

Manual conflict observation technique DOCTOR

Dutch Objective Conflict Technique for Operation and Research

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Preface

This manual is an English translation by A.R.A. van der Horst of the original manual of the DOCTOR technique by Kraay, Horst & Oppe (1986) in Dutch:

Kraay, J.H., Horst, A.R.A. van der & Oppe, S. (1986). *Handleiding Conflictobservatietechniek DOCTOR (Dutch Objective Conflict Technique for Operation and Research)*. (SWOV-rapport R-86-3). Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV; (Rapport IZF 1986 C-6). Soesterberg: Instituut voor Zintuigfysiologie TNO.

The translated manual has been supplemented by a list of more recent publications and reports on applications of the DOCTOR technique.

The translation has been made for the purpose of a training in Bangladesh. The Dutch foundation Safe Crossings has initiated in 2012 a programme for infrastructural speed reducing measures on national highways in Bangladesh. A pilot project on 3 locations is being implemented in cooperation with national authorities and researchers. The pilot project will be evaluated by the Centre for Injury Prevention and Research Bangladesh CIPRB. Road safety for all has advised CIPRB to use the so called conflict observation technique DOCTOR for the evaluation. At the request of , and in cooperation with Safe Crossing Richard van der Horst has provided in 2013 the CIPRB researchers in Dhaka with a training in this technique.

Road safety for all has decided to publish the English manual for two reasons. Firstly, it is believed that it will be of use for researchers abroad, notably in low and middle income countries. Secondly, in road safety research a renewed interest in traffic conflict techniques has been identified in Europe.

Contents

Contents 4

Part I	Method and application area	6
1	Introduction	7
2	Historical overview	10
3	The Conflict method	13
3.1	The definition of conflict behaviour	13
3.2	The severity dimension of conflicts	17
3.3	The reliability of the method	18
3.4	The validity of a method	20
4	Applications of the conflict method	22
4.1	Introduction	22
4.2	Application opportunities	22
5	International Cooperation	25
5.1	The ICTCT and its coordination task	25
5.2	The Malmö- calibration study	26
5.3	Applications and further developments	28
6	The Dutch situation	30
	References Part I	32
Part II	Training with the DOCTOR-technique	36
7	Introduction	37
8	The behaviour in a conflict situation	38
8.1	Occurrence of a conflict	38
8.2	The solving of a conflict	38
8.3	Instruction tape	39
8.3.1	Collisions	40
8.3.2	Critical situations	41
8.3.3	Detection of critical situations	42
8.3.4	Encounters with and without collision course	42
9	The DOCTOR technique	43
9.1	Concepts	43
9.2	Type of conflicts	45
9.2.1	Car – car conflicts	45
9.2.2	Car – bicyclist conflicts	47
9.2.3	Car – pedestrian conflicts	48
9.2.4	Bicyclist – bicyclist conflicts	48
9.2.5	Bicyclist – pedestrian conflicts	48

9.2.6	Some special aspects.....	49
10	Training.....	50
10.1	Training scheme	50
10.2	Training tape.....	50
10.2.1	Estimating of speeds and evasive actions.....	51
10.2.2	Detection of critical situations	52
10.2.3	Collision course	53
10.3	Observation form	54
10.3.1	Procedure	54
10.3.2	Scoring by means of the observation form	56
10.3.3	Filling out the DOCTOR observation form.....	58
11	Testing of the observers	59
11.1	Selection of observers	59
11.2	Test tape.....	59
12	The field situation	61
12.1	Traffic counts	61
12.2	Observation periods.....	62
12.3	The weather.....	63
12.4	Number of observers	63
12.5	Observation area	65
12.6	Observation position.....	65
12.7	Length of observation period.....	67
12.8	Estimating speeds	71
13	The analysis of the data	73
13.1	General	73
13.2	Analysis of cross tables	73
13.3	Analysis of small numbers of observations	74
13.3.1	Exact tests	74
13.3.2	Monte-Carlo method.....	74
13.3.3	Bootstrap method	74
13.3.4	Higher-order cross-tables	74
13.4	Weighed numbers.....	75
13.5	Comparison between accidents and conflicts	75
13.6	Presentation of observation data.....	75
	References Part II.....	76
	Appendix 1: Set-up of a training week.....	78
	Appendix 2: Overview literature TNO	79
	Appendix 3: Overview literature SWOV	82

Part I Method and application area

1 Introduction

The occurrence of traffic accidents is a symptom of a suboptimal functioning of the traffic system. The road traffic system involves a complex interaction between the psychological and physiological characteristics of road users, and the social and physical properties of the traffic environment. This interaction will result in certain behaviours, and as an ultimate consequence in traffic accidents.

Making a diagnosis is still a difficult task. Therefore, it is recommendable to gain knowledge on traffic behaviour of different types of road users in a number of traffic conditions such as (differences) in time, place, and circumstances.

The knowledge and opinions a road user has about the traffic environment or other road users (in other words: his/her traffic perception) determine behaviour on the road to a large extent.

The traffic perception and resulting behaviour, in general, will be based on a limited knowledge of the actual traffic situation and traffic safety. The experience of an individual person with traffic safety, in most cases, will be based on conflicts or near-accidents as experienced in a limited number of traffic situations.

One can imagine that the so measured traffic perception and the stated resulting traffic behaviour not always matches with the real traffic behaviour. Behavioural studies give more insight in the way different types of road users move in their traffic environment and in the way traffic measures/rules are accepted. To conduct behavioural studies can serve various purposes. A first one is to use behavioural variables for standardisation in accident analyses. A second, more important reason, is that one wants to understand why people behave as they behave in certain circumstances. Finally, when evaluating counter measures, one wants to investigate how a given measure has influenced traffic behaviour into a desired direction. This is under the assumption that a desired behavioural change positively influences traffic safety.

A special case of studying traffic behaviour consists of investigating conflicting behaviour between road users, or in other words of near-accidents or near-misses. In general, it can be stated that for application of the conflict method one looks for those aspects of traffic behaviour of road users mutually or of road users and their traffic environment that are supposed to be relevant for road safety.

In this part of the manual, we will focus extensively on a number of important aspects of the so-called conflict method. Apart from the theoretical background we will give an overview of applications in the Netherlands and elsewhere.

The basic principle of the conflict method is that traffic safety can only be studied seriously if considering it as an integral aspect of the total traffic and transport system. Studying the traffic process itself from a traffic safety point of view can give insight into the failure of this traffic process. The weak links in this total traffic process has to be discovered and not only the weak spots of contributing factors separately. Integrated knowledge can be the basis for an effective application of counter measures. Traffic safety research consists of studying safety critical

situations that result in traffic accidents. Death, severe injury, remaining disability, psychological traumas and damage only in road traffic are the result of un-intended energy transfer between participants and/or structures (Asmussen, 1983). The sole investigation of real accidents does not suffice. A lot of information essential for the occurrence of an accident, cannot be found in the accident statistics. To explain traffic (un)safety, one has to study this phenomenon in all its sub processes. A simple model that can be helpful, is given by Asmussen (1981) and presented in Figure I.1.

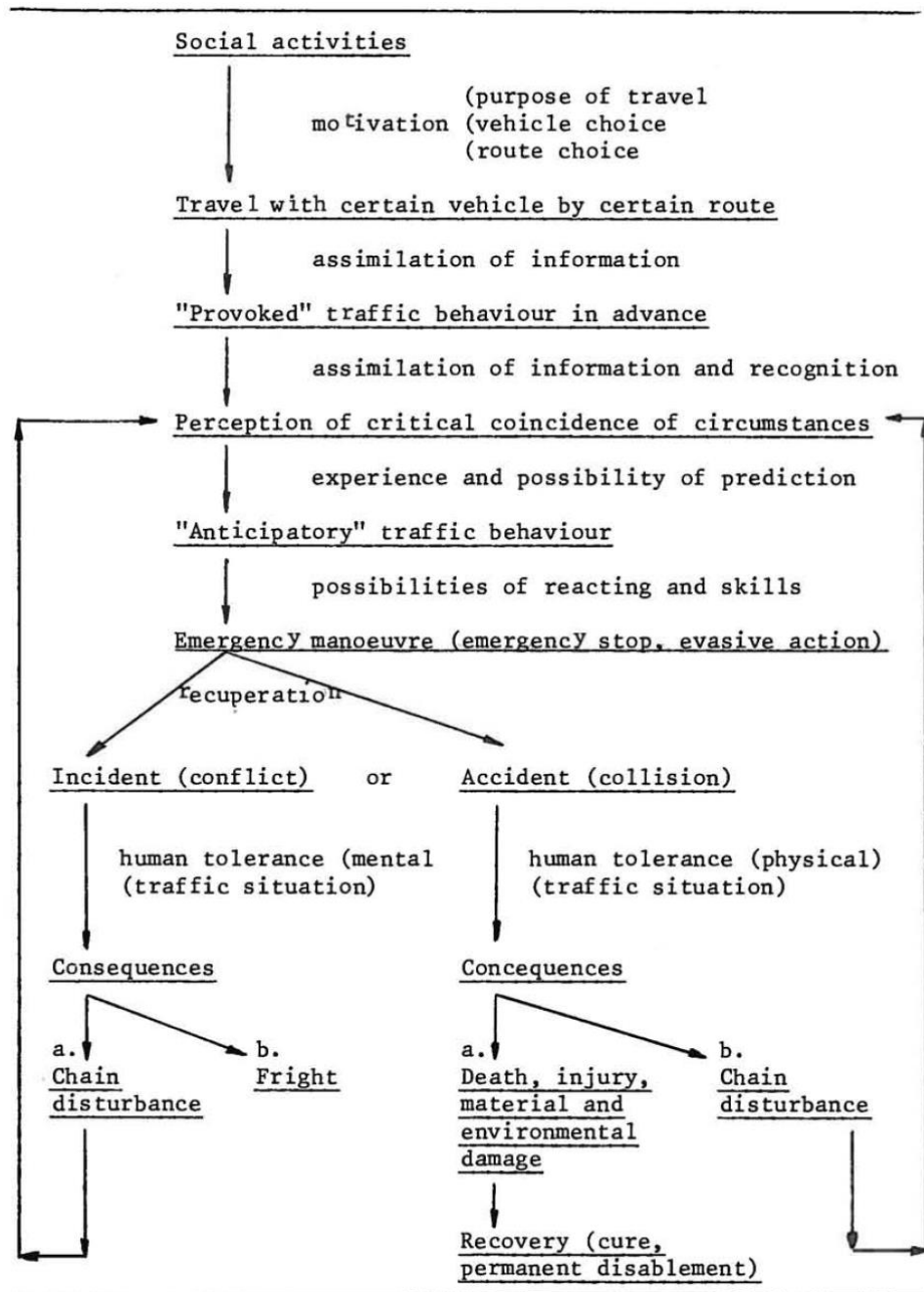


Figure I.1 Model of the accident process (Source: Asmussen & Kranenburg, 1982).

The theories about the intermittent processes can be tested by systematic behavioural observations and conflict observations in particular. Moreover, measures can be compared with each other with respect to their expected effects on the underlying processes. An analysis of the underlying processes also can take place if no statistical relationships are known; this can result in a better understanding of the accident causation process. In this manner a proper traffic safety analysis can be conducted, also in situations without a sufficient number of accidents to conduct a proper statistical analysis.

2 Historical overview

This chapter gives a brief overview of the development of different conflict observation techniques in various countries. Only, the major developments are presented.

Already since 1954 (Mc Farland & Moseley, 1954; Forbes, 1957) traffic observations are conducted for studying conflict behaviour between motor vehicles in safety critical situations. Only since 1966, attempts were made to systematically observe conflict behaviour.

In one of the first studies in this area, Perkins and Harris (1967) distinguished two categories of conflicts: sudden road users' actions to avoid a collision and traffic offences. Sudden evasive actions by road users become apparent by braking or changing lanes. Traffic offences are described as behaviour that is deviant from traffic rules. At intersections, Perkins and Harris investigated five types of conflicts: turning left, changing lanes, crossing traffic and rear-end situations. Because only one year of accident data had been collected, no validation of their conflict technique could be tested. The reliability seemed to be satisfactory.

Campbell and King (1970) made use of the same conflict technique and type of conflicts as Perkins and Harris did and came to similar conclusions. The only difference was that they had collected two years of accident data.

Baker (1972) more carefully evaluated the conflict technique as developed by General Motors Research Laboratories (Perkins & Harris, 1967). He investigated the statistical relationship between accidents and conflicts based upon a field study. The collected data confirm the hypothesis that conflicts and accidents correlate, but that the correlation was not very high. The used conflict technique appeared to be better applicable at intersections with low traffic volumes; according to Baker, this conflict technique can also be applied at other locations than only intersections.

In a study by Spicer (1971) all conflicts were measured, in which a sudden action took place by braking or swerving lanes by one or more vehicles to avoid a collision. This simple definition of a conflict did not significantly correlate with collisions. A next step consisted of a five scale severity score to make a clear distinction between severe and (less severe) slight conflicts, see Figure 1.2. A conflict was defined to happen if a vehicle is braking hard, is making a strong swerving manoeuvre, or is stopping suddenly to avoid a collision, all this in close proximity of another vehicle and no time available for a normal controlled collision-avoiding behaviour. The rank order correlation between collisions and serious conflicts measured by time of day and place on the road appeared to differ significantly from zero. Spicer (1972) confirmed the earlier findings of the 1971 study; moreover, he found a stronger correlation between conflicts and accidents as the traffic volumes increased.

Spicer (1973) repeated the 1971 study by adding another five intersections. Again, a significant relationship was found between conflicts and accidents, including a distinction by manoeuvre and by place on the road. Spicer concludes that his

results justify the use of their conflict technique as a fast method to specify the safety of intersections.

Conflict severity	Class	Definition
Slight	1	Precautionary braking or changing lanes or other anticipatory braking or changing lanes with a low probability of a collision
	2	Controlled braking or changing lanes to avoid a collision with little manoeuvring time
Serious	3	Strong braking, rapid changing lanes or stopping to avoid a collision, resulting in a near-crash (No time left for a controlled manoeuvre)
	4	Emergency braking or strong swerving resulting in a near-crash or slight collision
	5	Emergency action followed by a collision

Figure I.2 Classification of conflicts by severity (according to Older & Spicer, 1976).

Paddock (1974) continued working with the General Motors technique in field studies. The earlier studies indicated that the conflict technique can be a surrogate for accident studies, but also provides insight in the whole accident causation process. He gives an overview of the results of the General Motors conflict studies so far. The main conclusions are:

- The hypothesis that serious conflicts correlate with accidents is confirmed.
- Based upon several studies in different American states, traffic safety problems at intersections can be detected very fast and reliably.
- This technique is especially applicable for low traffic volumes where the accident level is low.
- This technique results in lower costs to provide countermeasures.
- The technique can be applied in situations other than intersections.
- The effects of counter measures can be evaluated rather quickly.

In Sweden, the PLANFOR (1972) group developed and tested a method in a study in Uppsala in 1972. The idea of this method is that the risk of personal injury can be described as the ratio between the number of participants of a traffic flow and the number of participants that is being involved in a serious conflict situation. The risk of personal injury varies with traffic environment, the traffic situation and means of transport. Together, these elements form a conflict class. Conflict classes with specific risks of personal injury have been selected from accident analyses. Within each conflict class, the risk of personal injury varies with the size of the conflict producing traffic flows. A conflict situation was defined as:

- Uncontrolled conflict avoiding behaviour resulting in a situation where the traffic participants pass each other in close proximity or come to a stop;
- Dangerous traffic behaviour resulting in an uncontrolled situation, in which the traffic participants pass each other in very close proximity.

These definitions coincide strongly with the ones by Spicer (1971).

Hayward (1972) does not want to focus on near-accidents because of the subjective elements involved in observation. He proposes to measure the time till the potential collision moment between two vehicles. These times were measured from film recordings. Near-accidents are those situations in which corrections (in

speed and course) have to be made in a short time span to avoid a collision. This “time-to-collision” method works as follows. The method classifies the near-accidents by determining the time that would last till two vehicles would collide if they keep their speed and course. From the analysis of near-accidents, Hayward concluded that a time lower than one second would be a good criterion for near-accidents. A disadvantage of this method maybe the high costs involved as he used continuous video recordings with the relevant events re-recorded on film for analysis.

Erke and Zimolong (1978) continued the work by Perkins and Harris by a study on three high volume signalised intersections in German cities. Different types of conflict behaviour have be determined for both the intersection area and the adjacent areas. In the analysis of the relationships between conflicts and accidents similar traffic situations (manoeuvre, type of road user) have been distinguished with for some traffic situations highly significant correlations between observed conflicts and matching registered accidents.

Malaterre and Muhlrاد (1976), though with a different conflict definition, came to similar conclusions. In their study at eight intersections in urban areas, they found a significant relationship between conflicts and accidents and between conflict type and type of accidents.

A limited number of researchers continued the work by Hayward (1972) on the ‘time-to-collision (TTC)’ technique. Hydén (1975; 1978) focussed on this technique for the development of a model to describe the risk of pedestrians and cyclists in different urban environments under different quantities of motorised traffic. Hydén makes use of trained human observers. Other examples of the ‘time-to-collision’ approach include Hakkert et al. (1977) and Van der Horst (1982). In the encounter process between two road users, Van der Horst objectively determines course, course changes, speed and speed changes, minimum mutual distance, minimum time-to-collision. He does not make use of human observers in the field, but quantitatively analyses video recordings of safety-critical events.

During a number of years, the English Transport and Road Research Laboratory (TRRL) focussed on the automated detection of vehicles with sensors in the road surface and a computer system to identify conflict situations (Older & Shippey, 1977). However, this development was stopped due to severe complications.

Cooper (1977) reports a development in Canada. After extensive analyses of the relationships between conflicts and accidents, he concludes that the “Post-Encroachment-Time (PET)” (defined as the time that the first road user leaves the path of the second and the moment the second road user reaches the path of the first) shows the highest correlation with accidents.

In the late seventies, the development of the conflicts observation techniques took off considerably. The nature of conflict studies starts to diverge (especially, the definitions of a conflict). Moreover, criticism is given on some applications of the method. For an extensive overview, the reader is referred to Williams (1980) and Kraay, 1983).

3 The Conflict method

Practically spoken, a direct observation by researchers of the occurrence of accidents is seldom possible. With that, also the analysis of traffic safety problems is hampered. Often, one will make use of historic accident data: the information of accidents that already have taken place. With the help of accident reconstruction, one tries to come up with an explanation why the accident occurred. A reconstruction is possible to a limited extent, because one can make use of limited, often subjectively collected, information of the accident. An alternate and more promising approach in preventing accidents is the studying of road user behaviour, especially with a focus on behaviour that is assumed to result in danger. The most frequently applied example includes the studying of conflict behaviour. The assumption is that in situations that frequently result in traffic conflicts, also many accidents will occur. The number of conflicts that is assessed is often used as an indicator of the traffic (un)safety. For an analysis of conflict behaviour, however, it is also important, apart from the similarities between traffic accidents and conflicts, to look at the differences. When does a conflict result in a collision, when is a collision inevitable? In other words, which behavioural aspects determine the severity of a conflict in particular circumstances? The conflict is not regarded as an unsafety indicator, but as an analysis unit for a safety analysis that results in an explanation of unsafety. Which behaviour results in which conflicts and what is the probability of an accident given that specific conflict type? If it is possible to answer these questions, then the conflict method may serve as a surrogate approach for accident research. But before that, a number of issues have to be addressed.

3.1 The definition of conflict behaviour

Conflict behaviour is a form of risky traffic behaviour. One speaks of risky behaviour or traffic risk when such traffic behaviour occurs in a situation that may result in negative consequences, especially when it includes injury. In traffic risk, the choice of a road user of several behavioural alternatives in relationship with the behaviour of other road users is crucial. What is the chance that specific behaviour will result in an unwanted chain of events with ultimately personal or material damage. How, in these events, do conscious or unconscious choices come about? Risk control supports the control of this choice behaviour. The various behavioural forms that appear in practice, can be studied together with the behaviour of other road users to identify which behavioural interactions result in the occurrence of fatal events. For those combinations of traffic behaviour one could speak of a conflict. The larger the probability of an accident, the more severe and thus more dangerous the conflict will be. For such a study, a first question then is which situations, which behavioural combinations have to be taken in consideration, in other words what is a conflict; a second question is how the severity of a conflict can be determined.

When defining a conflict, one may have different aims. One aim may be to approximately trace the 'universe of discourse', to specify which types of behaviours one aims for. However, it is more interesting if one tries to give an operational definition. Then, it is about defining the connotation of the notion of a conflict as is the case with an approximate definition. An operational definition is the rule how conflicts can be distinguished from non-conflicts.

During the first international symposium on the use of traffic conflict techniques in Oslo, a conflict was defined as:

“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”.

This definition not only intends to provide a general delimitation of the notion conflict, but also tries to give an operational definition. In fact, already in one of the first traffic conflict studies, viz. the General Motors research by Perkins and Harris, in which one tried to specify the unsafety on the road by the number of conflicts, one made use of such a broad definition of a conflict. Their definition is unambiguous and therefore easy to apply for conflicts between passenger cars. In practice, however, in applying the traffic conflict method in different situations, often a different definition is used. The following aspects play a role:

- A study often relates to one aspect of the unsafety. It deals with the safety of children, pedestrians, slow traffic, intersections, severe accidents, etc. Only, the most relevant types of conflict behaviour, are taken into account.
- The observation method plays a role. For subjective methods, dealing with observations in the most literal meaning, we find terms as ‘suddenly’ en ‘avoiding’. For these, a judgement of behaviour is needed. Objective methods make use of notions such as ‘Time-To-Collision’ (TTC) and ‘Post-Encroachment Time’ (PET), the time that is left till a collision if no action is taken, and the time that is left when two road users are passing each other, respectively. These notions require more or less the use of registration equipment.
- A distinction is made in the relevance of conflict behaviour. One speaks of severe and less severe conflicts in the sense that the probability of a collision is higher for conflict ‘x’ than for conflict ‘y’. In general, the severity dimension is less specified. The more or less suddenness of conflict behaviour or a shorter or longer TTC is, for example, the starting point. In a French study, a number of aspects are taken into account, of which some qualitatively determining the severity.

If the conflict analysis is regarded as a systematic study of risky, interactive traffic behaviour, then the relevant question is which aspects of this interacting behaviour in which situations result in danger. The essence of the usability of the method is not in predicting accidents, as often has been stated, but in the detection of unsafe situations. Because of the statistically rare occurrence of accidents, the prediction of the number of accidents often is not realistic. It is about estimating the probability of an accident and indicating which forms of established conflict behaviour contribute to an increase in the probability of accidents and their severity. Therefore, there is no fundamental difference between general traffic safety research and conflict analysis when it comes to a confirmation of a theory about risky traffic behaviour.

A conflict analysis technique is not only valuable if it correctly predicts the number of accidents, but especially if it convincingly indicates which forms of interacting traffic behaviour increase unsafety. Convincing implies that the analysis that is performed, is based upon a well-established theory, a theory of which the correctness has been proven. The value of the analysis of the safety should not be

limited to validity research for predicting the number of accidents, but more specifically focus on the verification of the severity contributed to certain forms of conflict behaviour based upon a traffic safety theory. The key of this latter use of the conflict method is the relationship between the severity of conflict behaviour and the amount of related unsafety (the possible consequences of this conflict behaviour). The definition of the severity of a conflict plays a key role in which an explanation of unsafety in terms of conflict behaviour has to be enclosed. The explanatory model I is schematically presented in Figure I.3.

Conflict behaviour type	Frequency of occurrence in traffic	Probability of accident by event	Expected number of specific accidents	Total number of accidents
$\begin{pmatrix} C_1 \\ C_2 \\ \cdot \\ \cdot \\ \cdot \\ C_n \end{pmatrix} \begin{matrix} \longrightarrow \\ \longrightarrow \\ \cdot \\ \cdot \\ \cdot \\ \longrightarrow \end{matrix} \begin{pmatrix} f_1 \\ f_2 \\ \cdot \\ \cdot \\ \cdot \\ f_n \end{pmatrix}$	$\times \begin{pmatrix} p_1 \\ p_2 \\ \cdot \\ \cdot \\ \cdot \\ p_n \end{pmatrix}$	$= \begin{pmatrix} A_1 \\ A_2 \\ \cdot \\ \cdot \\ \cdot \\ A_n \end{pmatrix}$	$\Rightarrow \sum_{i=1}^n f_i p_i = \sum_{i=1}^n A_i = A$	

Figure I.3 Relationship between specific types of accidents and conflicts, varying in type, number and severity (Model I).

In a given observation period, conflicts are being recorded. A distinction can be made in the frequency of occurrence (f_i) of the different types of conflicts one wants to distinguish. For each conflict type C_i the probability p_i of an accident is assumed to be known. The product of f and p results in the expected number of accidents of a given type by time unit. The summation of the expected number of accidents results in an estimate of the total number of expected accidents, which is the accident probability. P represents the severity of certain conflict behaviour, f the frequency of occurrence. For clarity, a closer description of C has not been given yet. This variable, in the light of the earlier presented risk concept, can be specified in more detail in terms of individual traffic behaviour. Furthermore, we did not include the weight that can be attributed to each accident based upon the consequences of that accident for all persons involved. If not the accident probability, but the accident risk is chosen as an indicator for the severity of conflicts, then a weighing factor for the consequences has to be added. If the conflict method is used as a detection method for determining the locations with a high accident risk, then one is only interested in a good prediction of A . If the method specifically will be used for analysing safety problems, then the distribution of f is important. If one assumes that all forms of interacting behaviour are included in C and not only conflict behaviour, then the analysis problem can be described as determining the amount of occurrence of desired and undesired behaviour, eventually detecting unacceptable ratios between those, and indicating of directions for solutions of the signalled safety problems in terms of desired changes in the distribution of f . As the severity of a given conflict type is higher, a high frequency of occurrence will be regarded as less acceptable.

In the application of the conflict method, usually no distinction in conflict severity is made. Only a distinction between conflict and non-conflict behaviour is made. For distinguishing both categories, often a given severity value is used. The dichotomy results in a simplification of the model together with a related loss of information. This model (Model II) is given in Figure I.4.

$$\begin{array}{l}
 \left(\begin{array}{c} C_1 \\ \cdot \\ \cdot \\ C_m \end{array} \right) \rightarrow (CF) \quad \sum_{i=1}^m f_i p_{cf} = A_{cf} \\
 \\
 \left(\begin{array}{c} C_{m+1} \\ \cdot \\ \cdot \\ C_n \end{array} \right) \rightarrow (\bar{CF}) \quad \sum_{i=m+1}^n f_i p_{\bar{cf}} = A_{\bar{cf}} \\
 \\
 \text{and } A = A_{cf} + A_{\bar{cf}}
 \end{array}$$

Figure I.4 Binary classification of traffic behaviour in conflicts (CF) and non-conflicts (\bar{CF}) (Model II).

A special case occurs if one defines a conflict in such a manner that $p_{\bar{cf}}$ equals zero ('without a conflict no accident'). For an estimate of A , the non-conflicts can be discarded, and all information about A is included in the number of conflicts and the probability of an accident given that conflict. An estimate of p_{cf} can be found from the ration between the number of accidents and conflicts. This thought formed the basis for the Oslo definition of a conflict. In fact, exposure has become an important factor in establishing the amount of unsafety. Not the severity of conflicts is decisive, but the number of conflicts.

With this approach, two problems arise:

- a) Is a dichotomy between CF and \bar{CF} with $p_{\bar{cf}} = 0$, really optimal?
- b) Which loss in information is the results from summing the Cs?

Both problems directly result from the reduction of Model I to Model II. In the above mentioned special case, in which each form of interacting behaviour that may result in an accident, is regarded as conflict behaviour, countermeasures have to result only in riskless behaviour. Regarding problem a) it is perhaps more realistic to turn high-risk behaviour into behaviour with a low risk. Or, in other words, to consider countermeasures that specifically reduce the number of severe conflict situations. In the TRRL technique, one tries to tackle this, by choosing the threshold value such that exposure becomes less important and the risk-increasing factors more important. One also only works with severe conflicts. Regarding problem b) one may question whether it is necessary to apply such a drastic reduction in information by only using a binary classification system with no weighing the severity within a category that one considers as relevant.

3.2 The severity dimension of conflicts

If the severity of conflicts is used as weighing factor for determining the weighted sum of conflicts, then we return to the model of type I. If the severity is proportional to the probability of an accident, the estimated number of accidents is determined except for a constant factor. In such a case, it is not necessary to adjust the definition of a conflict every time. For a specifically chosen goal (for example, pedestrian safety research), a different weighing of the determinants of a conflict can be necessary. In fact, this implies that only conflicts that are considered as relevant, get a weight larger than zero. The size of the weight determines the severity contributed to a relevant type of conflict behaviour.

If the severity of a conflict also is taken into account, then the problem of operationalizing of a conflict technique focusses on determining the determinants of a conflict and the agree in which the conflict results in danger. This implies that insight is needed into the relationship between the interacting traffic behaviour and the degree of generating danger. Here we are back to the main aim of the conflict analysis: to give an explanation of unsafety in terms of traffic behaviour: which (combinations of) traffic behaviours result in danger and need to be avoided? Conflict observation techniques then become real analysis techniques. Countermeasures will be focussed on excluding or limiting serious conflict behaviour and replacing it by safe behaviour. In-depth studies that indicate what is to be considered as serious conflict behaviour and what underlying factors contribute, are still rather rare. In most of the applications, it is not the intention to use the conflict observation technique as an analysis technique, but only to get a good impression of the unsafety of a given location in absolute terms, or relative to other locations. But also, then the severity dimension is important. We will give an example.

Consider for two locations the frequency distribution of the conflicts by their severity and situation as given in Figure I.5. In terms of Model I as discussed previously, the x-axis represents Cs ordered according to an high or a low p-value. Suppose that a given form of interacting behaviour C is regarded as a conflict if it is positioned at the right side of the point 'conflict' and as a serious conflict if it is positioned right of 'serious conflict', etc. Furthermore, suppose that the surface below the curve right of 'conflict' is considered as the number of conflicts, etc. then it is clear that the established relative safety of location 2 relative to location 1 depends on the choice of conflict definition. With the help of conflicts we predict more accidents for location 2, with serious conflicts more or less equal number of accidents, whereas at location 1 more accidents occur. From Figure I.5. it can be deducted that one tries to predict the surface of the small right tail of the distribution with the help of large parts of the total distribution. As such this is a delicate undertaking. At least more information about the shape of the distribution is needed.

How important the issues about the predicting value of a conflict technique may be, much more important is the potential the traffic conflict approach offers to get a better insight in the traffic safety problems at a specific location. Careful systematic observation of risky traffic behaviour may give more insight in the various factors that result in unsafe situations. Not only the identification of safety problems is

important, but also the identification of the causes to come up with effective counter measures. Many measures are based on implicit theories. The conflict methodology can be used to test these implicit assumptions. Especially, the conflict technique may be an excellent tool to analyse traffic safety problems and the evaluation of counter measures taken. For this, however, research into the usability of the method should focus on those aspects of conflicting behaviour that are dangerous. It is not so much about the validity of the technique, the predictive value in relation to the number of accidents, but more about 'construct validity', the factors that determine whether conflict behaviour is dangerous or not. The predictive validity is a derivative of this. Improvement of the construct validity will automatically result in improvement of the predictive validity.

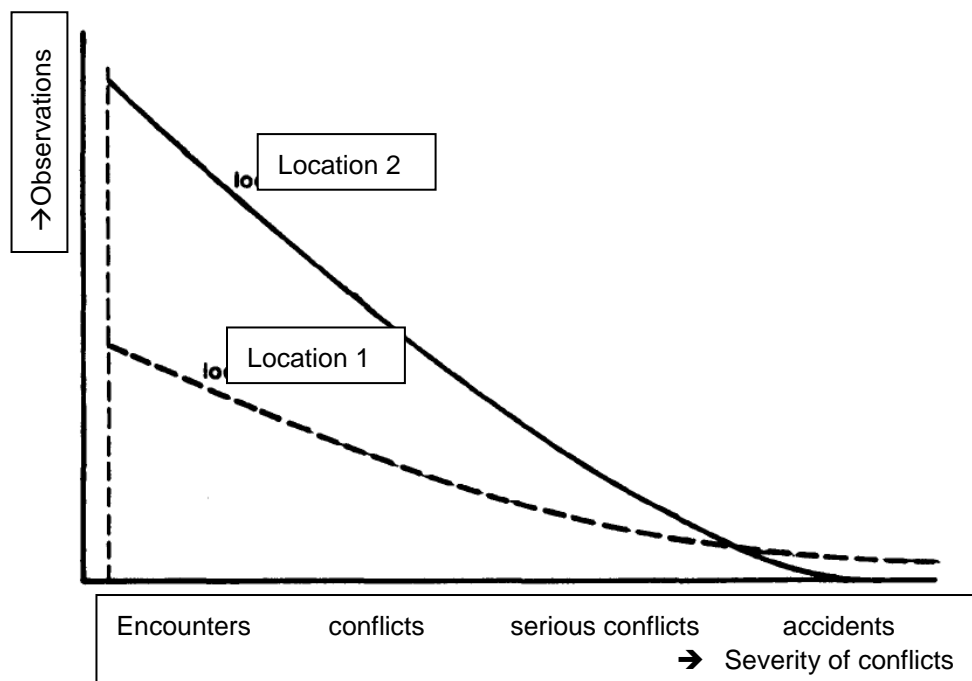


Fig. I.5 Frequency distribution of conflicts and accidents for two locations.

If the conflict method is regarded as a method of the systematic observing of risky behaviour, as part of a traffic safety theory in which the traffic process is central and not the unwanted resulting event of an accident, then it will be an excellent tool for controlling safety problems.

3.3 The reliability of the method

Most conflict observation techniques are often still rather strongly subjective in the scoring of conflicts, especially with respect to the severity of a conflict. As an example, an conflict observation technique can be mentioned for which observers have to estimate the time from the moment a vehicle is starting an evasive action till the moment of a theoretical collision if the evasive manoeuvre would not have occurred; if the estimated time is less than 1.5 seconds, then a conflict is scored (Hydén, 1976), see Fig. I.6.

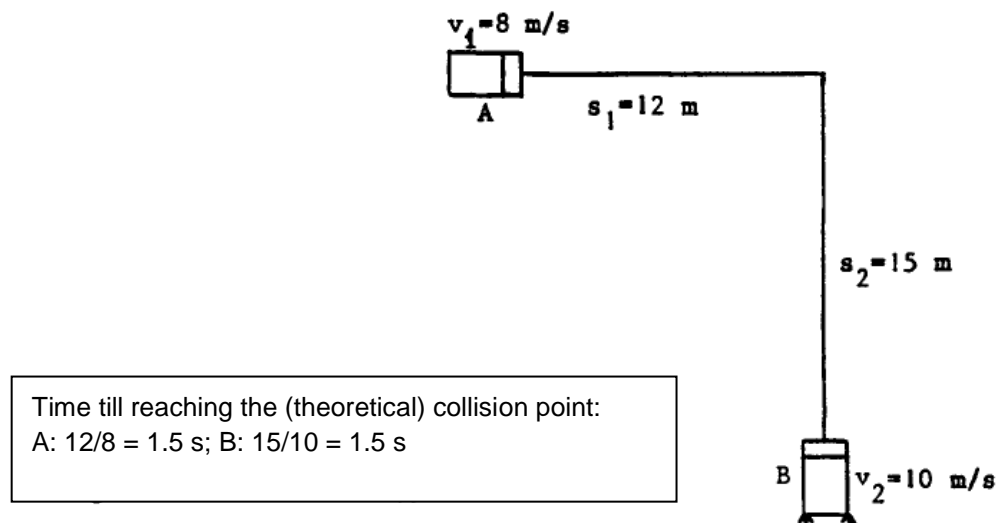


Fig. I.6 Time needed to reach the theoretical collision point, from the moment that one of the road users involved starts reacting by braking or swerving (Hydén, 1976).

The various conflict observation techniques can be ordered as follows:

- On-site observations at locations, such as intersections, with the help of video equipment as objective measuring tool. Observations can also be conducted by observers.
- Area-wide observations in areas, such as residential areas, with the help of observers that follow persons on their route through an area. If one wants to get an overview of conflicts in an area, then video often is not possible or practical.

By practical limitations to apply large-scale objective measuring techniques, human observers sometimes have to be accepted. The subjectivity of the approach with observers can be reduced by a careful selection and training, both with the help of video recordings and on-site situations. In some countries, manuals for training the observers are available.

In spite of the subjectivity involved in the scoring of conflicts by observers, it appears that the scoring from video recordings, both the reliability of one observer that scores situations several times and the reliability between different observers, is rather high (correlations are around 0.80 to 0.90). It should be mentioned that research into the reliability of various techniques has been conducted only at a small scale. From some studies it appeared that if pedestrian conflicts were removed from the available material, the correlations of internal and external reliability of the observers are lower than if pedestrian conflicts are taken into account. This may indicate that conflicts with pedestrians involved can more easily detected (and thus scored) than conflicts between other types of road users.

Hardly any research has been conducted to what extent measurements collected in a relatively short period of time, give a reliable insight for a longer period, in which a large variety of traffic conditions and environmental conditions such as darkness, slipperiness, rain, etc. occurs.

3.4 The validity of a method

As stated earlier, the conflict method is being used in particular to explain the occurrence of unsafe situations. This implies that a conflict study has to give insight in the accidents to be expected.

A first requirement is that a conflict method is effective. Even if the number of conflicts (for example, per annum) can be estimated consistently, it is still the question whether a good estimate can be made for the number of accidents. If that is the case, then one can speak of a high validity. If the validity would be 100%, then it would be sufficient to multiply the number of conflicts with a constant, the accident/conflict ratio. In practice, one has to accept less. On the one hand because the number of both conflicts and accidents is susceptible to fluctuation, on the other hand because conflicts are other phenomena than accidents. The validity issue mainly focusses on the latter. Of course, the ratio between accidents and conflicts vary among different classes of conflicts. Moreover, some types of conflicts will correlate stronger with certain types of accidents than other types. Research on this topic has been conducted only to a very limited extent.

In order to establish the relative level of traffic unsafety, the calculation of the constant does not to be calculated. Even then, the validity issue still exist. Some problems for validating conflicts to accidents are:

- For calculating the predictive value of conflicts relative to accidents, one chooses locations with a high accident rate. Then, the question arises to what extent an estimate can be made from the actually occurred accidents. The actually occurred number of accidents are also subject to chance fluctuations and don't provide an exact picture of the safety of a location. If the circumstances have not been changed too much, correction for the unreliability of the number of accidents may be possible.
- Another problem is that one wants to use conflict observation techniques in situations with a very low number of accidents. The question then is whether the method is transferrable to those situations. In other words, is it possible for those situations to make an accurate estimate of the expected number of accidents based upon the conflict method. It is difficult to verify whether the same relationships exist in situations with many accidents compared to situations with a few accidents. In the relationship between the reliability and validity, the question arises when the validity is high enough to better predict the expected number of accidents based upon conflicts than based on unreliable accident figures. A decision model taken from the psychological test theory, in which given the reliability and validity a choice is possible, already exists (Oppe, 1977).

Some other difficulties can be mentioned:

- In most studies, serious conflicts appear to correlate better with accidents than less severe conflicts. The latter, often, are also measures less reliably. Even with rather high correlations it is reasonable to assume that both conflicts and accidents correlate positively with traffic volumes. To what extent conflicts predict better than traffic volumes, has to be examined since that exactly may be the added value of the conflict method.
- Conflicts are being related to registered accidents (mostly, injury accidents). As mentioned earlier, only one third of all accidents are being reported.

- Conflict observations usually are conducted under normal conditions during a relatively short period of time. What has to be done with variations in the occurrence of accidents due to seasonal influences, weather influences, changes in speeds, traffic volumes, etc.? So far, no correction factors of these variables are known.
- How many accidents are necessary to provide a representative picture of the traffic safety, for example, at an intersection, with each type of accident that may happen, actually has happened? The same issue is valid for conflicts. An answer is not easily available.
- In studies with only the serious conflicts included, information on the validity is promising, but scarce compared with studies with all conflicts included.
- Conflicts do not explain all accident variability. Not all accidents are preceded by conflicts.

4 Applications of the conflict method

4.1 Introduction

So far, traffic safety analysis almost always occurs with the help of accidents. These analyses mainly refer to the extent of traffic unsafety. For example, typical for residential areas, the number of accidents, although rather frequent all together, will be rather low for each separate neighbourhood and they will be spread over the area. Also at urban arterials, even if these are qualified as black spots, the annual number of accidents is still rather low.

Besides the given remarks above about the occurrence of accidents, the following remarks can be made about the registration of traffic accidents:

- Accident data only contain information on registered accidents. In the Netherlands, only one third of all accidents is being registered (SWOV, 1976). The registered part is not representative. Certain types of accidents are either over- or underrepresented.
- As relatively few accidents occur, it is often impossible to collect sufficiently reliable data. The time needed for collecting sufficient numbers of accidents to perform statistical analyses, is often too long. With a long observation period of collecting, conditions and circumstances may change.
- The current standard procedure for registering accidents does not contain detailed information on what actually happened, for example on the manoeuvre preceding the accident.

These issues have been already extensively discussed both nationally and internationally.

A logical consequence for small scale studies in built-up areas is that in many cases accident studies cannot be conducted in a methodological sound manner and that one searches for another measurement tool. As an alternative, near-accidents and/or serious conflicts between road users are used as a measure for expressing the traffic unsafety. Anyway, the numbers of expected number of near-accidents or serious conflicts are larger than the number of registered accidents. The method of traffic safety research that takes (serious) conflicts as a starting point for study, usually is referred to as the conflict method. Both the observation and analysis of conflict behaviour are included, each with its appropriate techniques. The conflict method can be used to register the traffic unsafety at separate locations, for specific traffic situations, or for traffic participation in different conditions in cases that either no or insufficient information is available about traffic accidents or the available information is unreliable.

4.2 Application opportunities

For an international overview of the literature on the conflict method, the reader is referred to Kraay (1983). In studying the literature on the development and the usage of the conflict method, the following application opportunities occur:

- For the application of the conflict method, in general, it can be stated that one searches for those aspects of behaviour of road users mutually or in relation to the traffic environment that are relevant for the traffic safety. The

conflict method presumes the more interactions of the behaviours are conflicting, the more unsafety increases with more accidents as a result.

- Apart from applications that focus on determining the extent of traffic safety problems, some applications of the conflict method also focus on revealing the causes of unsafety with the help of different analysis techniques. The conflict method is used for the studying traffic safety problems both for specific locations (black spots) and for areas without enough accident data to conduct statistical analyses.

Usually, the traffic safety for a specific location is expressed as the average number of accidents/year, if possible related to a measure of traffic performance (exposure). However, as at specific locations (such as intersections) and in given areas (such as residential areas) only very few accidents occur annually, it is impossible to use accidents as a traffic safety criterion in short-term research. In these cases, one often applies conflict behaviour between road users as a surrogate traffic safety criterion, or in other words: conflict behaviour is then considered as a predictor for accidents.

The conflict method appears to be applicable at locations and/or in areas with a relatively low number of accidents and usually with low traffic volumes:

- As a diagnosis tool to identify unsafe locations;
- To study in-depth a number of aspects related to safety. Then, the research has a theoretical character;
- To evaluate countermeasures and their effect of traffic safety with the help of before and after studies;
- As a criterion for determining priorities in a programme for traffic safety research to improve locations and/or areas.

If accident data are insufficiently at hand, the ranking of locations can indeed be done by making use of traffic volumes. However, this approach does not guarantee that dangerous locations are being identified. Availability of man power and money and the availability of data may turn the scale in making a choice. A practical solution for making a ranking in dangerous locations may be:

- Make use of the conflict method in (residential) areas, at road sections and at 'quiet' intersections;
- Make use of accident data at busy intersections.

Of course, both approaches can be combined.

With systematic behavioural observation, relationships can be established between road user behaviour and factors such as geometrical lay-out of intersections, traffic volumes, weather conditions, and speeds. By a detailed description of road user behaviour it is possible to apply more specific and less expensive countermeasures. Besides, in case of traffic safety complaints by neighbours, a quick evaluation with the help of the conflict method can be conducted.

The conflict method also can be used to determine one of the indicators of *well-being* of road participants. For example, one can think of conflicts in the manner of panic reactions. Other items that are being mentioned include traffic quality of life and discomfort of road participants. This research into the traffic experience by road participants does not necessarily reflect the objective traffic safety. Feeling unsafe is often based upon experience with conflict behaviour and not with actual

accidents. Residents may have an unsafe feeling in their living environment that coincides with the actual traffic safety situation, but this will not always be the case. Anyway, unsafe feelings can directly influence the traffic behaviour of the persons involved. Apart from a direct relationship also an indirect relationship between unsafe feelings and traffic safety may be the case. The following example may illustrate this. As a consequence of the presumed relationship, after a redesign of their neighbourhood, parents experience a strong feeling of safety, because only very few conflicts between road users take place in their street or neighbourhood. If parents accompany their children less frequently towards and from school, then this behaviour of the parents may result in a situation in which children are being involved in traffic accidents than was the case before. The conflict method can be used to get more insight into the relationship between traffic safety, the perception of safety, and traffic behaviour.

Other advantages of the conflict method include:

- In a short time period, many measurements can be conducted to evaluate quickly traffic situations and traffic measures, also at locations with low traffic volumes.
- The measuring programme can be adapted to specific requirements of the study, with respect to type of traffic means, to traffic flows, type of manoeuvre, etc.
- General traffic data can be collected at the same time, so all data relate to the same time period. Most of the time, this is not possible when relating accident data to traffic data

Disadvantages of the conflict method include:

- The observations are costly and therefore are being collected for a short and not-representative period (day/night, workday/weekend, season).
- Frequently, the observations are being judged and scored subjectively: this requires a good training programme and a steady observation team to collect results that are comparable and consistent.
- Not always, a conflict is being defined in the same manner, so mutual comparison of results will be hampered.
- The conflict method presumes a relationship with unsafety in terms of accidents. This relationship should be present sufficiently and will certainly depend on the manner data have been collected and interpreted.

The first three disadvantages relate to questions of reliability of the method, the last point relates to the validity. The unreliability as a result of the subjective manner of judging and scoring may be reduced by training with video recording equipment. A good operational definition of each of the classification possibilities is also needed.

Finally, it may be mentioned that sometimes traffic offences are registered in addition to traffic conflict observations. Most of the time traffic offences are not being recorded as conflicts. Dependent on the traffic situations, some offences may have a relationship with traffic unsafety, but, in general, no unambiguous coherence between traffic offences and traffic unsafety can be found.

5 International Cooperation

5.1 The ICTCT and its coordination task

Since the first seminar on conflict studies in Oslo, Norway (Amundsen & Hydén, 1977) international contacts have been united. This seminar brought researchers together and let them discuss a number of methodological and practical developments of the conflict method. During this workshop a general definition of a traffic conflict was accepted, as indicated earlier. Moreover, the International Committee on Traffic Conflict Techniques ICTCT was founded with the most important task to establish research aims, to define research plans (such as a calibration study or a validation study) and to stimulate international research.

Since Oslo, more international discussion and cooperation started that resulted in an international experiment in March 1979 at two intersections in Rouen, France. The goal of this experiment (a calibration study) was to find out in how far the different operational definitions in detecting a (serious) conflict coincide or differ. The participating research teams came from England, Germany, Sweden, France, and the United States. In Rouen two intersections were selected with diverging environmental characteristics and traffic situations (Malaterre & Muhlrad, 1980). The Rouen experiment was experienced as successful by the participants in the sense that a better understanding of each other's techniques was created. However, the detection of conflicts differed considerably among the teams. On the same day, also video recordings were analysed and from this it appeared that in a number of cases no agreement could be reached about situations to be considered as a conflict or not. The setup of the study only allowed general comparisons without analyses among the teams nor with the video data.

This first international experiment clearly had a number of organisational shortcomings. The observed intersection was very complex in lay-out and very busy. Most countries had delegated teams with less observers than they were used to at home. It appeared difficult to find suitable observation positions for all teams. Moreover, the observation period was too short to make comparisons with accident data.

During the second seminar on conflict studies (Older & Shippey, 1980) in May 1979 in Paris, it was decided to give a follow-up on the Rouen study. For this, a preparation committee was installed within the ICTCT with the following tasks for preparation of the next experiment:

- The drafting of guidelines for an international calibration study with the purpose to establish the relationship between conflicts mutually, based upon the various existing traffic conflict techniques.
- The set-up of a research-design for an international validation study, or in other words: in which manner the functional relationship between accidents and conflicts should be established.

The proposal for a well-arranged calibration study was discussed during the third seminar in Leidschendam (Kraay (ed.), 1982).

In 1983, the international calibration study in Malmö was preceded by an international seminar in Copenhagen. At this seminar, the latest developments were

given and each participating team explained its technique. For the proceedings of this seminar the reader is referred to Asmussen (ed.), (1984).

5.2 The Malmö- calibration study

The most important aim of the study was to enable detailed comparisons of agreements and discrepancies among the various observation techniques in a field experiment. Special attention was given to the question in how far the observation teams agreed in identifying conflict situations and in how far these activities were influenced by the location, manoeuvre type, type of traffic participant, etc.

An aim in the long run was to determine whether criteria and data used by one technique sensibly could be applied in other techniques. This aim is especially important because it opens the possibility to exchange research data among the various techniques, also at an international level (Grayson (ed.), 1984).

The study in Malmö was conducted at three different locations, a non-signalised low-speed intersection with a general right hand right of way, a non-signalised high-speed intersection, and a signalised intersection. Each intersection was observed during three days, six hours per day. The observation periods were distributed such that the whole period between 07:00 and 18:00 hours was covered. A uniform observation protocol was applied.

Eight teams participated in the experiment, from Austria, Canada, Finland, France, Germany, England, Sweden, and the United States. Denmark participated partly with their own deviant observation technique. Israel and Belgium were present as observers. Apart from participation by the SWOV in the organising committee, the Dutch participation consisted of registering all traffic situations on video, the quantitative analysis of a part of this material for determining a number of objective data (speeds, distances, deceleration levels, Time-To-Collision (TTC), etc.). These measurements were also used for further analyses by TNO for their own technique. The statistical analyses for comparing the judgments by observers mutually and between these and the objective data from video have been conducted by the SWOV.

Figure I.7 gives an overview of definitions of a conflict and the severity dimension as applied by each team.

In total, almost one thousand conflicts were observed by at least one of the teams during the nine observation days. Two slight collisions were included. Passenger cars were involved in about 900 conflicts, bicyclists in 250, pedestrians in 160 and trucks in 95 conflicts.

Among the teams, large differences occurred in both the number and the type of conflicts. The team with the highest number of conflicts scored four times as many conflicts than the team with the least number of scored conflicts. Herewith it should be remarked that some teams have scored many conflicts, because in this experiment many slight conflicts have been included that normally speaking would not be recorded by a given team.

	Definition conflict		Interpretation of evasive action	Severity dimension	
	Estimation of			Based upon proximity	
	TTC	PET		Collision (all types)	Injury acc.
Sweden1 Finland	Fixed threshold			X	
Sweden2	Fixed threshold				Mean speed and type of road user
Sweden4	Threshold as a function of speed			X	
Canada		Fixed threshold	(X)		
England France2			Intensity and result		X
France1 United States Sweden3			Intensity and result		
Germany Austria			Intensity and result	X	
Netherlands	Calculated minimum value			X	

Figure I.7 Overview of definitions of a conflict and severity dimension by the teams participating in the Malmö calibration study.

A multivariate analysis of the subjective scores reveals a one-dimensional structure in the set of data that can be indicated as a severity scale. On average, conflicts are scored correctly on this dimension by all teams. This way of scoring, in fact, indicates that the severity rate is a common concept for all teams (or conflict techniques) despite the differences in definitions and procedures. Although this common dimension is strongly present, there are also differences in the scores of the various teams. An important finding is that the variation in the scoring of conflicts is mainly due to differences in detecting conflicts in traffic situations and not so much due to the assessment of the severity dimension.

In comparing the scores of the teams with the objective data of the conflict situations (as derived from the quantitative video analysis) it appears that the minimum Time-To-Collision (TTC_{min}) is most important variable. Other aspects of conflict situations that contribute are the minimum mutual distance between traffic participants, the conflict type, and to a somewhat less extent the type of manoeuvre. If homogeneous subsets of data are regarded, then variables such as speed and deceleration play a more important role.

The results reveal that in indicating the severity rate by observers, also a subjective dimension plays a role; even well-trained observers trained to identify specific

aspects such as TTC or PET, also take other aspects into account (for example, the chance of serious injury). Trained observers appear to agree on the assessment of the severity rate.

In addition to the analyses in the calibration study, each team also has made a diagnosis of the traffic unsafety at the three intersections under investigation. Despite the differences in techniques and traffic circumstances in their own countries, the teams agreed on the perceived safety problems at the three intersections.

Although it was not the intention of the calibration study to compare conflicts with accidents, it appeared nevertheless that the diagnoses made by the different teams corresponded with the picture from the accident statistics.

5.3 Applications and further developments

The Malmö experiment can be regarded as an important first step in the direction of a more systematic and methodologically more sound application of conflict analysis techniques. For the first time, it became clear to what extent techniques can be mutually compared and which aspects of traffic situations play a role in the judgment of the conflict severity. It became clear that observers from different countries vary considerably in the selection of situations they consider to be dangerous, but they agree to a large extent in the assessment of situations once these have been selected and in applying objective criteria that leads to this judgment.

This first step that resulted in knowledge on how observers can perceive conflict situations and how their judgment is reached, is important. However a necessary next step will be in determining the relevance of their observations and judgments in relation to safety. With the help of calibration studies the limited data available from various validation studies can be related to each other, so more general statements can be made about their predictive value (predictive validity).

The ICTCT focusses on answering the question which elements play a role in defining a conflict (construct validity) with tasks that relate to specific traffic safety problems and the applicability of the conflict method. This also includes the wider context of the systematic assessment of critical traffic situations in relationship with traffic safety and the potential of behavioural studies.

Conflict techniques as developed so far, provide valuable data in addition to accident data. Application of these techniques may vary from an process evaluation of traffic safety counter measures, behavioural analyses, the conduct of safety diagnoses and establish counter measures. More generally stated, the conflict method enables the studying the interactions between traffic participant and his/her environment (critical circumstances) and so contributes to the improvement of unsafe situations.

The ICTCT identified three areas for further international cooperation:

- The set-up of a manual for the application of the conflict method for potential users. The results of the Malmö studies are sufficiently promising to recommend the conflict method to other researchers and/or users.
- The validation of the method. The calibration study resulted in a better exchange of information and results of the individual countries. International cooperation can contribute to convincing people that are sceptical so far to the application of this measuring instrument.
- It became clear that the flexibility of the method (with its different techniques) and the insight it provides in traffic behaviour, enables further applications for several research areas such as traffic education, directed traffic surveillance, in-depth research (black spot analysis) and research in rural areas.

6 The Dutch situation

The conflict method is being applied in a number of countries for various and diverging practical situations. Based upon the results from the Malmö calibration study, also in the Netherlands it was decided to work on a more extensive application of the conflict method. As each technique has its own advantages and limitations, but also developed according to local circumstances, there was the desire to develop an own Dutch conflict observation technique that is generally applicable, methodological sound and can be applied in a controlled manner. On the one hand, the basis for this has been made by the conflict observation technique as developed by the NIPG-TNO (Güttinger, 1980) and the Swedish conflict technique from the University of Lund that has been applied in the Netherlands since 1983 (Hydén, 1983). On the other hand the basis consisted of the information available from the Malmö international calibration study and the behavioural analyses by IZF-TNO (van der Horst, 1980; 1984).

Because the technique makes use of observers in the field, it is necessary that a clear description of the application of the technique is provided by means of this Manual to ensure a systematic and controlled application.

The reasons why not simply an existing technique is adopted and a number of essential changes and additions are implemented, will be explained in the following paragraph.

The idea of conflict observations is to identify critical situations in traffic. This implies that one wants to get insight in both the *probability* of an injury accident and the possible *severity* of the consequences. The questions then to be answered are how large is the risk and what are the relevant points of view therewith.

For the conflict observation techniques from other countries, a number of shortcomings could be identified:

- Hardly any or no attention is given to traffic situations that involve pedestrians and bicyclists/mopeds.
- In most techniques the observations do not include both the probability of a collision and the severity of the consequences.
- When two traffic participants are on a collision course it is important to make a distinction between situations with two passenger cars or a car and a bicyclist as well as in the latter case who is approaching who. A bicyclist has, given his speed and distance, more possibilities to make an evasive manoeuvre with consequences for the probability of a collision.
- In some techniques, one considers the traffic situation from one single view point (for example, only TTC), in other techniques one makes a judgment of the traffic situation without indicating specific aspects. Both approaches give too little relevant information to make a sound diagnosis.
- In the calibration study, the Swedish and Finnish technique sometimes scored conflicts with a low TTC value with a low severity rating. A low TTC value appears to be an necessary but not sufficient condition.
- Another problem with TTC may be that some situations have the same TTC value, but belong to different manoeuvre types which should give different total scores with respect to the severity of a conflict.

In other words, the operationalization of the relevant behavioural characteristics and the systemisation of the observations are the difficulties to overcome for a good conflict observation technique. The probability of a traffic situation that may result in a collision is the key issue. Moreover, the amount of protection for both traffic participants involved in a potential collision and resulting energy transfer are important.

In general, it can be stated that too much attention was given only to the probability of an accident and that the consequences of a potential collision were not taken into account. Especially the possible severity of the consequences is an important element in assessing unsafe situations.

In Part II of this manual these aspects as mentioned above will be made tangible for the Dutch conflict observation technique DOCTOR.

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Part II Training with the DOCTOR-technique

7 Introduction

Behavioural studies gain attention for describing, explaining, and improving traffic safety. Risky behaviour, especially in encounters between traffic participants, plays a central role. In observing behaviour there will always be an interpretation by the observer. Observers tend to guide themselves according to their own expectations about what they consider as dangerous for given behaviours. Therefore, often, the observation will be subjective and selective. To come to a justified assessment of behaviour, observations need to be conducted systematically and objectively.

The Dutch conflict observation technique DOCTOR is a standardised observation technique with objective and well-defined observation units that can be conducted by trained observers. The components of the technique are being explained in this Part II in chapter 9 and 10. This manual is intended to be used as a guideline for the training of the DOCTOR technique. Besides a general instruction and training from video, the training also consists of a training in the real traffic practice. The set-up of a training week is given in Appendix 1. The manual can also be used as a reference for field research once the training has been followed.

8 The behaviour in a conflict situation

The behaviour by traffic participants involved in an conflict interaction can be subdivided in two phases. The first phase relates to the occurrence of the conflict situation at the beginning of a collision course till the onset of a collision-avoiding manoeuvre. The second phase contains the solving of the critical situation towards a new safe moving direction.

8.1 Occurrence of a conflict

The characteristics playing a role in the occurrence include the way of traffic participation, the (driving) speed, the (collision) course and the type of manoeuvre.

Traffic Participation

Traffic participants may induce a conflict by their way of behaving such as driving with a relatively high speed, a swaying course, committing a traffic offence, conducting a sudden evasive manoeuvre. Often this will be due to a lack of anticipating to the behaviour of another road user. Especially, this plays a role when different types of road users are involved in a conflict situation. For example, when a pedestrian occurs from behind a parked vehicle and unexpectedly finds him/herself in the course of an approaching car, the situation may develop into one in which a sudden or uncontrolled evasive manoeuvre needs to be conducted. If one of the participants involved, anticipates in an early stage how the situation may develop, then he may adapt his behaviour in a controlled manner. The other road user may react again on this behaviour, and, for example, accept exchanged priority. A traffic participant also may aggressively approach another traffic participant by his speed, with blinking his high beams, gesticulating, the late starting of a braking manoeuvre.

Speed

A traffic participant may, given a specific traffic situation, the available view and anticipation potential, move with a too high speed. A traffic participant also may, given his previous behaviour, brake or accelerate without apparently the need to do so given the traffic situation.

Course

The traffic participant may follow a course that given the local practice or the layout of the traffic situation is not to be expected. For example, swaying driving or walking, suddenly making use of a small gaps in a traffic flow or cutting off corners.

8.2 The solving of a conflict

Also in solving a conflict situation, the traffic participation, the speed and course play a role.

Traffic participation

The traffic participant conducts a manoeuvre to control the conflict situation; also the other can contribute to this. A reactive action takes place as the participant involved with respect to time and space, only has the option to avoid a collision by a fast reaction. If one of the traffic participants in his behaviour takes the behaviour of the other into account (for example, by wrongly taking the right of way), an encounter may be the case instead of a conflict. A conflict situation may also be solved by one of the parties by accepting the aggressive behaviour of the other.

Speed

The speed determines (partly) the manoeuvring space needed successfully conducting an evasive action. The conflict may be solved because at least one of the participants involved reduces his speed, slows down, stands still, accelerates or as a pedestrian jumps away.

Course

An evasive action may consist of a course correction, a swerving manoeuvre with or without a change in speed. Important again, is the available manoeuvring space. Sometimes, solving a conflict may induce another conflict.

8.3 Instruction tape

A description of the traffic process and especially the disturbances that may occur in there, remains always rather abstract and is difficult to transfer to practical situations. To meet this as much as possible, a video instruction tape has been compiled with which the aspects that play a role in the occurrence and solving of a conflict situation can be illustrated clearly by means of several examples. The instruction tape has the intention to introduce a number of concepts. Following this general instruction, the actual training starts with the help of a separate training tape. Finally, a test will be taken to get a good impression of the level reached by the candidates. This test will be conducted by means of a number of situations on a video test tape.

The instruction tape consists of a general part, a part that deals with the severity of conflicts, and a part with some specific aspects. Following an introduction of the traffic safety problem (four examples of collisions), in the first general part by means of eight situations, the concepts critical situation, near-miss, and conflict will be explained. Distinctions will be made between type of road user and type of manoeuvre, see also Table II.1. Further, the detection of critical situations will be illustrated by means of deviations of normal behaviour as well as some examples that demonstrate the collision course concept. The main part of the instruction tape consists of the second part that deals with the scoring of the severity of a conflict situation. In total, 17 situations are presented, subdivided into type of conflict (car-car, car-bicyclist, etc.), the most relevant manoeuvre types (for car-car situations), and for encounters between different road users who is approaching who. For all these scenes a graphical representation is mixed into the video of curves of the speed of both parties involved and of the 'Time-To-Collision' (TTC) as a function of time. Synchronously with the running time, a cursor directly relates the information in the graphs with the actual scene. In this manner, a relatively complex measure such as TTC can be explained rather easily and connected to other measures such

as speed and evasive actions. Table II.1 gives an overview of the set-up and lay-out of the instruction tape.

Table II.1 Set-up and lay-out of the instruction tape.

	Situation number
I General introduction	
Collisions	I 1 – I 4
Critical situations	I 5 – I 12
Detection	I 13 – I 16
Collision course	I 17 – I 19
II Scoring of severity of conflicts	
Car – car*	I 20 – I 23
Car – bicyclist**	I 24 – I 27
Car – pedestrian	I 28 – I 30
Bicyclist – bicyclist	I 31 – I 32
Bicyclist – pedestrian	I 33 – I 36
III Special cases	
Merging/swerving as evasive action	I 37 – I 39
Injury consequences	I 40 – I 44
Unexpected situations	I 45 – I 46

*All fast traffic to be included

**Also mopeds

8.3.1 Collisions

During video-recordings over the years (about 500 hours of observation) a few collisions have been registered. Collisions appear to remain very rare events. Besides, these collisions had a slight character. From the on video registered collisions, four have been selected, each of which has something typical for the traffic safety problem, see Table II.2. These situations make it also obvious that for collisions a distinction has to be made between slight and severe crashes. Apart from the fact that really a crash had occurred, it is equally important to get insight in what happened just before the collision to find out possible causes. For example, it makes a difference when a rear-end collision is the result of a slow approach speed without evasive action or when the second car is approaching with a high speed and after very hard braking comes to a standstill just too late. Intuitively, the second situation is much more severe, a somewhat slower reaction had maybe resulted in severe material damage and/or personal injury. Furthermore, for a safety diagnosis it is important whether given accidents are the result of very rare circumstances and therefore are a unique event or that accidents are the consequences of normal road user behaviour in a given traffic provision. In the first case, countermeasures should focus on preventing such unique situations, in the second case measures should relate to an change in the normal functioning and therefore much more influence the whole traffic process.

Table II.2 Selection of four collision as registered on video.

Situation	Type	Manoeuvre type	Brief description
I 1	Bicyclist - car	Rear-end	Car is stopping abruptly, reason? Bicyclist hits the rear bumper, consequences?
I 2	Car - car	Rear-end	Example of slight collision at very low speed, no evasive action
I 3	Bicyclist - bicyclist	Head-on	Consequence of a by designer not-intended path choice, 'potential' injury severity present
I 4	Bicyclist-pedestrian	Right-angle	Crossing pedestrian unexpectedly, elements in the process preceding the collision, status of traffic light, when does the pedestrian starts crossing (auditory signal?), etc. no evasive action, high injury risk.

8.3.2 Critical situations

As indicated in Part I of this manual, the conflict method focusses on identifying those characteristics of traffic behaviour of road users mutually or of road users in relationship to their traffic environment that are being considered relevant to traffic safety (critical situations or conflicts). The distinction between slight and severe collisions also counts for conflict situations. Especially the traffic process that results in a critical situation and the manner in which such a traffic situation is solved are important for assessing the conflict severity. In Table II.3 examples are given of 8 traffic situations with more or less severe encounters between road users by type of conflict and type of manoeuvre.

Table II.3 Overview of examples of critical situations.

Situation	Type	Manoeuvre type	Brief description
I 5	Car - car	Right-angle	Controlled, not severe
I 6	Car - car	Right-angle	Uncontrolled, hard braking, critical situation
I 7	Car -car	Right-angle	Critical situation, uncontrolled braking
I 8	Car - car	Right-angle	Probability of collision, braking at last moment, speed low
I 9	Car - car	Rear-end	Late reaction 2 nd car, near-miss
I 10	Car -> moped	Turning	Suddenly critical situation for moped rider, for a short moment uncontrolled swerving
I 11	Bicyclist - car	Right-angle	Near-miss, critical situation
I 12	Car -> pedestrian	Right-angle	Severe situation, pedestrian standing stock-still, car is

			braking hard
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8.3.3 Detection of critical situations

In processing traffic at an intersection, frequently encounters between road users take place. Most of the time, these encounters are being solved in a normal manner because road users timely react on each other. Occasionally, a critical situation develops. The detection of these situations in which deviations from normal behaviour occur, is an important element in conflict observation. Some examples that illustrate this, are given in Table II.4.

Table II.4 Detection of critical situations.

Situation	Type	Manoeuvre type	Brief description
I 13	Car – car	Right-angle	Collision course, both cars brake
I 14	Car – car	Right-angle	Car 1 is braking for bicyclist, car 2 just behind
I 15	Car -> moped	Right-angle	Car starts braking at a late moment on bicycle path, moped rider goes first
I 16	Bicyclist -> car Bicyclist-bicyclist	Right-angle Rear-end	Collision course bicyclist – car, not serious rear-end between two bicyclists

8.3.4 Encounters with and without collision course

An encounter between road users is at hand if at least one of the parties involved needs to do something to avoid a collision, in other words the road users are on a collision course. In some cases, road users pass each other very narrowly without a noticeable evasive action has taken place. Also such situations can be critical, a small disturbance in the approach process could easily have resulted in a collision. In Table II.5 some examples are given.

Table II.5 Encounters with and without collision course.

Situation	Type	Manoeuvre type	Brief description
I 17	Car – car	Rear-end	Collision course, low speeds
I 18	Car – car	Left-turn	First collision course, followed by PET situation
I 19	Car – car	Right-angle	No collision course

9 The DOCTOR technique

9.1 Concepts

In the previous chapter already some relevant concepts are given, such as encounter, critical situation, traffic conflict, collision course, detection of deviations from normal traffic behaviour, evasive action, etc. for systematic observations resulting in unambiguous and reliable registrations, besides formal definitions, also operational definitions are crucial.

At an intersection, traffic approaching from different directions ultimately has to make use of the same (partial) space. If we limit ourselves to at-level crossings, only a separation in time between two intersecting traffic flows can prevent collisions. This separation in time may be imposed externally, for example by applying traffic lights. Most of the time, however, road users have to deal with each other by themselves, yes or not supported by additional behavioural rules. A great part of the road users may pass the intersection without being influenced by other road users (free riding cars).

Often, an *encounter* will be present, a traffic situation in which two road users approach each other in time and space and may influence each other's behaviour. For the majority of encounters, a controlled adaptation of course or speed will be sufficient to realise a normal settlement of encounters.

Road users experience a *collision course* if at least one of them has to take any action to avoid a collision. The closer the moment of reaction, given the approach speeds and reaction potential of the road users involved, to the moment of collision, the more dangerous the traffic situation potentially will be.

If the available *manoeuvring space* is smaller than the space needed for a normal reaction, then we are looking at a *critical traffic situation*.

A *conflict* is a critical traffic situation in which two (or more) road users approach each other in such manner that a collision is imminent and a realistic probability of personal injury or material damage is present if their course and speed remain unchanged.

The *severity of a conflict* is determined by both *the probability of a collision* and the *extent of the consequences* if a collision would have occurred. These consequences can comprise both personal injury and material damage.

After the detection of a conflict situation, first of all, the observer has to provide a *total judgment of the severity* by scoring on a scale from 1 to 5 (from slight to very severe). After this first judgment a further substantiating is asked by means of a separate judgment of both aspects probability of a collision and extent of consequences.

The *probability of a collision* is determined by the Time-To Collision (TTC) measure and/or the Post-Encroachment Time (PET). The TTC is defined as the time required for two vehicles to collide if they continue at their present speed and on the same path. As long as the road users are on a collision course, a TTC is present and a continuous function of time. A theoretical shape of a TTC curve as a function of time is given in Figure II.1, The lowest value that is reached during the approach process is given by TTC_{min} . The minimum TTC (TTC_{min}) as reached during the

approach process of two vehicles is taken as an indicator for the severity of an encounter. In principle, the lower TTC_{min} the higher the risk of a collision will be. In general, TTC_{min} values of less than 1.5 s constitute a potential dangerous situation in urban areas.

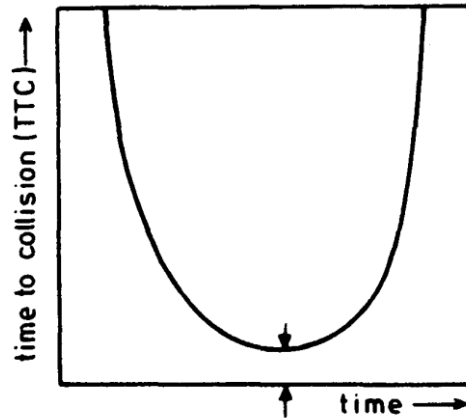


Figure II.1 Theoretical shape of a TTC curve.

The TTC concept requires the presence of a collision course. If two road users miss each other by hanging on a hair with a relatively high speed without notable course or speed changes, strictly spoken there will be no collision course. Nevertheless, the probability of a collision is realistically present, a small disturbance in the process could easily have resulted in an actual collision. The PET value is a measure that also includes these 'near misses'. It is defined as the time between the moment that the first road-user leaves the path of the second and the moment that the second reaches the path of the first (see Figure II.2). The PET value consists of one value and indicates the extent to which they missed each other. In urban areas, PET values of one second and lower are indicated as possibly critical.

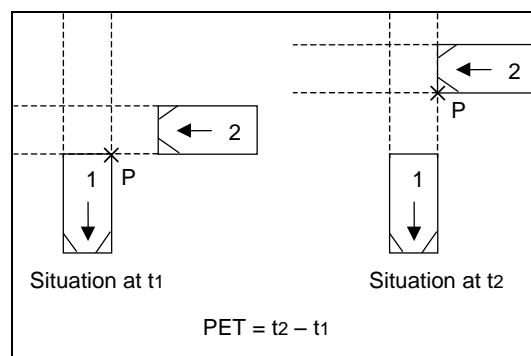


Figure II.2 Definition of PET.

The *extent of the consequences* if a collision course would have occurred (personal injury or material damage) is mainly dependent on the *potential collision energy* and the *vulnerability* of the road-users involved. Affecting factors are the relative speed, available and necessary space for manoeuvre, the angle of approach, the type and condition of road-users, etc. The mass and manoeuvrability of the vehicles are very much determining the final outcome. For estimating the extent of the consequences in case of a (hypothetical) collision, a comparison has to be made between the manoeuvring space needed to react normally in such encounters (for example,

anticipatory braking with a normal (comfortable) deceleration) and the really available manoeuvring space at the onset of the evasive action. In critical situations, this difference usually will be negative. Together with the type of road users (among other things mass and vulnerability) the amount of this difference is determining the extent of the consequences, from now on indicated by *injury severity*. The greater the (negative) difference between the normally needed and available manoeuvring space, the stronger and perhaps the more complex (both swerving and braking) the evasive action has to be to avoid a collision. Without a (additional) reaction by at least one of the road users involved, a collision will be the result. To obtain an as unambiguous estimate as possible of the injury severity and for additional information for analysis and diagnosis, several aspects are scored and registered. Besides indicating types of road users involved and an estimate of speeds (mostly at the onset of the evasive action) the characteristics of the evasive action has to be registered (with/without evasive action, controlled/uncontrolled, braking, accelerating, swerving). Between a bicyclist and a truck large differences exist in masses, manoeuvrability, reaction speed, effectiveness of an evasive action (necessary manoeuvring space). In situations in which road users (different in their protection against each other in case of collision) approach each other, it is very important to know *who is approaching who* for determining the injury severity. A bicyclist has, given a certain speed and distance, more possibilities for an evasive action than a truck driver. The difference between available and normally needed manoeuvring space will be smaller when a bicyclist approaches the side part of a car, than when a car encounters a bicyclist. In a typical PET situation mass and speed of the second road user at the moment he reaches the path of the first one and the vulnerability of both determine the injury severity.

9.2 Type of conflicts

9.2.1 Car – car conflicts

In car – car encounters at an intersection, the three main types of interaction by manoeuvre are right-angle, rear-end, and left-turn. According to this subdivision, Table II.6 gives the on video available car-car encounters. As indicated before, in these video scenes the speed and TTC curves are mixed as a function of time. Synchronically with the time a pointer is running in the scene, that unambiguously couples the information from the image and from the curves. Figure II.3 gives an example, Figure II.4 separately provides the curves.

Table II.6 Car – car conflicts (V = speed (m/s), A = acceleration (m/s²), TTC (s), PET (s)).

Situation	Type	Manoeuvre type	V1	V2	A1	A2	TTC _{min}	PET
I 20	Car-car	Right-angle	2.8	5.4	-2.2	2.6	0.5	0.9
I 21	Car-car	Right-angle	2.6	12.2	-1.0	-5.1	0.6	-
I 22	Car-car	Rear-end	10.4	12.0	-3.7	-4.4	0.6	-
I 23	Car-car	Left-turn	12.4	2.2	-4.3	1.4	0.6	0.5

In situation I 20, the car coming from the right (having the right-of-way) brakes at the last moment, his speed is not high; an example of enforcing unsuccessfully the right-of-way, the party not having the formal right-of-way goes first, the probability of a collision is rather large, the injury severity low.

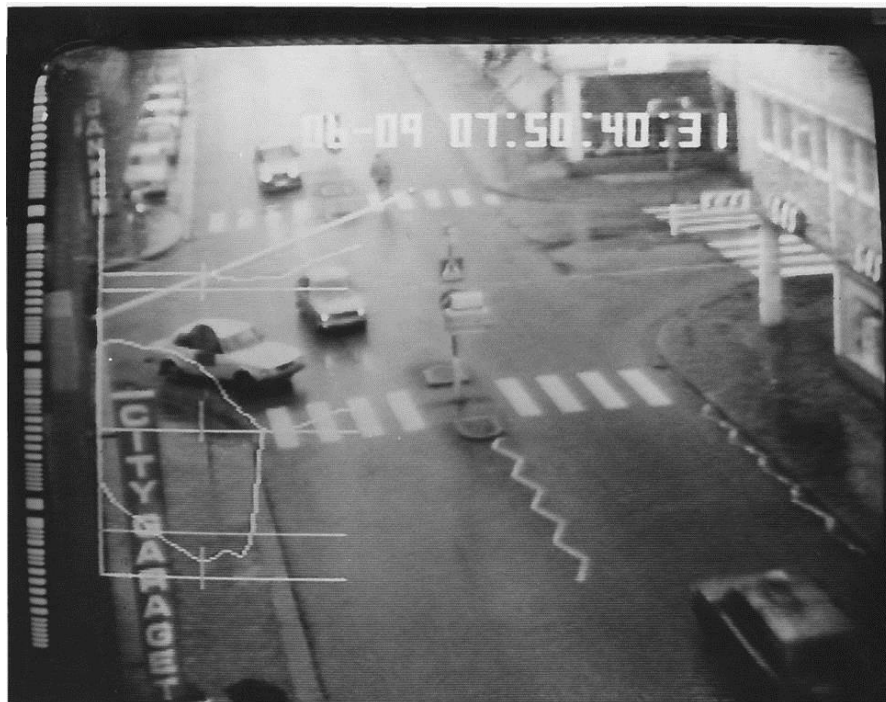


Figure II.3 Example of the coupling of information from the image and the curves. The top curve represents the speed of the right-turning Saab, the middle curve the speed of the car coming from above. The bottom one represents the TTC-curve. The vertical stripes give the running time (situation I 21).

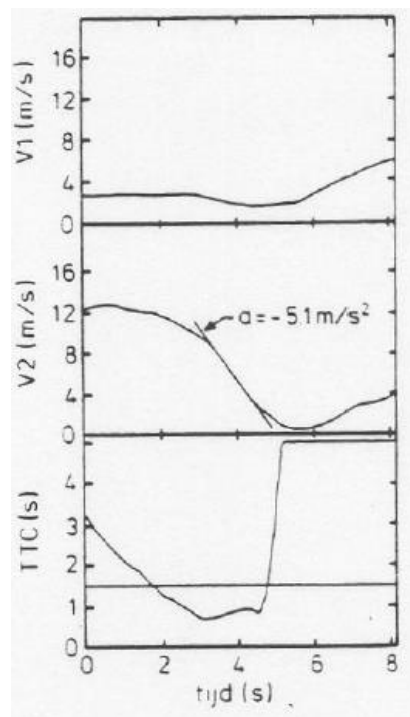


Figure II.4 Curves of Figure II.3, V1 and V2, maximum scale is 20 m/s (72 km/h). maximum deceleration $a = 5.1 \text{ m/s}^2$. In the TTC-curve, the horizontal line indicates a TTC value of 1.5 s.

Situation I 21 is comparable with I 20. Here, the taking of priority of the party that has formally the right-of-way, after awaiting for a while what the other party actually is doing (horizontal part of the TTC-curve), has finally success. It is a critical situation, the straight going car from above has to brake strongly and even has to swerve to avoid a collision. A deceleration level of 5.1 m/s^2 on a wet road surface is already rather extreme.

In the rear-end conflict of situation I 22, the following vehicle brakes a little too little at first, and has to brake additionally at last. The remaining space is limited, the injury severity is not very large.

For situation I 23, a clear collision course is present at first. The left-turning vehicle accelerates, At about a TTC of 1.5 s, the straight-going vehicle brakes heavily. Also a realistic PET value occurs (0.5 s). The speed of the second car is already rather low, though.

9.2.2 Car – bicyclist conflicts

For these ‘unequal’ road users it is important, as stated previously, to distinguish who is approaching who and who has the right of way. Table II.7 gives the situations on video.

Table II.7 Car (C) – Bicyclist (B) conflicts. (V = speed (m/s), A = acceleration (m/s^2), TTC (s), PET (s)).

Situation	Type	Manoeuvre type	V_C	V_B	A_C	A_B	TTC_{\min}	PET
I 24	C -> B	Right-angle	2.1	4.3	-2.1	1.3	0.5	0.3
I 25	C -> B	Right-angle	15.6	4.4	-4.0	-1.0	-	0.4
I 26	C -> B	Right-angle	1.3	5.4	-0.9	-0.4	-	-
I 26	B -> C	Right-angle	1.3	2.6	1.2	-0.8	0.4	-
I 27	B -> C	Right-angle	6.0	4.1	-1.6	-2.0	0.0	-

In situation I 24 and I 25 the car approaches the bicyclist. In situation I 24, the car accelerates and brakes again at the last moment. His speed is low, the bicyclist has the right of way and passes first. In situation I 25 the bicyclist crosses first in front of the car, while the car has the right of way. Strictly speaking, no collision course is present (no TTC). However, the car brakes briefly, the probability of a collision is determined by PET (0.4 s) and the injury severity is high because of the relatively high speed of the car ($15.5 \text{ m/s} = 56 \text{ km/h}$) and the vulnerability of the bicyclist.

I 26 is an example of a situation in which both a car approaches a bicyclist and a second bicyclist approaches the car. None of these encounters fall in a serious category. In the first encounter, the car brakes a little at a low speed and the bicyclist swerves a little. In the second encounter, a collision course is present, the bicyclist has a reasonable time to react, the car blocks the passage of the bicyclist (the bicyclist has the right of way).

It is a pity that in situation I 27 the bicyclist enters the image so late. Although the bicyclist approaches the car, it is clear that this deals with a serious situation, a real near-miss. An uncontrolled braking and swerving of the bicyclist (who has the right of way) just prevents a collision, the margins are very small. TTC_{\min} practically reaches a value of 0. In the calculation of TTC the dimensions of the parties involved have to be taken into account. A bicyclist is considered as a rectangle of

0.5 m wide and 1.80 m long. When turning the steering wheel this may result in small deviations. The moment the evasive action is started, is not known.

9.2.3 Car – pedestrian conflicts

The 'inequality' between road users also strongly apply to car – pedestrian encounters. Characteristic for a pedestrian is the relatively low speed and the potential to stop fast or accelerate. His vulnerability, however, is very large.

Table II.8 Car (C) – Pedestrian (P) conflicts. (V = speed (m/s), A = acceleration (m/s²), TTC (s), PET (s)).

Situation	Type	Manoeuvre type	V _C	V _P	A _C	A _P	TTC _{min}	PET
I 28	C -> P	Right-angle	11.4	1.8	-6.3	-0.8	0.5	-
I 29	C -> P	Right-angle	6.7	1.3	-3.3	-0.1	0.1	0.2
I 30	P -> C	Right-angle	2.7	1.4	-3.2	-1.4	0.0	-

9.2.4 Bicyclist – bicyclist conflicts

In bicyclist – bicyclist encounters, the readiness to give right of way is sometimes limited. As evasive action, in first instance, swerving is mostly the most important one. Decelerating only follows if no other option is left. Both examples in Table II.9 illustrate this. The injury severity remains limited at low speeds.

Table II.9 Bicyclist (B) – bicyclist (B) conflicts (V = speed (m/s), A = acceleration (m/s²), TTC (s), PET (s)).

Situation	Type	Manoeuvre type	V ₁	V ₂	A ₁	A ₂	TTC _{min}	PET
I 31	B – B	Right-angle	5.3	2.3	-1.1	-0.9	0.6	0.2
I 32	B – B	Right-angle	4.8	4.1	-1.3	-1.8	0.4	0.8

9.2.5 Bicyclist – pedestrian conflicts

The detection and judgment of the severity of a critical encounter between a bicyclist and a pedestrian often is difficult because of the suddenly upcoming character. A collision course usually occurs rather unexpectedly and can be undone quickly again. Both parties involved can quickly react to each other. A bicyclist usually will make a swerving manoeuvre, a pedestrian can stop in a very short time moment or on the contrary accelerate. Encounters between both road users only may become critical if they find themselves in a close proximity and only react to each other at a very late moment. Table II.10 gives four examples. In the first two situations the bicyclist approaches the pedestrian, for I 35 and I 36 the pedestrian is approaching the bicyclist from aside (I 33 is an example of a not-severe situation). I 34 (the collision between bicyclist and pedestrian) illustrates the potential injury severity may be large even in an encounter between a bicyclist and a pedestrian. Not so much because of the size of the collision energy, but the vulnerability of the parties involved is what counts. The fall backwards by the pedestrian is clearly indicating that; falling in this manner with hitting you head on the curb, may be fatal.

In situation I 35 the elderly pedestrian is being surprised by a passing moped rider. In I 36 the woman with a stroller holds in while the bicyclist swerves around the stroller at the last moment in an uncontrolled manner.

Table II.10 Bicyclist (B)/Moped (M) – Pedestrian (P) conflicts. (V = speed (m/s), A = acceleration (m/s^2), TTC (s), PET (s)).

Situation	Type	Manoeuvre type	V_B	V_P	A_B	A_P	TTC_{min}	PET
I 33	B -> P	Right-angle	4.5	1.4	-0.4	-0.2	0.8	0.5
I 34	B -> P	Right-angle	5.2	0.1	-0.7	0.9	0.0	0.0
I 35	P -> M	Right-angle	9.7	1.0	-1.7	-1.1	0.2	-
I 36	P -> B	Right-angle	6.4	1.6	-2.4	-0.5	0.1	-

9.2.6 Some special aspects

In the previous subsections, various encounters between road users have been dealt with systematically. The following series of situations focusses on some specific aspects. In Table II.11, situations I 37, I 38 and I 39 are examples of swerving as the solving of critical situations. Situations I 40 and I 41 reflect the involvement of trucks or buses to illustrate the potential injury severity. I 42 is a typical PET situation in which the motorbike rider with high speed passes just behind the crossing bicyclist. I 43 and I 44 are almost identical situations in which I 44 is less severe because of the greater distance between car and bicyclist. In the judgment of the injury severity score in I 45 the large difference between bicyclist and truck combination plays a role. In I 46 a bicyclist waiting on the roadway is confronted with an overtaking car.

Table II.11 Some specific situations (V = speed (m/s), A = acceleration (m/s^2), TTC (s), PET (s); T = Truck/Bus, C = Car, B = Bicyclist, P = Pedestrian, M = Motor bike).

Situation	Type	Manoeuvre type	V_1	V_2	A_1	A_2	TTC_{min}	PET
I 37	T - C	Same direction	13.1	3.2	-2.4	-3.7	-	-
I 38	C - C	Same direction	0.0	11.2	-2.3	-2.8	1.0	-
I 39	B -> C	Rear-end	2.6	1.4	-1.7	-2.5	0.3	0.3
I 40	C -> T	Right-angle	16.1	1.8	-5.3	1.5	0.2	0.4
I 41	T -> C	Left-turn	4.1	3.7	-2.1	-1.8	0.9	-
I 42	M – B	Right-angle	19.7	4.9	-0.5	-2.0	-	0.5
I 43	C – B	Right-angle	4.7	6.5	-4.3	-3.8	0.9	-
I 44	C – B	Right-angle	3.2	5.4	-3.5	-3.4	1.0	-
I 45	B - T	Right-angle	3.7	11.3	-0.8	0.5	2.0	-
I 46	B – C	Right-angle	2.4	16.3	-1.0	0.6	1.2	-

10 Training

10.1 Training scheme

The training with the DOCTOR technique consists of a part in which by means of examples on video the different observation units are dealt with. The training with video is intended to teach the detection and judgment of critical behaviour in a systematic manner. The observing of traffic situations from video, however, may differ considerably from observing in the field, such as estimating distances, speeds and time measures. Besides, information on additional behavioural and environmental characteristics may be lost. Therefore, the training also comprises a part with observations in the real traffic practice. During these field observations traffic situations are being registered at the same time. Afterwards, the individual scores of the course members is being compared with the data from video.

10.2 Training tape

The treatment of situations on the training tape is following the general introduction with the instruction tape. It is assumed that with that most concepts are globally known. The intention of the training tape is to be able to completely filling in the DOCTOR observation form after a detailed treatment of a number of separate aspects. Separate parts will be trained, for each situation shown, questions have to be answered and/or judgments given. The possibility is left open to briefly discuss the results after each sub-session to enable fast feed-back. Occasionally, this may be done with the help of video scenes.

The training tape consists of an introductory part followed by the actual training for completing the DOCTOR observation form. In the first part elements such as estimating speeds, the detection of critical situations and of collision course come up for discussion, see Table II.12. For clarity, this part is limited to car – car and car – bicyclist encounters. In the second part, a series of 21 situations is displayed four times in total, three times to separately train aspects such as overall severity score, probability of a collision and injury severity, and the fourth time to fill in the DOCTOR observation form in one run. In the series of 21 situations a distinction is made between type of road user, who is approaching who and type of manoeuvre.

Table II.12 Training tape set up.

		Situation
Ia	Estimating speed	Tr 1-6
Ib	Detection of critical situation, simple	Tr 7-12
	Detection of critical situation, complex	Tr 13-18
Ic	Collision course	Tr 19-23
IIa	Scoring severity conflict situation	Tr 24-44
IIb	Scoring probability of collision	Tr 24-44
IIc	Scoring estimated injury severity	Tr 24-44
IId	Filling in Form	Tr 24-44

10.2.1 Estimating of speeds and evasive actions

Sometimes, the estimating of speeds from video is difficult and different from direct observations in real practice. For example, the estimation of speed from video may depend on the lens size used during the recordings and how a given vehicle moves through the scene (for example, either across or in the camera view direction). For recordings with a wide-angle lens, in which a relatively large part of the roadway fills only a small part of the image, speed may be easily underestimated by a wrong estimate of distance travelled in a given time. The same may be true for a long-focus lens in the direction of the camera viewing. If the image is strongly zoomed in, vehicles only move slowly over the screen. Also detecting evasive actions and estimating the strength of it depends to some degree on the way the recordings have been made.

What yields for the scoring from video, is also somewhat valid for direct observation in the field. Dependent on the observation position in the street, speeds, mutual positions of vehicles, deceleration levels, etc. may be observed more or less accurately. Mutual relationships between speeds, such as faster, slower or about equal to the mean may be stated well. As is the case in field observations, an absolute estimate is necessary by means of a number of tuning measurements. A simple aid is the measurement of the time difference between the passing of two cross-sections (p_1 and p_2) with a known distance, according to:

$$V = 3.6 \cdot d(p_1, p_2) / (t_2 - t_1) \text{ km/h}$$

In which:

V is the speed in km/h

$d(p_1, p_2)$ = distance between p_1 and p_2 in m

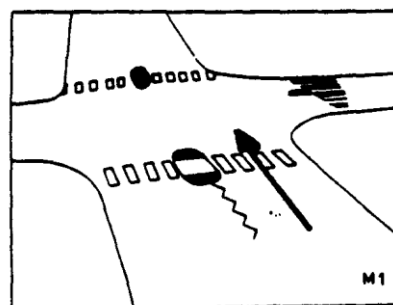
t_1, t_2 = passing moment p_1, p_2 in s, respectively.

The assumption then is, that the vehicle in the measuring section no notable speed changes displays.

The training tape starts with three vehicles at two intersections. Per intersection, these are shown consecutively. Respond on the answering form for the three situations whether the speed has been higher, lower, or equal to the average speed.

Intersection 1: southern leg, average speed 24 km/h

Situations Tr 1, 2 and 3



Tr 1: Volvo

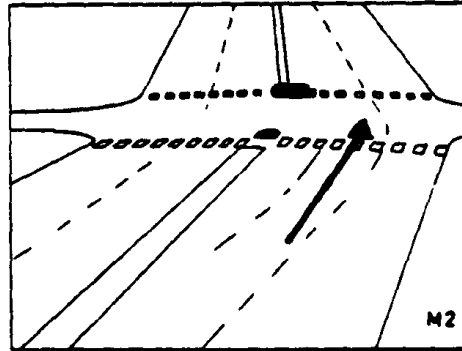
Tr 2: Renault 5

Tr 3: Ford Transit

Do the same for the following three situations, try to provide also an absolute estimate.

Intersection 2: southern leg, average speed 47 km/h

Situation Tr 4, 5 and 6



Tr 4: Mercedes

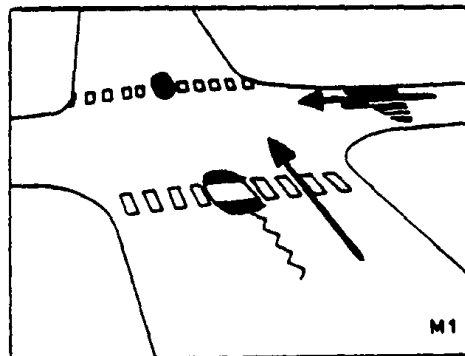
Tr 5: VW Golf

Tr 6: Renault 16

10.2.2 Detection of critical situations

In this part, the main purpose is to learn how to distinguish possibly critical situations from situations in which the parties involved react 'normally' on each other. In the conflict observations, especially the deviations from normal behaviour are important. First, two series with each identical manoeuvres are shown. The first series is dealing with three car – car encounters (Tr 7 through Tr 9). Traffic from the right has the right of way. Indicate for each situation if you notice something that gives rise to potentially critical or from normal deviating behaviour (yes or no).

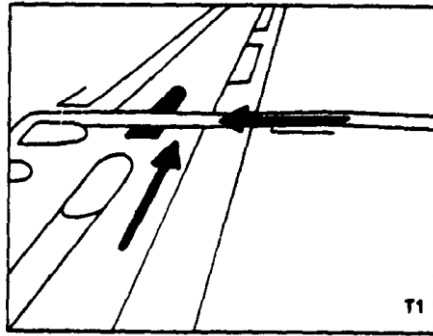
Situations Tr 7, 8, and 9



Give an order of rank for the three situations by severity with 1, 2, and 3 (3 stands for most severe).

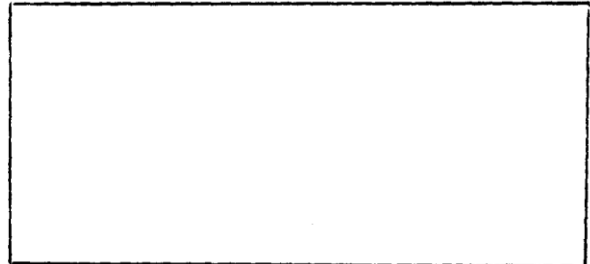
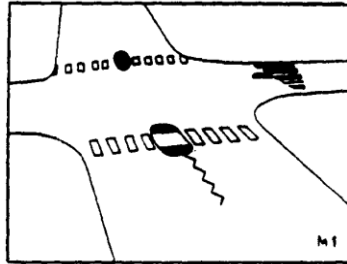
Next, do the same for the second series. These deals with three car – bicyclist encounters Tr 10 through Tr 12. The bicyclist from the right has the right of way.

Situations Tr 10, 11 and 12



The following part contains consecutively six more complex situations in which either one or more road users are involved or a few encounters take place within the same scene, Tr 13 through Tr 18. Provide schematically in the space aside of each situation the potentially critical encounters that you think can be distinguished, number these all.

Situations Tr 13, 14, 15, 16, 17, and 18

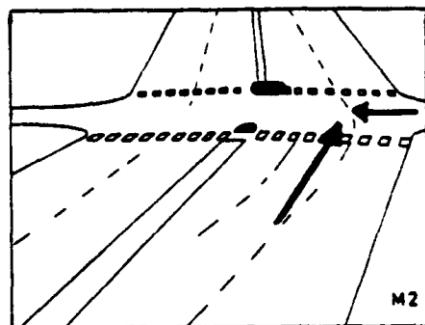


10.2.3 Collision course

An important element for detecting conflicts consists of the point whether or not road users are on a mutual collision course. A collision course implies that if none of both conduct a course or speed change, a collision will be the result. If a collision course is at hand, an evasive action has to take place to avoid a collision. However, an evasive action as such does not always imply that there has been a collision course.

Indicate if a collision course has been present in the following four situations Tr 19 through Tr 22.

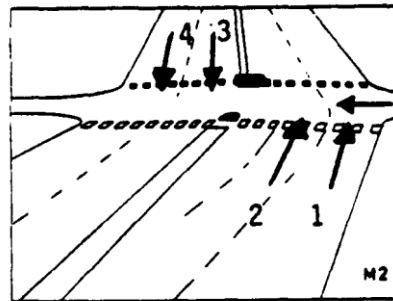
Situations Tr 19, 20, 21, 22



Collision course

Yes	No
-----	----

The following scene contains four encounters between a bicyclist who crosses from the right to the left and cars on the main road. Indicate for all four encounters if a collision course was present.



Collision course

1	
Yes	No

2	
Yes	No

3	
Yes	No

4	
Yes	No

10.3 Observation form

10.3.1 Procedure

For each observed conflict situation, the DOCTOR observation form has to be filled in completely (Figure II.5). The section on the upper part of the form is intended for providing information on the observer, the location under investigation, the weather condition, the condition of the road surface and the observing times. These data usually are filled in at the start of the observation period or changed during the observation when the circumstances change.

Severity of a conflict

The severity of a conflict is acquainted with a scale from 1 to 5 for a slight conflict to a very serious conflict, respectively.

For an observed conflict, first of all an overall impression is asked by giving a score from 1 to 5. Both the probability of an collision and the potential severity of the consequences if a collision would have occurred, have to be taken into account. In fact this deals with a combination of characteristics such as mutual speed differences, the available and necessary manoeuvring space, the approach angle, the types of traffic participants involved, etc. Moreover, very important, the time has to be registered as accurately as possible.

Some data that are registered on the observation form, serve as to correct the severity of a conflict, if necessary. Sometimes, it is possible that combinations of data that have been registered later on, lead to reconsidering the first estimate of the conflict situation.

Minimum TTC and/or PET

The probability of a collision is indicated by the estimation of the minimum TTC that occurs during the approach process. Apart from TTC-situations, also PET-situations may occur, or situations with both a minimum TTC value and a PET value. In those cases that a PET (also) is present, the estimated PET time is scored on the form.

Extent of consequences (Injury severity)

If a collision would have occurred, then an estimate has to be made of how severe the possible result of the collision could have been.

DOCTOR OBSERVATION SHEET		no:																												
OBSERVER WEATHER: sun <input type="checkbox"/> cloudy <input type="checkbox"/> rain <input type="checkbox"/> ROAD: dry <input type="checkbox"/> wet <input type="checkbox"/> DATE:	LOCATION: MUNICIPALITY: OBSERVATION-PERIOD:																													
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Figure II.5 The DOCTOR observation form.

It will be clear that a collision between a bicyclist and a truck may have a different outcome than a rear-end collision between two passenger cars. Besides, the speeds of the traffic participants play a role, as well as the character of the manoeuvre and, possibly, the involvement of a third road user. On the form, it has to be indicated whether the extent of the consequences (injury severity) would have been either very small, small, reasonably large, or large.

Conflict type

In this section, the road users involved have to be filled in. Attention please, that by means of an arrow is indicated who is approaching who.

Speed

The moving speeds of the road users involved is estimated just at the onset of an evasive manoeuvre. After all, indeed, if no reaction would have occurred, these speeds would have determined the severity of the consequences of a collision.

Evasive action

A number of aspects of the manoeuvre conducted, is registered (no reaction, controlled, uncontrolled, and type of action (braking, accelerating, swerving)).

Manoeuvre drawing

On a map of the location under investigation the traffic participants and their movements have to be sketched together with the indication which one is number 1 and 2, as well as the observation position of the observer.

Remarks

Apart from the sketch, the observer gives in his own words his opinion about the situation. From the sketch and this brief description is should be clear what the causation of the conflict and what possibilities for avoiding a collision there might have been. Also indirectly involved traffic participants that might have influenced the situation have to be indicated on the sketch and mentioned in the description of the possible cause.

At the end, the task of the team coordinator consists of checking that the observation forms are filled in as completely as possible.

10.3.2 Scoring by means of the observation form

The following series of situations on the training tape has the intention to consecutively practice the different steps in the scoring of a conflict, viz. a judgment of the overall severity, the probability of a collision, and an estimate of the possible consequences (injury severity). The latter aspect has to be based upon a number of aspects such as the speed of the party involved at the onset of an evasive action, the character of the evasive action (controlled or uncontrolled, braking, swerving, accelerating) and the types of road users (who is approaching who, vulnerability, time and space for reacting, necessary manoeuvring space, and the like). For these steps, a series is presented three times. Finally, a fourth presentation is given after which the observation form needs to be filled in one run.

The series consists of 21 situations, subdivided in 8 sub series. The sub series distinguish from each other by type of road user, and for the car – car situations according to the most important types of manoeuvres, see Table II.13.

Table II.13 Training series type of conflict and type of manoeuvre.

Subseries #	Type	Manoeuvre type	Number
1	Car – car*	Right-angle	3
2	Car – car	Left-turn	3
3	Car – car	Rear-end	3
4	Car – bicyclist**		3
5	Bicyclist – car		3
6	Car – pedestrian		2
7	Pedestrian – car		2
8	Bicyclist – bicyclist		2
Total			21

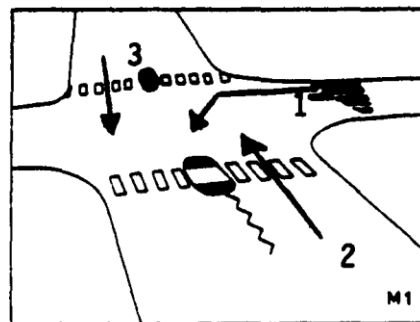
*car may imply both passenger car and truck/bus

**including moped

Severity of conflict situation

For the following 22 situations (Tr 24 through Tr 44), first of all a judgment is asked for the total severity of the conflict situation on a scale from 1 through 5 (1 is slight, 5 is very severe). On the answer form, the movement directions of the road users involved have been indicated already (see for example Tr 24). If necessary (according to the judgment by the instructor), after each sub series, in principle, the possibility exists to discuss the scores.

Situations Tr 24 through Tr 44



Severity conflict situation

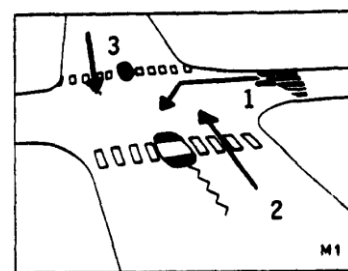
1	2	3	4	5
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Slight Very severe

Probability of a collision

The same 21 situations are presented again for giving a judgment of the probability of a collision by means of an estimate of the minimum time-to-collision (TTC) value and/or post encroachment time (PET) in seconds, see example.

Situations Tr 24 through Tr 44



MIN. TTC

0	0,5s	1,0s	1,5s	2,0s	>
---	------	------	------	------	---

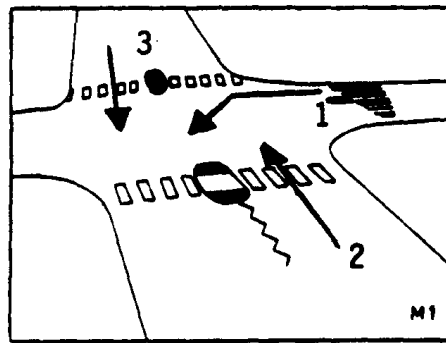
PET

0	0,5s	1,0s	>
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Extent of consequences (injury severity)

Tr 24 through Tr 44 are displayed once more to indicate the extent of consequences (injury severity) in case a collision would have occurred. This judgment goes from very small, small, reasonably large, or large.

Situations Tr 24 through Tr 44

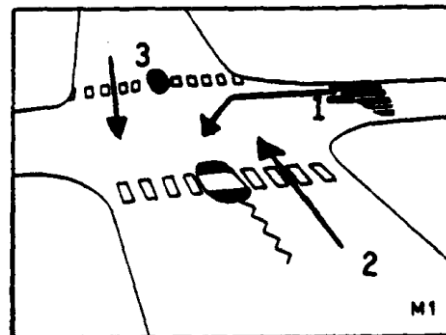


Extent of consequences (injury severity)			
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Very small	small	reasonably large	large

Conflict type, speed, evasive action

To specify the conflict type it is important to indicate who is approaching who. Furthermore, an estimate of the approach speed of both road users involved is asked for as well as the character of the evasive action (see Figure II.5).

Situations Tr 24 through Tr 44



10.3.3 Filling out the DOCTOR observation form

Finally, at the end of the training session the total series of 21 situations is shown once more with the intention to completely fill out the DOCTOR conflict observation form (see Figure II.5) at the end of each scene.

11 Testing of the observers

11.1 Selection of observers

Observers for the DOCTOR technique have to be selected and trained. Frequently, authorities such as municipalities make use of part-time employees to conduct simple measurements and observations in road traffic. It seems logical to hire these persons for conducting conflict observations as well. It is assumed that persons selected for conflict observer at least has a (technical) education at a HBO (Higher Vocational Education) level because of the complex observation task and the further analyses of the research data. Since, apart from an extensive training, also practicing experience is crucial on a regular basis, it is cheaper and more efficient to have a permanent observation team that can be operational more or less continuously, instead of having to search, select and train observers for each study separately. Moreover, attention should be paid to the handling, interpretation and reporting of the conflict observation data. Apart from his knowledge of the conflict observation technique, the supervisor of a team needs to have these additional skills.

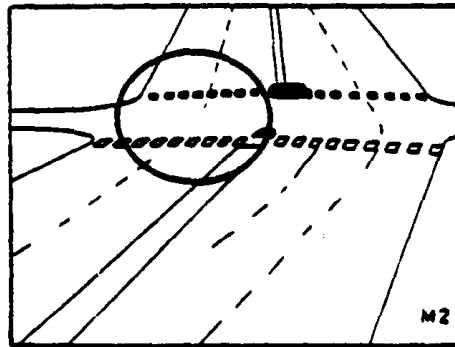
11.2 Test tape

At the end of the theoretical part of the course, a test is taken. Presumption for this test is that the course members have received an instruction and a training by means of the corresponding video tapes. The test is not intended so much to assess the level of the course members in an absolute sense, but to check whether the basic concepts and elements of the conflict observation technique have been understood and can be applied. The test takes place by assessing traffic situations from video. Explicitly, it is stated that the application of video is necessary to offer sufficient variation in the type of encounters under controlled circumstances. Video remains, however, a supporting tool. A training in the field is crucial to gain the proper experience in the systematic observation in practice. The training in the field situation should ultimately indicate whether observers are sufficiently qualified.

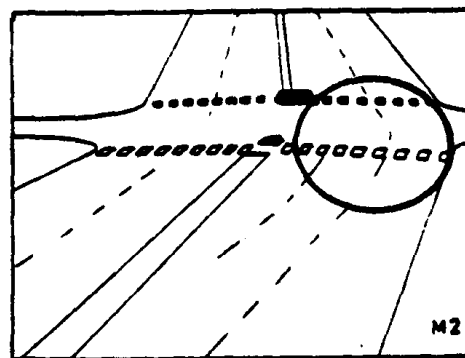
Because during the training for completing the full observation form, the situations have been presented several times, the actual test is preceded by a pilot series of 5 situations. During this pilot, questions can be dealt with, if needed. Following this series, the actual test takes place with in total 21 traffic situations on video. Contrary to the procedure followed in the instruction and training phase, the situations are presented in an arbitrary order, i.e. not structured according to type of conflict or manoeuvre.

To prevent that given situations will be overlooked completely, in advance of each scene, the place of occurrence in de video scene is encircled on a lay-out sketch of the intersection at hand, see below.

Pilot test Te 1 through Te 5



Test series Te 6 through Te 26



12 The field situation

For the set-up of a field study, one has to develop a plan in which the problem definition fits with the observation periods, observation location, manoeuvres to be observed, etc. Moreover, organisational matters, such as breaks, have to be arranged by the team leader.

The research plan may be based upon an accident analysis, complaints by neighbours, ideas of the police. It may be the case that either only some given types of conflicts are dominant/relevant, or that all possible conflict types have to be taken into account. The collection of additional information by the observers at the same time is not recommended as it interferes too strongly with the actual task of observing conflicts

12.1 Traffic counts

A conflict observations always comes together with traffic counts. Counts of the traffic volumes are needed to relate the number of occurring conflicts with the amount of traffic or the number of potential conflict situations (encounters). It is logical to conduct the traffic counts during the same days and hours of conflict observation. If it is not feasible for practical reasons to count traffic at the same time of the conflict observations, then the traffic counts should be done on corresponding days and hours. The conflict observer cannot conduct traffic counts by the conflict observer at the same time. For this a separate person is needed. Figure II.6 gives an example of a scheme of how traffic counts can be registered.

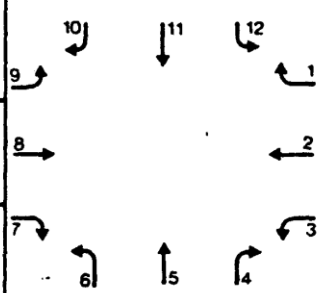
Location _____				Observer _____							
City _____				Organisation _____							
Date _____											
Observation period _____											
											
								← Truck/bus			
								← Passenger car			
								← Bicyclist/moped			
								← Other			

Figure II.6 Overview of traffic flows.

12.2 Observation periods

The choice of observation periods and observation length is important and mainly follows from the problem definition of the study. If the starting point is the availability of accident data and the observation is intended to be complementary, the following is important. If from the accident statistics reveal some patterns in given periods of the day, days of the week, months or seasons, then it is to be recommended to conduct the observations at the same time periods. Although morning and evening peak periods may have comparable traffic volumes, the directions of the traffic flows may differ as well as critical circumstances. For example, if most accidents occur

during August with holiday traffic, it does not make much sense to have observations in January. Even if more than two peaks in the accident pattern are identified at one given location, it does not necessarily mean that the causation factors are the same. Especially, this may yield for causation factors of night accidents. In general, these accidents should not be taken into account. In a before-and-after study design the observation periods need to be the same.

Remark

It is to be recommended to inform the police authorities about the intended study at a given location. In this manner, discussions at the spot with a supervising officer may be avoided and the police may easily respond to phone calls from neighbours. Moreover, it is recommendable to provide the observers with a legitimisation or a letter that explains the purpose of their activity at the spot, together with a phone number of a contact person if problems or discussions (for example, with the press) occur.

12.3 The weather

The weather is an important factor in the decision whether or not to observe. It may be that accident peaks have to do with extremely bad weather in a relative short period of time (for example, black ice). Most of the time, it is not sensible to continue observations in these periods, unless this is the relevant research factor. Rain or wet road surface does not need to withhold a study, because these may be rather regular conditions, and, consequently, accidents also occur in those circumstances. However, in evaluation studies, the weather conditions should be as much as possible similar to the period in which the accidents were collected.

12.4 Number of observers

In the set-up of a conflict study, the location under study should be looked at from the standpoint of the safety of the observer, the overview an observer has of the location, as well as the necessary number of observers. Important, is also that the observer is noticed by road users as less as possible. Dependent on the size and complexity of the location under study, one to four observers may be applied. If only one traffic stream or one leg of an intersection is investigated, usually one observer may suffice. The time between the conflicts is most of the time sufficient to make the required notes. Also at quiet intersections in residential areas, usually one observer will suffice. At intersections of access roads or arterials, two to four observers may be required, dependent of the amount of traffic, complexity of the traffic situation and manoeuvres to be studied. If a four-leg complex intersection is studied, it is recommendable to let the observers change position now and then to avoid one-sided workload on the person. This may also be used for assessing possible differences among observers. If observing with more than one observer, then it has to be settled how observations and observation areas between them are split up to avoid that conflicts may be counted double (for example, see Figure II.7).

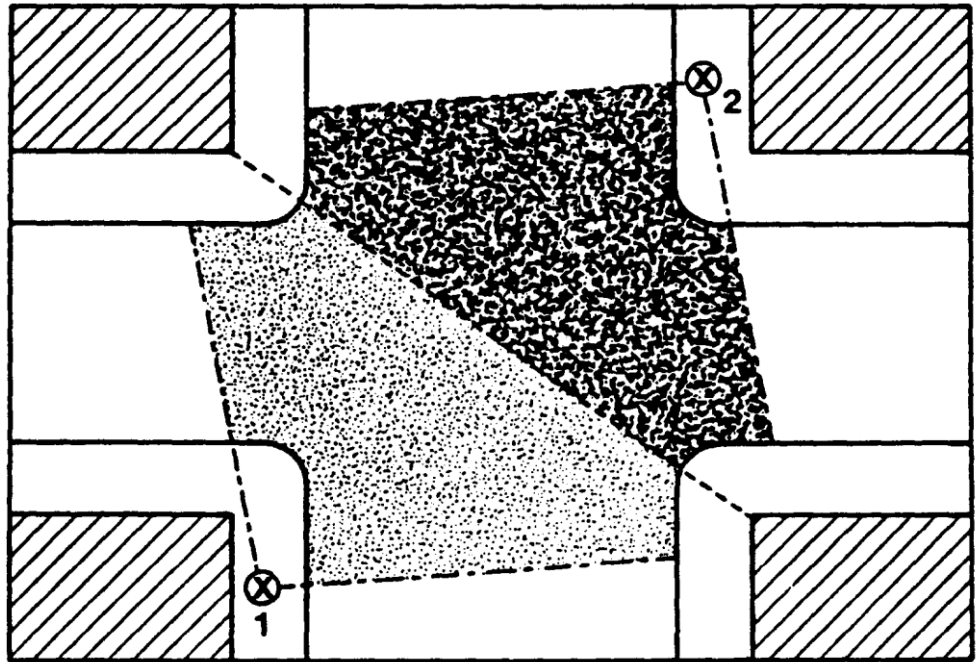


Figure II.7 Example of splitting up the observation area with two observers.

It also is possible to observe specific traffic streams, see Figure II.8. Conflicts that have been scored by more than one observer, should then be selected on the basis of the description and the time of the conflict occurrence (see the observation form) such that they are represented in the final data only once.

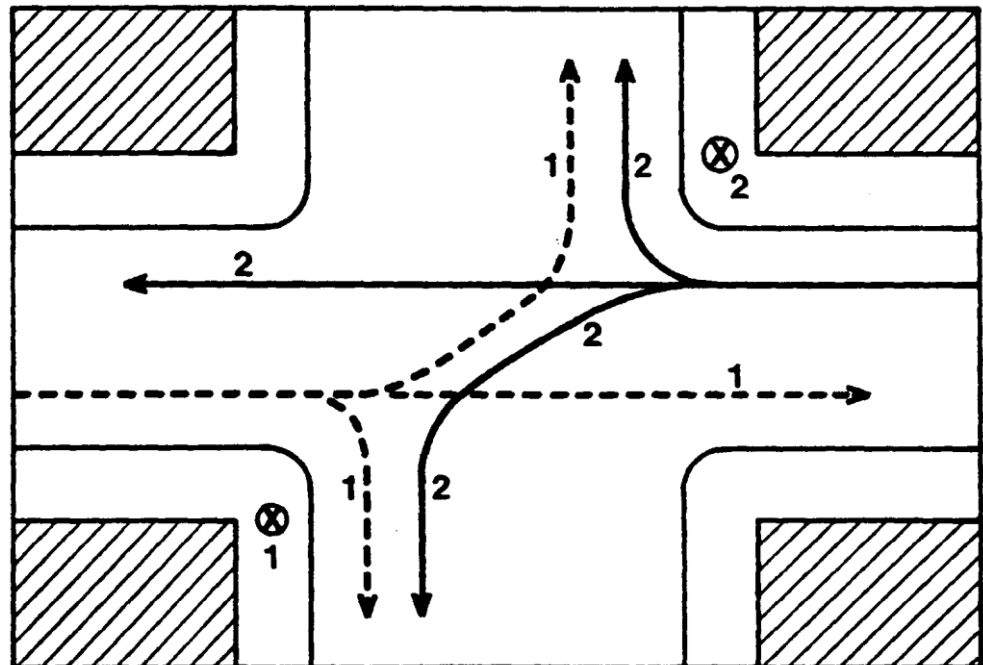


Figure II.8 Example of splitting up traffic streams.

12.5 Observation area

The observation area needs to be clearly defined. The size of the observation area is dependent on the research question. For example, if it relates to a sub problem of an intersection, such as right-turning bicyclists from a minor road and their conflicts crossing pedestrians, then only a specific part of the intersection needs to be observed with consequences for the number of observers and the observation position (see Figure II.9). It is recommended to draw the observation area on the situation sketch of the observation form.

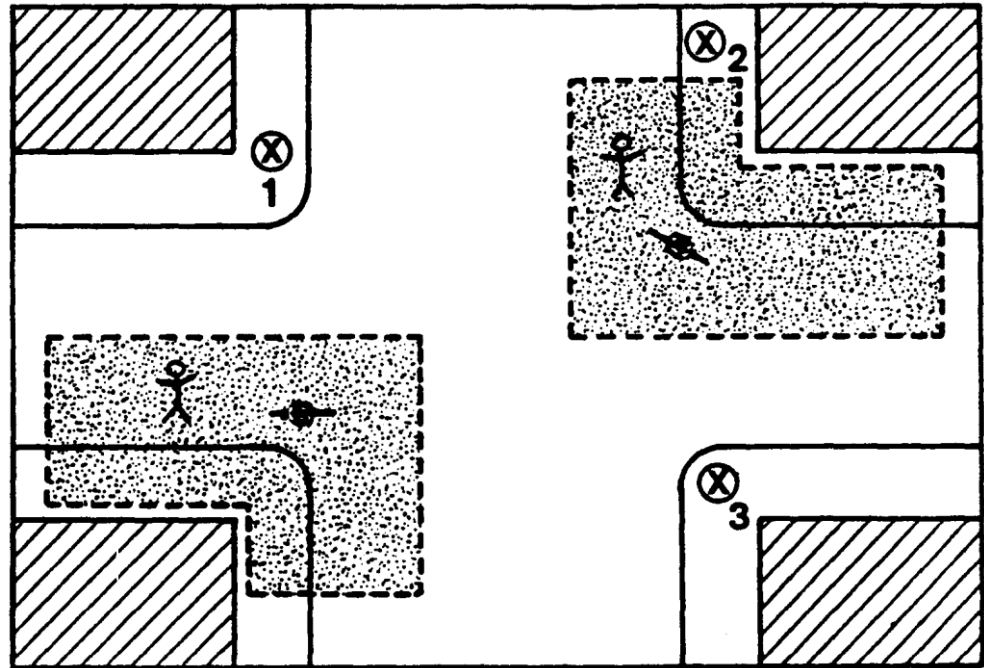


Figure II.9 Example of the area under investigation.

It is important that the observation area and the traffic within it, can be easily overviewed by the observer. If needed, the observer for the left observation area in Figure II.9 may choose position 1, 2 or 3. For understanding the occurrence of a conflict, it is obvious not to limit the observation area too narrow.

If conflict observations have the aim to provide complementary information over accident data, then only the conflicts that coincide in the corresponding areas have to be counted. As an example, in Figure II.10 the conflicts 1, 4, and 5 are not worked out, contrary to the conflicts 2 and 3 in the research area.

12.6 Observation position

In general, the observation stand point should be chosen such that the traffic situation can be overviewed from the view point of the traffic participant (see for example, the case of rear-end conflicts in Figure II.11). The view is taken that observations take place from a standing position. From the problem definition of the study it is derived which traffic behaviour from which direction and from which standpoint should be observed. The observer takes a position that always is located outside the observation area itself. Moreover, he/she tries to choose a position that

is unobtrusively as much as possible to avoid influencing the behaviour of road users. It is not recommended to take a higher position (for example, on a balcony of an apartment building). Relevant aspects of the traffic process may be lost; think of noise, head- eye movements etc..

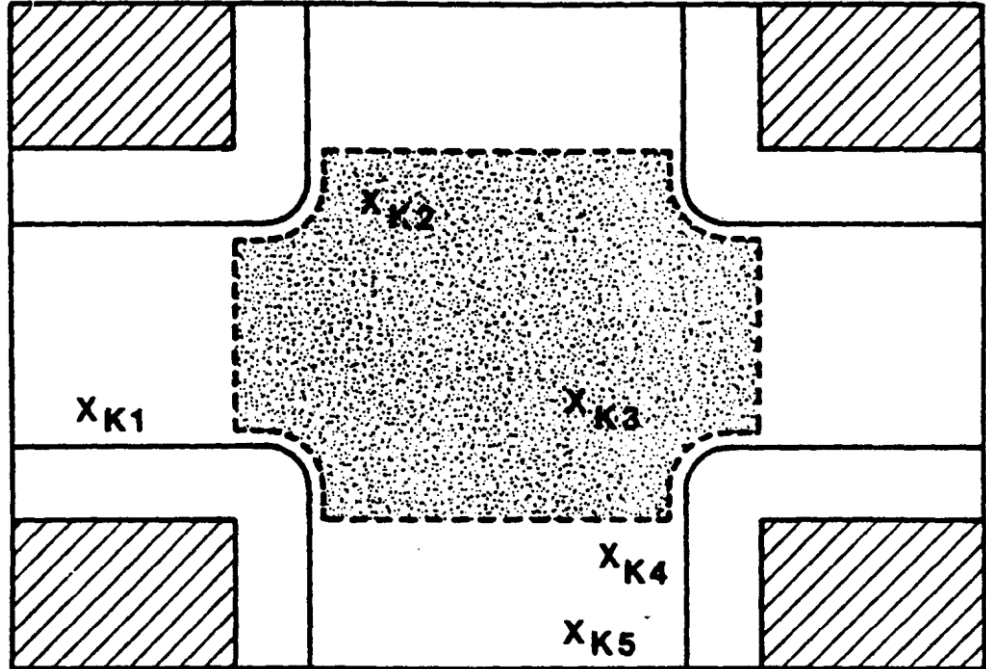


Figure II.10 Example of the research area.

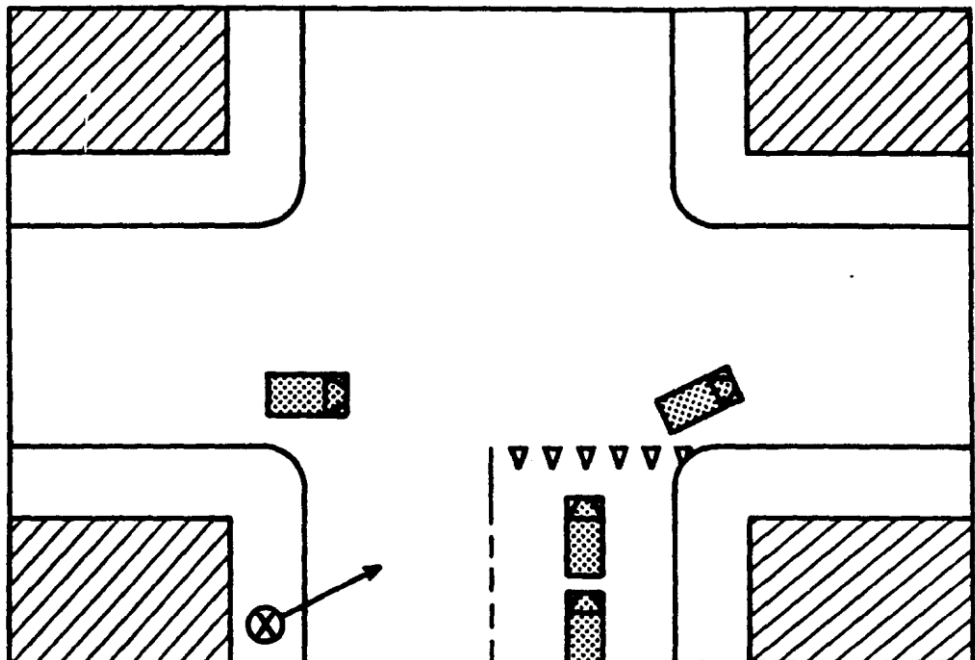


Figure II.11 Example of the observation position of an observer.

12.7 Length of observation period

The problems of a traffic situation may be investigated more reliably and detailed, according as a longer period is being observed. How long one has to observe at a given location, is a point for discussion. Two aspects count in this:

- The length of the period of observing an location needed to account for accidental or systematic fluctuations in a sufficient manner (representative measuring period).
- The length of the period needed to get a good insight in the traffic situation to determine a diagnosis or to assess the effects of counter measures in a before-and-after study.

Moreover, the specific problem definition in each study plays a role. It makes a difference whether one wants to evaluate a whole intersection or only a left-turn manoeuvre. From an US study (Glauz & Migletz, 1980) it appears that the observation length to get a reliable number of conflicts/hour, may differ from 3.5 hours for all conflicts from one direction till 30 hours for conflicts for left-turning and straight-going traffic (see Table II.14).

Table II.14 Guidelines for data collection amounts (Source: Glauz & Migletz, 1980).

Conflict Category	Mean Hourly Count	Hours of Observation*
Left-turn, same direction	7.14	4.6
Right-turn, same direction	4.89	5.1
Slow vehicle	3.21	5.9
Opposing left-turn	0.77	21.6
Right-turn from right	0.71	23.9
Cross traffic from right	0.31	39.3
Left-turn from right	0.59	24.5
Left-turn from left	0.78	18.1
Cross traffic from left	0.39	30.0
All same direction	15.48	3.4
All cross traffic from left	0.82	20.0
All cross traffic from right	1.45	14.8

* Hours of data required to estimate mean hourly count within \pm 50% with 90% confidence.

The Swedish technique has a standard observation length of 3 days or 18 hours, on which corrections are possible, dependent on the amount of traffic and the problem definition of the research Mattson, 1983). From the German guidelines (Erke & Gestalter, 1983) it appears that with an observation length of 12 hours on one day a reliability coefficient of 0.83 may be reached. The reliability increases with an observation length of 24 hours towards 0.91 till 0.95 for an observation length of 60 hours. Oppe (1980) demonstrates that, based upon traffic counts, formulas for enlarging tests in psychological test durations may be perfectly applied to this type of problems. Apparently, in France, one wants to exclude systematic or random effects, since the French technique observes a location from Monday till Friday. Hauer (1977) states that a small increase in the reliability quickly minimizes with an increasing observation length. He concludes that relatively little is gained with observations longer than three days.

For a field study, of course, it is important to make the distinction between an evaluation study and a study focussed only on the making of a diagnosis. In general, however, the following procedure may be applied to answer the question of the observation length. Starting point is the question how many conflicts one can expect in a period of 18 hours (for the DOCTOR technique, a standard duration of 18 hours is applied). This estimate of this number is reasonably to make after one day of observing (6 hours). After the first day, one may decide either to finish the observations and to stop the field studies, or to adapt the observation period or keep it on 18 hours. If one wants to make the decision how long to observe beforehand, and not after one day of observing, then the information from Figure II.12 and II.13 may provide guidance. However, this is only a rough estimate that may be more or less appropriate, dependent on the situation.

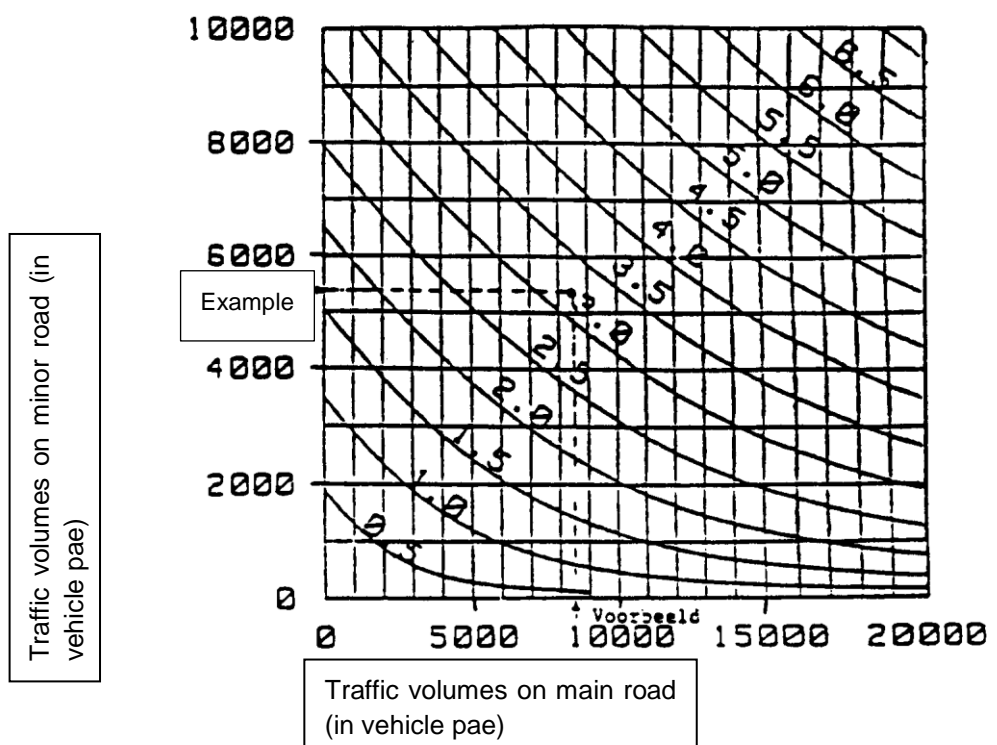


Figure II.12 The expected number of serious conflicts for a two-hours observation period at a *four-leg* intersection with a main and a minor road situation.

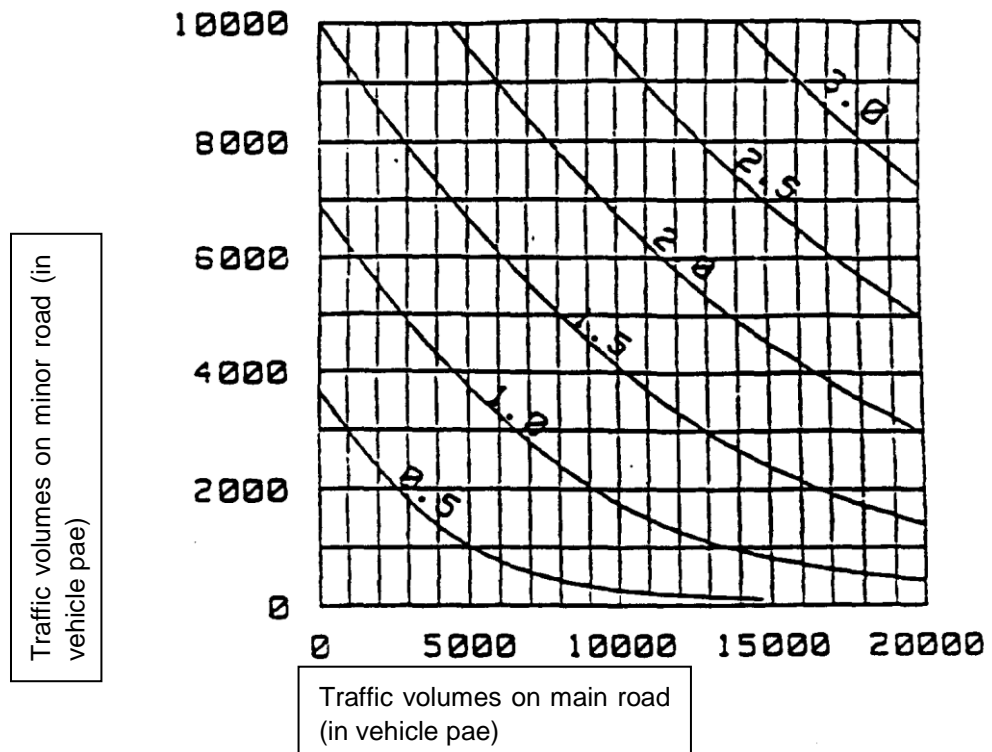


Figure II.13 The expected number of serious conflicts for a two-hours observation period at a *three-leg* intersection with a main and minor road situation.

Example: At a four-leg intersection, daily 8.500 vehicles arrive via the main road and 5.400 vehicles via the minor road. The expected number of conflicts for a two-hour observation period, then is 3.25. In 24 hours, 39 conflicts are expected to occur.

If the effects in a before-and-after design study are being collected, then one wants to know when a significant effect occurs. Table II.15 gives an overview (Gstalter et al., 1981) of the number of events in the after study (N) that significantly differ from the number of events in the before study (V) by a significance level of 1%, 5%, or 10%, respectively. In the situation with 40 conflicts in the before period, a number of 25 conflicts or less can be regarded as significantly lower at a 5% level. Only to determine whether a reduction is present, a reduction in the number of conflicts of 40% is needed.

In Table II.16 four examples are given of measuring results from field studies. Based upon the available data, some remarks will be made.

Example 1: In total, 8 conflicts were scored during one day of observing. On the basis of this number, a systematic evaluation of the measure is not possible, unless the situation in the after situation is much worse. For a three times longer observation period of 18 hours (the standard period), according to expectations, 24 conflicts would have taken place. So, a statistical evaluation study would be possible under the condition that the before period is enlarged with two days to get a reliable image of the situation. If one only uses the number of conflicts of one day and this number multiplies by three to get the estimated number for three days, then it may be difficult to qualify an occurring difference as meaningful.

Table II.15 Tables for proofing significant differences of Poisson distributed variables (Gstalter et al., 1981).

v	1%	N 5%	10%	v	1%	N 5%	10%
0	/	/	/	51	29	34	37
1	/	/	/	52	30	35	38
2	/	/	/	53	30	36	39
3	/	/	/	54	31	37	40
4	/	/	0	55	32	38	41
5	/	0	0	56	33	39	42
6	/	0	1	57	33	39	43
7	0	1	2	58	34	40	44
8	0	1	2	59	35	41	44
9	0	2	3	60	36	42	45
10	1	3	4	61	37	43	46
11	1	3	4	62	38	44	47
12	2	4	5	63	38	44	48
13	2	5	6	64	39	45	49
14	3	5	7	65	40	46	50
15	3	6	7	66	41	47	51
16	4	7	8	67	41	48	52
17	5	7	9	68	42	49	52
18	5	8	10	69	43	50	53
19	6	9	10	70	44	50	54
20	6	10	11	71	45	51	55
21	7	10	12	72	46	52	56
22	8	11	13	73	46	53	57
23	9	12	14	74	47	54	58
24	9	13	15	75	48	55	59
25	10	13	15	76	49	56	60
26	11	14	16	77	50	57	60
27	11	15	17	78	50	57	61
28	12	16	18	79	51	58	62
29	13	16	19	80	52	59	63
30	13	17	19	81	53	60	64
31	14	18	20	82	54	61	65
32	15	19	21	83	54	62	66
33	15	20	22	84	55	63	67
34	16	20	23	85	56	63	68
35	17	21	24	86	57	64	69
36	18	22	25	87	58	65	69
37	18	23	25	88	59	66	70
38	19	24	26	89	59	67	71
39	20	24	27	90	60	68	72
40	21	25	28	91	61	69	73
41	21	26	29	92	62	70	74
42	22	27	30	93	63	71	75
43	23	28	31	94	64	71	76
44	24	29	31	95	64	72	77
45	24	29	32	96	65	73	78
46	25	30	33	97	66	74	79
47	26	31	34	98	67	75	79
48	26	32	35	99	68	76	80
49	27	33	36	100	69	77	81
50	28	33	37				

Table II.16 Some examples of observations in field studies in The Netherlands.

	Location	Observation length	Conflicts	
			Serious	Slight
1	Kamperweg – Klaverweg (Heerde)	6 hours	2	6
2	Kerkenbosweg – schooluitgang (Zuidwolde)	2 hours	0	1
3	Sportlaan – Joubertstraat (Gouda)	6 hours	8	3
4	Baden Powelstraat –Ophijslaan (Den Bosch)	6.5 hours	36	4

Example 2: One day of observation during school hours, resulted in only 1 slight conflict. In this situation, it does not make sense to continue an evaluation study, unless one is prepared to take the risk of a very long measuring period.

Example 3: In this case it is sensible to conduct a diagnosis of the traffic situation, especially, because the serious conflicts dealt with the same traffic participants and manoeuvres. If, after three days of observation, a stable image of the problem shows up, an evaluation study is possible.

Example 4: One day of observing resulted in 36 serious conflicts. That is much for a residential street, but it has to be mentioned that this location was identified as an accident black spot. This traffic location lends itself to both a diagnosis and an evaluation study under the condition that for an evaluation study the before period is extended with two days. Whereas in the previous examples only judgments could be made about the whole traffic situation as such, in this example it seems possible also to make a subdivision by traffic participants, manoeuvres, etc.

In the DOCTOR technique observations take place during 18 hours per location, spread over three days. The time schedule for the observations might be as follows:

07.30 – 07.55 hours	12.00 – 12.55 hours	15.30 – 16.25 hours
08.00 – 08.55 hours	13.00 – 13.55 hours	16.30 – 17.25 hours
		17.30 – 18.30 hours

In this manner, in usual studies with conflict analyses, the most important time periods in which accidents occur, are covered (see Figure II.14).

As observing is a rather intensive and loading task, it is recommended to let an observer, on average, observer not longer than 4 hours with a maximum of 6 hours. This implies two observers per observation position for an 8 hours observation day.

12.8 Estimating speeds

For conflict studies, a conflict observer should be able to make a good judgment and registration of the speeds of vehicles. For this, a training in the field is needed for estimating speeds. The estimates of the speeds are compared with values from a measuring instrument (for example, a portable speed gun). In general, an observer is functioning well if his estimates do not differ more than 20% from the measured value.

To provide the observer with a good 'feeling' with which speed a vehicle is driving, he will be trained at locations with legal speed limits of 50, 80 and 100 km/h. It is also important to estimate speeds of vehicles with an extreme low and extreme high speed. This is especially the case for low speeds at intersections with turning vehicles. For pedestrians no speeds estimates are conducted as speeds of pedestrians usually lie within a very narrow interval.

Where possible, speeds are estimated of vehicles with movements

- Towards the observer
- Away from the observer
- Perpendicular to the observer.

As conflict studies are being conducted at a given location, it may be useful to learn estimating speeds at this location, or on places with comparable circumstances and speeds.

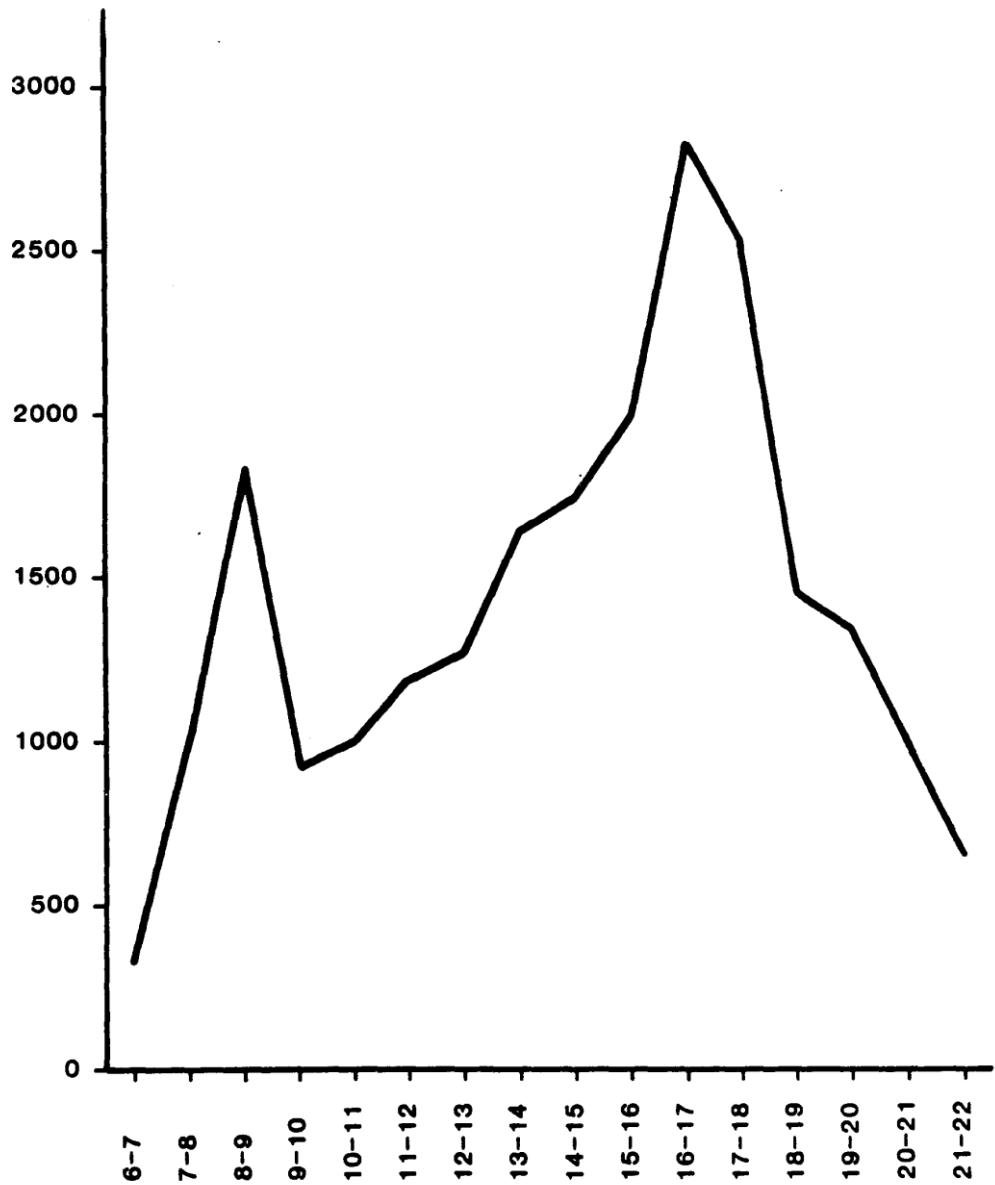


Figure II.14 Number of injury accidents on weekdays in 1982 by time of day.

13 The analysis of the data

13.1 General

Representativeness and reliability of the data are important issues in the analysis of observed conflicts. Systematic deviations may occur in determining the numbers of conflicts, for example, because one is only measuring during a limited measuring period, or only on weekdays, or only in spring. Also random deviations may occur. The random errors may be caused by not foreseen disturbances in the design of the study, such as a market day, or a procession, a road closure, etc. Systematic errors and random errors can only be dealt with by adapting the study design. Central question is a measuring period representative for the situations one want to investigate. Statistical tests cannot solve these problems. At most, it may be concluded that a given disturbance has had a significant effect on the observations.

If the measuring period is considered to be representative, then also other accidental factors may influence the results of the observations. Variable sources may consist of fluctuations in the traffic itself resulting in encounters or not. Only by an encounter one may speak of a potential conflict. Upon such coincidences one cannot adapt the research design. Moreover, even trained observers may overlook situations or not always interpret unambiguously. The size of both fluctuations in number of observed conflicts can be identified by applying the Poisson distribution to determine the reliability borders of an observed number of conflicts. The same approach is often used for accident numbers. Also for this, similar error sources may apply. Because a Poisson distribution yields for both conflicts and accidents, it is possible to relate both in a statistical manner. To make judgments about the reliability of observed numbers of conflicts or to determine effects of counter measures in a before-and-after study by the conflict method, the same approach can be applied as in accident studies. An excellent overview of commonly used elementary statistical tests for the problems as dealt with here, can be found in the Manual Approach Traffic Accident Concentrations (AVOC) (V&W, 1979). In this document, one may also find reliability boundaries for observation numbers based upon the Poisson distribution.

Finally, we discuss alternate statistical analysis approaches for more complicated problem statements. We limit ourselves to a brief general description together with references to the corresponding statistical literature. A more extensive treatment does not fit in this manual.

13.2 Analysis of cross tables

In the AVOC manual one limit oneself for practical reasons to a cross table analysis of two characteristics with each two classes (before/after study with experimental and control location), for which a chi-square test is used. A first extension is the one with characteristics with more categories (for example, experimental locations, interacting areas, control locations, for which the chi-square test can be conducted as well. How to do this, can be found in each statistical handbook.

13.3 Analysis of small numbers of observations

13.3.1 Exact tests

Less trivial for this, is the extension of applying the exact Fisher test (to be used for small numbers of observations) on larger tables than 2x2 tables. A description may be found in Verbeek and Kroonenberg (1984). In exact tests one takes the marginal frequencies in a table, and given these frequencies, all possible tables are generated. The next step consists of checking how many of the possible tables are even extreme or more extreme than the factual observed table. The proportion extreme tables exactly reflect the probability of an extreme table if one is randomly chosen. Besides, the rules of thumb from Cochran (1952) apply to determine the boundary values for too low numbers of observations for a reliable chi-square test, although recently some refinements are made on a number of aspects.

13.3.2 Monte-Carlo method

Sometimes, it is not feasible and realistic to account for all possible tables since a fast computer would need days to find all tables. In that case, by means of the same border frequencies the probability of an observation in each cell is often estimated. Next, given these probabilities, tables are generated by means of a random test sample. For each table, the χ^2 -value can be calculated. Instead of testing the χ^2 -value of the original table with the help of the theoretical χ^2 - distribution as usually is applied for large numbers, this χ^2 -value is tested against the distribution of χ^2 -values as generated by the Monte-Carlo method. With his test it can be determined whether the original table is plausible given the null-hypothesis. This procedure can also be found in Verbeek and Kroonenberg (1984).

13.3.3 Bootstrap method

A rather recently by Efron developed method is the bootstrap method (Efron, 1981). In this approach, one does not start from a theoretical chance distribution as is the case with the Monte-Carlo method, but takes the original test sample as a starting point. The test sample is considered as a population, from which a test sample is taken with replacement. The resulting test sample then can be converted into a table for which a χ^2 -value can be calculated. Applied to cross-tables, in fact, this comes down to a Monte-Carlo study for which the probabilities per cell are not derived from marginal frequencies, but from the cell frequencies found. In this manner, it is possible for log-linear analyses of tables with small numbers, to give reliability estimates of analysis results that also apply for marginal distributions.

13.3.4 Higher-order cross-tables

For a number of problems tables with more than two characteristics apply. For example, this is the case if in a before-and-after study a distinction is made between different types of conflicts. In such cases one may make use of log-linear analysis techniques. In almost all well-known statistical packages this option is available. Specific packages are Ecta (developed by Goodman, 1978) and GLIM (developed by Nelder & Wedderburn, 1972). With log-linear techniques also trends in numbers may be investigated. An excellent description for practical use can be found in Goodman (1973).

13.4 Weighed numbers

Often, one does not want to directly compare conflicts mutually, but only after a correction has been made. For example, if the length of the observed time periods is different, or if one wants to compare the number of conflicts per encounter among locations or by type of conflict. Then, a chi-square analysis cannot be applied just like that. If the correction factor for each situation is a constant such as the time factor (that, of course, may differ from situation to situation), then the chi-square test can be adapted such that it enables a comparison of the ratios. If, for example, one would like to correct for the number of encounters, then one may apply this method as well if the number of encounters is an order larger than the number of conflicts. Actually, it is not really a constant, but in practice it may be applied. Description of this approach may be found in Andersen (1977), Hamerslag (1977), De leeuw & Oppe (1976). Some statistical packages for log-linear analyses include this option.

13.5 Comparison between accidents and conflicts

In this case, it is practically not possible to apply the method of correction. Instead, both tables may be compared to see in how far they are equal except of a constant factor. Goodman (1973) gives an example of this approach based upon log-linear analysis techniques.

13.6 Presentation of observation data

Many options are available for presenting observation data, dependent on the specific problem statement for the topic of research. An example of the manner the presentation of observations may be found in Van der Horst and Kraay (1985).

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Appendix 1: Set-up of a training week

Day 1 morning:

- Introduction
- Discussion Manual Part I

Day 1 afternoon:

- Discussion Manual Part II, chapter 1 and 2; Instruction tape

Day 2 morning:

- Training by means of video, Part II, chapter 3; Training tape

Day 2 afternoon:

- Test of observers; Test tape

Day 3 morning:

- Discussion field situation, Part II, chapter 5
- Analysis of observation data, Part II chapter 6

Day 3 afternoon:

- Field training (estimating speeds; conflict observations for two hours); video is running simultaneously

Day 4 morning:

- Discussion of observations previous day

Day 4 afternoon:

- Field training, same as Day 3

Day 5 morning:

- Discussion of observations previous day

Day 5 afternoon:

- Discussion and summary
- Evaluation forms

Appendix 2: Overview literature TNO

Papers and articles

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