert an der Geschwindigkeit des Gesamtvorganges
- Geschwindigkeit des "Rettungs"-Manövers (Verzögerung, Beschleunigung, Richtungswechsel)

Diese Kriterien werden bei uns für eine mitfahrende Beobachtung verwendet.

Die Fixierung von Vorgängen als Konflikte, wobei auch das Adjektiv "rasch" abgegrenzt werden soll, erfolgte hermaneutisch :

Immer dann, wenn der Meinung zweier Beobachter nach ein Konflikt vorlag (mit einem "raschen" Rettungsmanöver) sollte dieser Vorfall als Konflikt festgehalten werden.

Bei einer relativ niedrigen Zahl von Versuchspersonen stellten wir dabei eindrucksmäßig für Konflikte generell eine gute Übereinstimmung fest. Das heißt, gewisse Situationen werden übereinstimmend als Konflikte erlebt. Der Fall, daß eine Person ein Geschehnis als Konflikt beurteilt, eine andere dasselbe Geschehnis aber nicht als solchen einschätzt, kommt unserem Eindruck nach hingegen eher selten vor. Eine Quantifizierung wird erst nach einer größeren Reihe von Versuchsfahrten möglich sein.

Schwieriger erscheint uns allerdings eine genaue Abgrenzung von leichten bis mittleren zu den schweren Konflikten zu finden. Ob es im Rahmen unseres Versuches gelang, aufgrund einer semantischen Unterscheidung eine valide Trennung zwischen leichten und schweren Konflikten zu finden, kann man bisher nicht beurteilen. Die Ergebnisse bisher weisen in die Richtung, daß schwere Konflikte äußerst seltene Ereignisse sind : Bei 27 Fahrten wurden bisher insgesamt nur 2 Konflikte des Stärkegrades 2 registriert; in diesen Fällen allerdings übereinstimmend von je 2 Beobachtern.

Wir erhalten von allen Vpn aber auch die Versicherungsdaten und so werden wir folgendes analysieren :

1. Wie stimmt die Zahl aller registrierten Konflikte einer Person mit ihrer bisherigen Fahrgeschichte überein ?
2. Wie stimmt die Zahl der leichten Konflikte mit ihrer bisherigen Fahrgeschichte überein ?
3. Wie stimmt die Zahl der schweren Konflikte mit ihrer bisherigen Fahrgeschichte überein ?
4. Wie stimmen qualitativ unterschiedliche Konfliktarten mit der bisherigen Fahrgeschichte einer Person überein ?
5. Wie unterscheiden sich diese Werte je nach Beobachter ?

Die genannten qualitativen Unterscheidungen könnten nach der Situation getroffen werden, in der sie erfolgten (Auffahrkonflikt, Spurwechselkonflikt, Wendekonflikt, Abbiegekonflikt mit Kraftfahrzeugen oder Fußgängern bzw. Radfahrern, Kreuzungskonflikte mit Kraftfahrzeugen oder Fußgängern bzw. Radfahrern). Eine andere Möglichkeit wäre, sie nach den vorangehenden Fehlern zu differenzieren - falls sich derartige Zusammenhänge herausstellen sollten (Abstand, Geschwindigkeit, Vorrang, etc.).

Schließlich besteht noch die Absicht, nach Konflikten mit ursächlicher Beteiligung der beobachteten Person und solchen ohne deren ursächliche Beteiligung zu trennen.

2. COMMENTS TO THE DIFFERENT SESSIONS

## COMMENTS TO THE DIFFERENT SESSIONS

### 1 History of ICTCT

The Steering Group that was established at the Paris Workshop in 1979 now has the following members:

Christer Hydén, chairman  
Ezra Hauer  
Joop Kraay, clearing house  
Nicole Muhlrاد, secretary

The activities carried out since 1979 have unfortunately been limited. One main reason for this is that external funding of a joint international calibration study has failed. In 1980 an application was sent to NATO-Scientific Affairs Division in Brussels for a study in Detroit, U.S. The application however, was turned down mainly because til then NATO only sponsored pure research mainly in other disciplins than transportation.

Another application was directed to the ZIF - Centre for Interdisciplinary research - in Bielefeld, GFR, through Professor Erke in Braunschweig. ZIF turned down the application that aimed at field-studies in Braunschweig and in-door sessions at the Centre in Bielefeld.

The clearing-house activities also have been limited because ICTCT-members have not reported any activities. Only att two occasions work has been reported. It has become obvious that the present system has to be modified so that the ICTCT-members become more active in reporting current activities and completed projects.

The secretarial function just recently has been taken over by Nicole Muhlrاد.



2 State-of-the-art reports and presentations

The reports included in the proceedings cover most of the presentations given at the workshop. Some short comments about the use of TCT in the different countries represented at the workshop might be added.

Generally it looked as if the domestic activities at present were a bit low and that external support was needed in order to convince authorities to support further development and actual use of TCT. The international activities was mentioned by some countries as an important catalyst for increased domestic activities.

The presentation showed that a regular use of TCT in safety-evaluation on a local level was only carried out by the U.K. and Sweden.

Doubts about their own definitions used so far were expressed by some countries. Lack of resources and interest for further validation studies was also reported. Again it seems obvious that international comparisons might be of help for individual member countries in identifying optimal definitions and methods for validation studies.

3 The second international joint calibration study, Malmö, Sweden, May 30th to June 13th, 1983

A tentative program was prepared at a Steering Group meeting in Sweden in March, 1982. The enclosed Research program is the final outcome of this program after the discussions that took place at the workshop.

There was a general agreement on the study that was outlined. At the same time it was highly stressed that the further planning of the study had to continue without any disturbances. Sweden (LTH), as the organizing country, announced that financing of their responsibilities was secured domestically.

It was stated at the workshop that each country primarily had to rely on internal funding of their expenses. However, all possible means will be taken to achieve partial or full funding through international or national organisations. The first step in this direction is already taken by an application to NATO-Scientific Affairs Division for funding of a preparatory

meeting that should take place immediately before the study in Sweden. A second application to NATO will also be forwarded, for funds to the second meeting in the autumn of 1983, provided the first application is approved.

Internal funding could at this point already be foreseen for some countries and the funding problem was not looked upon as critical for the whole venture. In order to keep costs down low-cost accomodation will be available during the study.

At the Steering Group meeting, in Sweden, March 1982, a site-inspection was carried through at a number of intersections that might be of interest for the joint study. There was general agreement on the choice of three intersections varying mainly according to intersection control and average vehicle speeds. When choosing the intersections the following criteria were used:

- good mix of road users
- good size of intersections (easy to observe)
- presence of observers should be possible without too much interference
- comparability of signalized and non-signalized intersection according to all other aspects.

The following characterize the three intersections:

1) Non-signalized intersection, right-hand priority, low average speeds.

Appr 17 000 vehicles (ADT) on the main road and 5 000 vehicles (ADT) on the side road.

In the CBD. Rather heavy pedestrian and bicycle volumes.

2) Signalized.

Appr 15 000 vehicles (ADT) on the main road and 4 000 vehicles (ADT) on the side road.

In the CBD. Heavy pedestrian and bicycle volumes. (At the same main road as 1), only 50 metres away).

3) Non-signalized. Give-way priority.

Appr 15 000 vehicles per ADT on the main road and 4 000 vehicles per ADT on the side road.

Semicentral. Rather heavy pedestrian and bicycle volumes.

Further information about the intersections (including sketches) will be distributed in advance of the study.

It was agreed at the workshop that each team that is going to join the studies in Sweden also should prepare a manual of their technique well in advance of the study. These manuals are ment to fulfill two aims:

- a) To join part of a report describing the different techniques involved in the study.
- b) To form the basis for designing of the joint studies.

#### 4 Newsletter

At the meeting there was a general agreement about the need for a continuous exchange of information among the ICTCT-members. The clearing-house activities haven't been sufficient and members have to become more aware of the need for their participation in the information process.

A newsletter, for instance twice a year, makes it possible both to give information regularly about current activities and to remind the ICTCT-members regularly of the need for continuous exchange of information.

It was also expressed at the workshop that a newsletter might be used for extending the circle of people/countries that gets a continuous information about activities in the TCT-area. Different ways of how to extend the circle will be further discussed within the ICTCT-Steering Group.

#### 5 Calendar for future international cooperation

Down below the major activities carried out by ICTCT til the end of 1983 will be listed. The greatest part of the activities deals with the organisation and implementation of the joint study.

- 1) Final invitation to the joint international calibration study in Sweden, May 30 to June 13, 1983 June 1982
- 2) Domestic efforts to get financial support to the study. Mainly autumn 1982
- 3) ICTCT-Steering Group efforts to get external funding of the study. Mainly autumn 1982
- 4) The first ICTCT-newsletter will be distributed Mainly autumn 1982

- 5) Distribution of information of the intersections selected (photos, traffic flow data etc). Before December 1983
- 6) Circulation of a proposed common data sheet for comments. Before February 1983
- 7) Nordic ICTCT-meeting in Finland. January 1983
- 8) A manual for each technique will be prepared by each team that is going to participate in the study, including information about the actual number of observers that is going to be used by each team, and other comments according to the design and organisation of the study. Before February 1983
- 9) Final design and organisation of the study will be decided on at an ICTCT-Steering Group meeting. February 1983
- 10) Distribution of the common data sheet. (For training purposes,) Before April 1983
- 11) Final information about the study will be distributed to participating teams. Before April 1983
- 12) Joint international calibration study in Malmö, Sweden. May 30-June 13 1983
- 13) Data analyses. Summer and autumn 1983
- 14) In-depth analysis of accident-reports from the three intersections selected will independantly be carried out by staff at the Department of Traffic Planning and Engineering in Lund, Sweden, and at the Council for Road Safety Research in Denmark. The results of the analysis will be compared in a second step. Before September 1983
- 15) A one week meeting will be organised to discuss the results of the study and to formalize the findings. A final report will also be prepared. Time and place of the meeting will be decided on later. Autumn 1983

3. JOINT INTERNATIONAL STUDY FOR THE CALIBRATION OF TRAFFIC CONFLICTS

TECHNIQUES

Research project of the International Committee on Traffic Conflicts Techniques

ICTCT

## JOINT INTERNATIONAL STUDY FOR THE CALIBRATION OF TRAFFIC CONFLICTS TECHNIQUES

Research project of the International Committee on Traffic Conflicts Techniques ICTCT

### INTRODUCTION

Safety analyses are generally performed using historical accident data as the basic source of information. However, there are many problems with accident data which sometimes limit its usefulness as the basis for safety analysis. Such problems include:

1. Poor data quality
  - a. Non-reporting of a percentage of accidents that may be high, either because of reporting criteria or because of operational problems.
  - b. Poorly defined information on the accident report form.  
Errors in identifying the precise location of the crash.
  - c. Insufficient information as to the events leading to an accident.
2. Relative infrequent occurrence of injury accidents
  - a. Need for a large period of time to accumulate adequate sample of accidents at a given location.
  - b. Fluctuations in accident experience at a site due to changes in traffic, weather conditions or obvious human errors (speeding or drunk driving).

Because of these problems with accident data, the Traffic Conflicts Technique (TCT) is developed for use as a supplement to accident data. The technique is aimed at providing administrations and research organisations, with an alternative to accident data for identifying safety and operational problems and selecting appropriate improvements.

The Traffic Conflicts Technique (TCT) was originally introduced by Perkins and Harris at General Motors Research Division in U.S.A. It has since then been developed in a number of countries (UK, France, Netherlands, Germany, Sweden, USA). The TCT is based on the assumption that near-accidents and accidents occur as a consequence of the same process, only the outcome is different. The advantage of using the TCT is the higher frequency of near-accidents.

### I. BACKGROUND

#### 1.1. First International Traffic Conflicts Workshop

The increasing international interest in the TCT resulted in the First International Workshop on Traffic Conflicts Techniques in Oslo, September, 1976.

At this workshop there was agreement on the possible aims served by a traffic conflict technique. This was stated as follows:

1. A basis for before and after studies, or, generally speaking, evaluation studies.
2. A tool for safety diagnosis, to help identifying the causes of a dangerous situation and designing the appropriate countermeasures.

The participants of the workshop also agreed on a general definition of a traffic conflict:

"A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged."

The discussions at this workshop established the fact that differences exist in definitions and data collection techniques among the participating countries. Some of these involve definitional elements like evasive action, severity scale, speed, angle of collision, etc., and also methods of data collection (manual, semi-automated, fully automated, etc.).

The participants in the workshop agreed on the need for comparative studies of the different techniques in the same situations. These studies are necessary in order to make a meaningful assessment of the differences and similarities in definitions and working procedures.

## 1.2. Second International Traffic Conflicts Workshop

The Second Workshop, held in Paris, May 1979, was preceded by an international pilot study initiated by the French team from ONSER and the Swedish team from Lund Institute of Technology. Five teams joined the study that was carried out in Rouen, France, March 1979, and included UK, France, Sweden, Germany and USA. The study indicated that there was a large area of overlap in the identification of conflicts by the various countries, and; the different subjective observation techniques seem to some extent to be measuring the same thing. However, there is a need for a larger study enabling more sophisticated statistical examination to be able to draw more precise conclusions.

The papers presented at the Parish workshop and the discussions held during the sessions showed that there have been developments in the use of the technique since the First Workshop was held in Oslo 1976. These developments have included refinements in the techniques used by the individual research groups working in this area. In addition, it was observed that most countries involved in research or use of TCT have made significant progress in its use as measures of operational deficiency in traffic systems but not as measures of safety.

The final discussion at the workshop showed that there was wide agreement that there should be some continuing form of organization if the needs outlined at the workshop were to be met.

It was agreed that the most effective form of organization was:

1. A Steering Group of four people who had a direct interest in some of the topics mentioned at the workshop.
2. A larger group representing the range of international interests in the TCT. The Steering Group could invite individuals from this larger group for assistance on working sessions, or to carry out certain tasks.

The terms of references of the Steering Group should be:

1. Decide objectives, and then plan, design, and execute further international studies on calibration and validation of techniques.
2. Prepare a "State-of-the-Art" report.
3. Organize an efficient research report distribution system and information clearing house.
4. Organize future meetings as necessary, which may consist of full workshops or small meetings on more specialized aspects.

This application is only concerned with the funding of a further joint calibration study.

At Steering Group meetings in Crowthorne, UK, April 1980, and Lund, Sweden, March 1982, a listing of objectives was developed for a calibration study, along with a research plan, as described below.

## II. OBJECTIVES OF THE CALIBRATION STUDY

The calibration study will form the basis for comparisons of safety studies carried out in different countries with different techniques. This is of great importance regarding the possibilities of extending the information on studies dealing with traffic-safety issues of mutual interest for many countries.

The objectives of the proposed calibration study can be stated as follows:

1. To provide, by means of joint field studies, detailed comparisons of similarities and differences between the techniques in incident identification and severity scaling, and compare the prediction of safety and operational problems identified by each technique.

The study must be designed to provide answers to the following questions:

- a. What differences and similarities in severity ratings exist between events as classified by different teams?
  - b. Do conflict data recorded by different techniques differ? If so, to what extent can the differences be explained by type of location, vehicle manoeuvres, road-users' behaviour, etc.
  - c. What modifications of the various techniques are suggested?
2. The second objective is to discuss the outcome of the study and present its implications for validation studies.

This calibration study is the first step towards a better understanding of to what degree different techniques are related to accidents. Further joint studies will be necessary in order to increase this understanding to an acceptable level. Differences which exist today must be made clear and kept under control. Among such differences the following may be mentioned:

- The different theoretical and operational approaches may reflect accidents differently.
- The accident data-base may differ between countries, for instance according to the reporting of accidents.

The result of this international calibration study should be of help in designing the future international validation study, as well as in comparing the results of validations carried out nationally, in order to be able to draw implications for invalidated techniques.

## III. RESEARCH PLAN

The proposed study will include seven basic tasks in order to successfully accomplish the desired objectives. These steps are as follows:

Task A - Introduce and discuss techniques.

Task B - Collect conflict and complementary data and prepare for data analyses.

Task C - Determine the relation between different severity scalings.

Task D - Explanations and discussions of those differences and similarities found.

Task E - Determining locational problems using various conflict techniques.

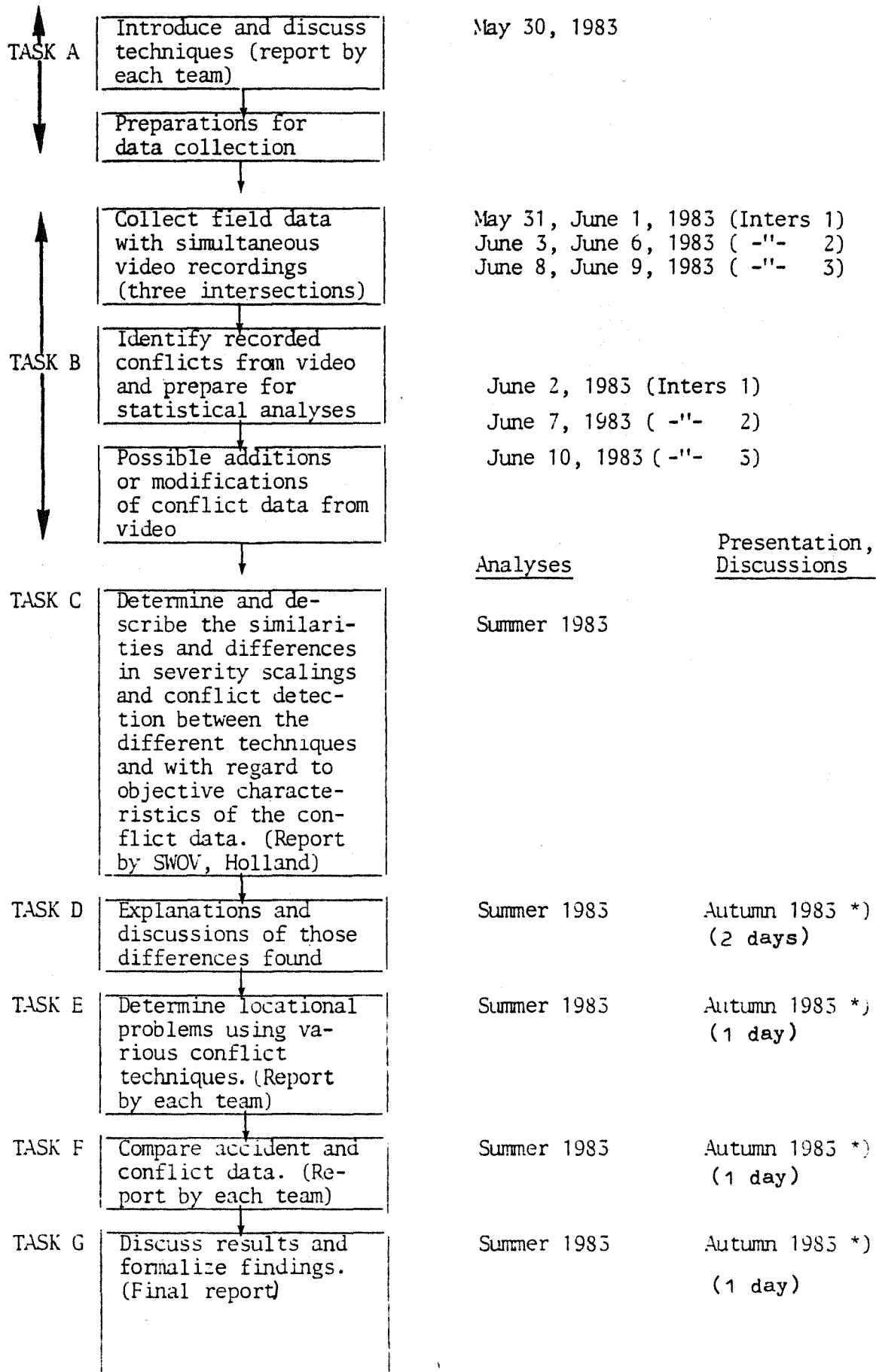
Task F - Compare accident and conflict data with regard to locational problems.

Task G - Discuss results and formalize study findings.

Two weeks will be required to complete the field studies (Task A and B). Discussions of the results will require one week. The following are details of proposed work plan, as illustrated in Figure 1.



FIGURE 1: FLOW CHART OF THE PROPOSED STUDY



\*) A one week meeting will be arranged in the autumn of 1985. Time and place will be decided later on.

Task A - Introduce and discuss techniques

The first half day will involve the introduction of the different techniques represented by teams of experts from the participating countries. It is assumed that preparations will have been made to ensure:

- that documentation of theoretical and operational characteristics of each technique will be provided in advance by all participants,
- that the differences between normal procedures and the procedures actually used in the joint study will be minimized for each technique and properly stated.

The second half of the first day will be used for preparation of the field studies.

Task B - Collect conflict and complementary data and prepare for data analyses

Data will be collected in one city at three locations selected from a list of intersections identified as having typical safety and/or operational problems.

The intersections chosen will include:

1. A non-signalized, low-speed intersection.
2. A non-signalized, high-speed intersection.
3. A signalized intersection.

At all three locations there will be a great mix of different road-user categories, i.e. motor vehicles, bicyclists and pedestrians.

In order to facilitate conflict data comparison, use of a common data sheet has been agreed upon by the teams likely to participate. After the field observations at each intersection to simultaneous video recordings will be viewed by representatives of all teams, in order to identify all conflicts and give each a time-label. On-site observers will not participate in the labelling.

All data collected at the three intersections will be summarized separately by each data collection team using their respective traffic conflict techniques. Other appropriate traffic and infrastructure information will also be collected, for analysis purposes.

Task C - Determine the relation between different severity scalings

The first step in data analysis will be the comparison the scores for all conflicts for the various teams (the scoring is based on the definition of a conflict and severity scaling used by each team).

The analysis will result in a severity ranking of the conflicts and information about the agreement and disagreement of teams with regard to this ranking. Furthermore, it will result in a rescaling of the values for each team to the same scale so that the severity scores of different teams can be compared.

The second step will relate the scores of the conflicts to objective characteristics of the conflicts, measured from video tape, such as traffic-volume data, speeds, conflict types, manoeuvres, in order to describe the similarities and differences of the ways of scoring for various teams.

A report of the findings will be prepared for the second session. This report will include:

1. Description of the study design.
2. Description of an objective evaluation of the conflicts recorded on video. This evaluation will be carried out by the Institute for Perception (TNO), Soesterberg, The Netherlands, with a technique developed there.
3. Description of the data-analysis techniques used and the results of the analyses.

Task D - Explanations and discussions of those differences and similarities found

Based on the data analysis described under Task C two types of conflicts will be selected for detailed discussions:

1. Conflicts recorded by some team(s) but not by others.
  2. Conflicts where the severity scaling differs between different teams.
- The detailed discussions will be based on video-screening of the conflicts and will focus on the elements included by each team to define a conflict and to scale it in a certain way according to severity.

NB. Task E and F are not primary tasks of the joint calibration study. They are intended to give a qualificative indication as to how each technique can be used for safety analysis.

Task E - Determine locational problems using various conflict techniques

The data collected in Task B will be used to determine safety and operational problems at each of the three intersections. Each team will use their respective traffic conflict data along with other traffic data and road layout information to identify the locational problems. Each team will prepare a brief report on each intersection summarizing the specific problems identified.

Task F - Compare accident and conflict data with regard to locational problems

Accident data will be available only after Task E is completed. A summary of information collected on each accident will then be provided to each participating team for comparison of their findings. Accident reports for approximately 3 to 5 years will be analysed. The minimum data requirements will cover the following items:

1. Severity of accidents.
2. Types of road-users involved.
3. Accident types (rear-end, head-on, right-angle, etc.).
4. Time factors (time of the day, day of the week, month, etc.).
5. Weather and road-surface conditions.
6. Other contributing circumstances (drunk driving, vehicle malfunctions, etc.).

Collision diagrams will also be provided to participating teams for each intersection. Comparisons will be made between the accident history of each location and the perceived safety and operational problems, as determined from each conflict technique. The results will be presented in a brief report prepared by each team.

Task G - Discuss results and formalize study findings

This task will involve the discussions of the results from all data collection and analysis activities carried out during the joint study. Conclusions will be drawn in relation to the stated objectives of the study. Related research areas deserving further work will be identified.

At the conclusion of the session, a report will be prepared and submitted to all participants. Copies of the final report will also be sent to any other interested person or agency.

APPENDIX A

Joining teams and observers and the role they play at the two meetings

It is expected that between 5 and 10 teams will take part in the first study (June 1983). Each team will on average consist of 4 persons out of which 2-3 persons per team will carry out the field studies.

It is of great importance that those teams that take part represent the various types of conflict techniques developed according to working definition of a conflict and degree of automation the recording of conflicts. The working definitions should range from subjective to objective ones, and the degree of automation should range from surely manual to automatic recording.

An additional 5 to 10 interested observers are also expected to attend. At the two-week period of field studies these observers primarily will attend the session dealing with introduction and discussion of the different techniques. During the actual field studies there will be opportunities for these observers to study the operational use of the techniques and to discuss techniques with team members.

The one week meeting in autumn 1983 will be attended by approximately 2 members from each team that participated in the first meeting. The 5 to 10 interested observers will also be able to attend this second meeting.

MEMBERS OF THE INTERNATIONAL COMMITTEE ON TRAFFIC CONFLICTS TECHNIQUES ICTCT  
and  
RESEARCH INSTITUTES INVOLVED IN TRAFFIC CONFLICT OBSERVATION STUDIES

MEMBERS OF THE INTERNATIONAL COMMITTEE ON TRAFFIC CONFLICTS TECHNIQUE ICTCT

STEERING COMMITTEE

Christer Hydén (Sweden) as Chairman, with special responsibility for organising future international studies  
Ezra Hauer (Canada) with special responsibility for editing a state of the art report  
Joop H. Kraay (The Netherlands) with special responsibility as bibliographer and for organising a literature clearing house  
A fourth member, as yet unnamed, who could act as a technical secretary and meeting organiser

MEMBERS (in alphabetic order)

ABDULGHENI, KHALED  
Michigan State University  
Civil Engineering Department  
E LANSING, Michigan 48824  
U.S.A.

ALLEN, BRIAN  
McMaster University  
HAMELTON  
Canada

AMUNDSEN, F.  
Institute of Transport Economics (TØI)  
Grenseveien 86  
P.O. Box 6110 Etterstad  
N-OSLO 6  
Norway

BAGULEY, CHRIS  
Transport and Road Research Laboratory  
CROWTHORNE  
Berks RG 11 6AU  
United Kingdom

BAKER, W.T.  
Federal Highway Administration FHWA  
Office of Traffic Operations HTO-31  
400 7th Street, S.W.  
WASHINGTON D.C. 20590  
U.S.A.

BALASHA, D.  
Road Safety Centre  
Technion City  
HAIFA  
Israël

BOGSRUD, N.E.  
Public Roads Administration  
P.O. Box 8109 Oslo Dep.  
OSLO 1  
Norway

BURTCH, TERRY  
Transport Canada  
Road Safety Branch  
Place de Ville  
OTTAWA  
Canada K1A 0N 5

CHRISTENSEN, J.  
Danish Council of Road Safety Research  
Adademivej, Building 371  
DK-2800 LYNGBY  
Denmark

CROWLY, F.  
National Institute for Physical  
Planning and Const. Research  
St. Martin's House  
DUBLIN  
Eire

DARZENTAS, J.  
Royal Holloway College  
EGHAM  
Surrey TW20 OEX  
United Kingdom

DATTA, T.K.  
Goodell-Grivas Inc.  
17320 West Eight Mile Road  
SOUTHFIELD Michigan 48075  
U.S.A.

DOUVIER, A.  
Centre for the Study of Urban Transport  
8, Avenue Aristide Briand  
92220 BAGNEAUX  
France

DUPRE, M.  
Ministry of Transport  
Local Technical Service  
CETE of Rouen  
Chemin de la Poudrière  
76 GRAND QUEVILLY  
France

ENGEL, ULLA  
Danish Council of Road Safety Research  
Academivej, Building 371  
DK-2800 LINGBY  
Denmark

ERKE, H.  
Technische Universität Braunschweig  
Institut für Psychologie  
Spielmannstrasse 19  
3300 BRAUNSCHWEIG  
Germany

GÄRDER, PER  
Lund Institute of Technology (LTH)  
Department of Traffic Planning and  
Engineering  
John Ericsson väg 1  
P.O. Box 725  
S-22007 LUND  
Sweden

GLAUTZ, W.D.  
Midwest Research Institute  
425 Volker Boulevard  
KANSAS CITY, Missouri 64110  
U.S.A.

GSTALTER, H.  
Technische Universität München  
Lehrstuhl für Psychologie  
Lothstrasse 17  
8000 MÜNCHEN 2  
Germany

GÜTTINGER, VIKTOR A.  
Netherlands Institute for Preventive  
Health Care TNO  
Wassenaarseweg 56  
LEIDEN  
The Netherlands

HAKKERT, A.S.  
Road Safety Centre  
Technion City  
HAIFA  
Israël

HAUER, E.  
University of Toronto  
Department of Civil Engineering  
TORONTO  
Canada M5S 1A4

VAN DER HORST, RICHARD  
Institute for Perception TNO  
Kampweg 5  
P.O. Box 23  
3769 ZG SOESTERBERG  
The Netherlands

HUGUENIN, R.D.  
Schweizerische Beratungsstelle für  
Unfallverhütung  
Postfach 2273  
CH-3001 BERN  
Switzerland

HYDEN, CHRISTER  
Lund Institute of Technology (LTH)  
Department of Traffic Planning and  
Engineering  
John Ericsson väg 1  
P.O. Box 725  
S-22007 LUND  
Sweden

KRAAY, JOOP H.  
Institute for Road Safety Research SWOV  
Duindoorn 32  
P.O. Box 170  
2260 AD LEIDSCHENDAM  
The Netherlands

KRITZ, L.B.  
Transport Research Delegation  
Sveavägen 166, 14tr.  
S-11346 STOCKHOLM  
Sweden

KULMALA, RISTO  
VTT/TIE/AUR  
Revontulentie 7  
02100 ESPOO 10  
Finland

LAWSON, J.J.  
Transport Canada  
Road Safety Branch  
Place de Ville  
OTTAWA  
Canada K1A 0N 5

LIGHTBURN, ANGELA  
University of Nottingham  
Department of Psychology  
NOTTINGHAM NG7 2RD  
United Kingdom

LINDERHOLM, LEIF  
Lund Institute of Technology (LTH)  
Department of Traffic Planning and  
Engineering  
John Ericsson väg 1  
P.O. Box 725  
S-22007 LUND  
Sweden

LINDSTRÖM, ULF  
Väg - och Vattenbyggnadsstyrelsen  
P.O. Box 20  
SF-00131 HELSINKI 13  
Finland

LUDVIGSEN, H.S.  
The Road Directorate - The Secretariat  
for Safety Road Improvement  
Skallgårdsvej 2  
DK-4700 NÆSTVED  
Denmark

MALATERRE, G.  
National Organisation for Road Safety  
(ONSER)  
2, Av. du General Malleret-Joinville  
P.O. Box 34  
94114-ARCUEIL-CEDEX  
France

McCARTHY, LAWRENCE  
Federal Highway Administration FHWA  
400 7th Street, S.W.  
WASHINGTON D.C. 20590  
U.S.A.

McDOWELL, M.R.C.  
Royal Holloway College  
EGHAM  
Surrey TW20 OEX  
United Kingdom

MORTELMANS, J.F.C.  
K.U. Leuven  
Dept. of Civil Engineering  
Gelestijnenlaan 200 A  
B-3030 LEUVEN  
Belgium

MUHLRAD, NICOLE  
National Organisation for Road Safety  
(ONSER)  
2, Av. du General Malleret-Joinville  
P.O. Box 34  
94114-ARCUEIL-CEDEX  
France

NILSSON, G.  
National Swedish Road and Traffic  
Research Institute  
Fack  
S-58101 LINKÖPING  
Sweden

OPPE, SIEM  
Institute for Road Safety Research SWOV  
Duindoorn 32  
P.O. Box 170  
2260 AD LEIDSCHENDAM  
The Netherlands

PEDERSEN, T.O.  
Institute of Transport Economics (TØI)  
P.O. Box 6110  
Etterstad  
OSLO 6  
Norway

RISSER, R.  
Kuratorium für Verkehrssicherheit  
Ölzeltgasse 3  
Postfach 190  
A-1031 WIEN III  
Austria

SALUUSJÄRVI, M.  
VTT/TIE/AUR  
Revontulentie 7  
02100 ESPOO 10  
Finland

SCHÜTZENHÖFER, A.  
Kuratorium für Verkehrssicherheit  
Neutorgasse 51  
8010 GRAZ  
Austria

SHAUL, JEAN  
University of Newcastle Upon Tyne  
Department of Civil Engineering  
Claremont Road  
NEWCASTLE UPON TYNE NE1 7RU  
United Kingdom



SPICER, B.  
Transport and Road Research Laboratory  
CROWTHORNE  
Berks RG11 6AU  
United Kingdom

STARR, P.A.  
Royal Holloway College  
EGHAM  
Surrey TW20 OEX  
United Kingdom

THOMSEN, LARS  
Danish Council of Road Safety Research  
Academivej, Building 371  
DK-2800 LINGBY  
Denmark

TRIGGS, T.J.  
Monash University  
Department of Psychology  
CLAYTON  
Victoria  
Australia 3168

WENNEL, J.  
Royal Holloway College  
EGHAM  
Surrey TW20 OEX  
United Kingdom

WILLIAMS, M.J.  
Australian Road Research Board  
600 Burwood Highway  
VERMONT SOUTH  
Victoria  
Australia

ZIMMERMAN, G.  
Bundesanstalt für Strassenwesen (BAST)  
Brühlerstrasse 1  
Postfach 510530  
5000 KÖLN 51  
Germany

ZIMOLONG, B.  
Technische Universität Braunschweig  
Spielmannstrasse 19  
3300 BRAUNSCHWEIG  
Germany

ZUZAN, W.D.  
Kuratorium für Verkehrssicherheit  
Südtirolerplatz 3  
5021 SALZBURG  
Austria

RESEARCH INSTITUTES INVOLVED IN TRAFFIC CONFLICT OBSERVATION STUDIES

(Institutes carrying out research in this field, coordinate activities for institutes having an observation-team)

AUSTRIA

Kuratorium für Verkehrssicherheit  
Ölzeltgasse 3  
Postfach 190  
A-1031 WIEN III

AUSTRALIA

Australian Road Research Board  
600 Burwood Highway  
VERMONT SOUTH (Victoria)

CANADA

Transport Canada  
Road Safety Branch  
Place de Ville  
OTTAWA (Ontario) K1A ON5

FINLAND

VTT/TIE/AUR  
Revontulentie 7  
02100 ESPOO 10

FRANCE

National Organisation for Road Safety  
(ONSER)  
2, Av. du General Malleret-Joinville  
P.O. Box 34  
94114 ARCUEIL-CÉDEX

GERMANY

Technical University Braunschweig  
Institute for Psychology  
Spielmannstrasse 19  
3300 BRAUNSCHWEIG

ISRAËL

Road Safety Centre  
Technion City  
HAIFA

THE NETHERLANDS

Institute for Road Safety Research SWOV  
Duindoorn 32  
P.O. Box 170  
2260 AD LEIDSCHENDAM

Advise  
Nieuwe Uitleg 36  
2514 BR DEN HAAG

Institute for Perception TNO  
Kampweg 5  
P.O. Box 23  
3769 ZG SOESTERBERG

SWEDEN

Lund Institute of Technology (LTH)  
Department of Traffic Planning and  
Engineering  
John Ericsson väg 1  
P.O. Box 725  
S-22007 LUND

UNITED KINGDOM

Transport and Road Safety Research  
Laboratory TRRL  
Department of the Environment  
CROWTHORNE  
(Berks) RG 11 GAU

Royal Holloway College  
EGHAM  
Surrey TW20 OEX

University of Nottingham  
Department of Psychology  
NOTTINGHAM NG7 2RD

U.S.A.

Federal Highway Administration FHWA  
Office of Traffic Organisation HTO-31  
400 7th Street, S.W.  
WASHINGTON D.C. 20590

Midwest Research Institute  
425 Volker Boulevard  
KANSAS CITY (Missouri) 64110