BACKGROUND AND DEVELOPMENT OF THE CONFLICT METHOD

Contribution to the report of the International calibration study on traffic conflict techniques, organised by ICTCT - the International Committee on Traffic Conflict Techniques, Malmö, May 30th - June 10th 1983.

R-83-54
Joop H. Kraay, research sociologist
Siem Oppe, research psychologist
Leidschendam, 1983
Institute for Road Safety Research SWOV, The Netherlands

BACKGROUND AND DEVELOPMENT

1. Introduction

The interest of authorities in traffic safety investigations, both on national and international level, undoubtedly moves to an increasing extent towards the traffic safety problems arising in built-up areas. Their concern is mainly concentrated on subjects like traffic unsafety in (older and newer) residential districts, in the surrounding of schools, on bicycle lanes in town centra and on the consequences of the redesigning of certain streets and entire residential districts.
There is a lot of uncertainty about the safety control in these areas and about the effect of safety-countermeasures taken. Therefore there is a need for research on safety problems and quick evaluation of safety-countermeasures.

Conflict observation is a way of looking at the unsafety of particular locations or situations in traffic. Unsafety as such is not visible. We call a location unsafe if the probability of an accident is too high. Accidents are rare events and can seldom be systematically observed. The accident potential is still harder to get at. We may arrive at a statement about unsafety from several sources.
Sometimes a general theory about traffic safety is applied to situation and leads to statements such as "This particular lay-out of the intersection causes too much risk to the cyclists coming from the right". In this case the statement is assumed to be proven in general and applicable to the situation under investigation.
In general, traffic safety theory cannot be confirmed unambiguously and statements like the above ones must be regarded as hypotheses that need confirmation. More often one derives the unsafety of a location from empirical evidence. The frequency of accidents in the past is used to estimate the probability of an accident.
In many cases however the accident frequency is too low to permit reliable estimates and additional information is needed to get a more reliable statement about the unsafety of a location.
A typical feature of residential districts is the low figure of traffic accidents in general which, as a rule, occur in a wide range of the investigation area.

The annual figure of traffic accidents is also rather low on through-going roads in the interior of built-up areas and even on "black spots". In addition to the aforementioned remarks about the prevention of traffic accidents, the following comments can be made upon the mode of recording them:

- Accident data only provide information on recorded accidents. Thus, for ex. not more than about one third of the accidents taking place in the Netherlands are being recorded (SWOV, 1976). The recorded accidents cannot claim to be sufficiently representative: some types of accidents are overrepresented, while others are underrepresented.
- It is sometimes impossible to get sufficiently reliable data from the relatively small number of recorded accidents. The period of time necessary for gathering together the amount of accident data required for statistical analyses is more often than not, too long. During such long periods of time the conditions and circumstances under which the accidents occurred, may have changed.
- The present standard recording system comprises (as yet) no detailed information about all the facts of the accident, for ex. about manoeuvres which had been carried out prior to the accident.

The indicated situation has already been fully described on national and international level.

A logical consequence of the aforementioned issues is that there is no suitable methodology for carrying out in some cases small-scale studies of accidents occurring within built-up areas. Thus, it is not surprising that attempts are being made to replace the accident with another means of measuring.

Conflicts that are observed during a short period of time are often used as if they were accidents, in order to estimate the accident potential. Therefore the conflict technique is sometimes regarded as a surrogate measure for accidents, used to detect the unsafety of locations or situations.

However, even if the conflict technique can be used for the detection of unsafety, this is only the first step in the process of unsafety analyses. Much more important is what happens after the detection.

In order to improve safety, one has to analyse the problem and find the causes of unsafety and how these causes are provoked. In most cases accident histories are scarce and far too incomplete to be used for these deductions, even if we use in-depth studies.
Observation of traffic behaviour at locations that are found dangerous (black spots) may clarify the safety problems and lead to effective safety measures. If we look at the traffic conflict analysis technique as a behavioural observation technique, it becomes clear that the technique is useful not only for the detection of dangerous situations, but also for the analysis of safety problems.

Based on the aforementioned it can be concluded that the conflict method is suitable for establishing traffic unsafety on different locations, in special traffic situations, under various conditions, in case there is no (or not enough) information available about traffic accidents or in case the information cannot be depended upon.

2. Definition of conflict behaviour

Traffic unsafety is the result of the various risks road-users are exposed to, take or cause if they take part in traffic. In general, traffic risk can be defined as the personal or material damage that may result from the decisions road-users take on being involved in particular situations or on encountering with other road users. In order to control risks, one has to know first which dangerous decisions are taken and in which situation or under what circumstances these (conscious or unconscious) decisions are inspired or made.

The study of dangerous traffic behaviour is fundamental for a good understanding of traffic unsafety. This study starts with the observation of behaviour and the context and the circumstances of that behaviour. Because "the dangerousness" of the behaviour as such is not visible, an evaluation and interpretation of the situation is needed in order to detect "dangerous traffic behaviour".
Because of the subjectivity of such an evaluation and interpretation it is necessary to define strict observation rules to obtain objective data. Scoring rules must be made explicit in such a way that there is an unam-

biguous mapping of cues in conflict severities. This implies more than agreement between observers only.
The traffic conflict analysis technique may be regarded as a technique that permits the systematic observation of dangerous traffic behaviour (conflicting behaviour). There are various conflict techniques, each using its own observation rules. In order to compare results from different conflict techniques, one has to know how the technique has been used and from what kind of situations the data have been obtained.

The first question is, what kind of situations a special investigator is concerned with, or state otherwise, what is and what is not a conflict. The second question is, how dangerous is the situation he observed, or how serious is the conflict.
One may have different aims in defining a conflict. It is possible to give a global demarcation of the concept and to define the "universe of discourse". It becomes more interesting however if someone tries to give an operational definition of a conflict, in order to state the detonation of the concept instead of a connotation.

An operational definition is a rule to separate conflicts from non-conflicts. During the first International symposium on Traffic conflict techniques in Oslo, 1977, conflicts were defined as follows: "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 seems to encompass the universe of discourse, but is was primarily meant as an attempt to define a conflict operationally. In fact, Perkins & Harris (1968), in their now classic paper, also used such a broad operational definition of a conflict. Their definition is unambiguous and easy to apply to car-to-car conflicts. In practice, however, the conflict technique has been used with regard to various situations and each time a different operational definition has been given.

The following aspects in an operational definition are of importance:
- The investigation mostly regards only one aspect of traffic safety, e.g. the safety of children, pedestrians, intersections, serious accidents etc. Only those kinds of conflicting behaviour are classified that are relevant for the aspect under consideration.

- There is a variety of observation methods. With more subjective methods we find terms such as "sudden behaviour" or "evasive action" as part of the definition, terms that presuppose a judgement of the observer. Objective methods use terms like "time-to-collision" (TTC) or "post-encroachment-time" (PET), terms that refer to recording apparatus.
- There is more or less differentiation in relevance of conflicting behaviour. Terms like "serious" and "less-serious" conflicts have been used, referring to the difference in accident potential. The seriousness dimension is seldom specified - and if so - usually one dimensionally (sudden action or not, short or long TTC, etc.). Only in a few investigations we can use more aspects (including qualitative aspects such as the kind of road usage), to define the severity.

If we regard the conflict analysis technique as a systematic way of observation and investigation of risky interactive traffic behaviour, the most important question is which aspects of traffic behaviour are dangerous in which situations. The usefulness of the conflict analysis technique does not, (as it is often stated,) depend on the extent to which accident numbers are correctly predicted but on the possibility whether safety problems can be detected or not. The prediction of accident numbers is often unrealistic due to (statistically speaking) their rare occurrence. Validation of conflict techniques with regard to accident numbers will always be difficult, especially in situations where there is no dense traffic. This kind of validation is not the only one. Another validation procedure that primarily regards the fundamental issues of traffic unsafety is much more important. Special attention must be given to the confirmation of the conflict analysis technique as a theory about risky interacting traffic behaviour, thus the confirmation of a theory that tells us which behaviour is dangerous in which situation.
To do this, it is not enough to classify observations as conflicts. One has to specify the seriousness of the conflict with regard to the accident that may result from it. In order to do this, one has to state the relevant cues and the weight these cues have with regard to the seriousness of the conflict.

The calibration experiment is the first international effort to arrive at such a better understanding of danger in traffic. First we have to know

what a specific investigator is doing and how his doings are related to interactive traffic behaviour. This is a premise of understanding the results of his work and of relating these to ones own findings.
If we take the seriousness of conflicts into account, the problem of finding a useful operational definition of a conflict will be translated into the assessment of the determinants. Knowledge of the relation between interactive traffic behaviour and safety is needed in order to state the degree of dangerousness of conflicts: the explanation of traffic unsafety in relation to traffic behaviour. Once this relation is established, safety measures may be directed to the limitation or complete removal of serious conflict behaviour and the replacement by safe behaviour. In-depth studies of serious conflict behaviour as a tool for safety analysis are not yet well established.
In many cases one does not have the intention to accomplish a safety analysis, but as mentioned before, one will use the conflict technique only to state the degree of unsafety of a location (absolute or relative, with regard to other locations). However, also in later case, the seriousness of conflicts is of importance.

3. Application of the conflict method

In practice, the choice of an operational definition of the term "conflict" seems to depend to a far extent on the aim which has to be achieved by the conflict method. There are already several definitions in use. The most frequently occurring elements of the definitions are: the kind of manoeuvre and the risk the road users are exposed to be the manoeuvre; the proximity of involved vehicles in time and space; the speed of the vehicles and the changes in their speed; the vehicles' direction of motion and changes therein, furthermore the various categories of traffic participants. These elements are usually applied in combination. In most studies conflicts are also classified according to the degree of severity.
Based on a General Motors investigation (Perkins & Harris, 1968), in most American studies the switching-on of the brake lamps and/or the change of the lane are regarded as conflict criteria. However, these criteria do not distinguish clearly minor accidents from severe ones, since the brake lamps are switched on not only on energy stops, but during normal braking manoeuvres as well.

The risk of accident in a given situation depends on the time which is at the driver's disposal for preventing a collision.

A previously established time interval, as an indicator of the severity of an accident, can only be built in the definition of the conflict with comparable angles of the different driving directions, like for ex. on intersections, where conflicts are caused by rectangular or nearly rectangular encounters. In this respect the type of the vehicle is important as well.

The most frequently applied elements of the definitions in use are: braking/change of lane and time interval. Combinations of these elements with other ones will supply types of conflicts. These types, as a rule, differ from one another in the manoeuvre effected (front-flank, head-tail) and the mode of traffic participation (vehicle/pedestrian, vehicle/bicycle, etc.). Various studies usually deal with one special type of conflicts. In case several types of conflicts are discussed in a study, it is, as a rule, assumed that all conflict types belong to the same category of severity.

There is only one study (Malaterre & Mühlrad, 1976), in which the observed conflicts are multiplied by a degree of severity, consisting of a number, which indicates vulnerability in case of a collision. The degrees of severity are defined by the angle of collision, the speed of the vehicle, the type of conflict and the category of road users involved. On the basis of extended accident analyses, the degree of severity has been defined in a subjective manner for the aforementioned combination of variables per each road user catergory.

It would be desirable to realise a greater uniformity in the use of definition elements and conflict types. This would make the comparison of study results easier. However, these problems have not been studied enough thoroughly up till now.

It could be assumed that a clear definition should also comprise the dominating elements of the driver's task as well. Therefore it is somewhat surprising that the definitions used at present include no such

elements as the movements of the eyes and head. There are some studies applying psychological parameters, like the galvanic skin resistance (GSR) in measuring anticipated risks. A drawback of this method is its ambiguity: both a high GSR and a low one may indicate a risk which was perceived by a driver as a dangerous one. The problems connected with establishing and scoring such behavioural variables account sufficiently for the limited application of similar measurements.

In most studies interactions between motor vehicles (drivers) are duly taken into consideration. However, the question has to be raised, whether the relations between pedestrians and other road users do not require a conflict definition which differs from the definition indicating the relations between motor vehicles only.

In various countries different conflict definitions are in use, it was found. As yet, no agreement could be reached on this subject, which hinders the comparison of investigation results. However, unambiguous definitions would be useless in case of different investigation methods. It seems necessary to provide a detailed description of the definition elements and the procedures to be followed in scoring the conflicts. This would permit the comparison of investigation results.
For an international survey of literature relating to conflict methods we refer to Kraay (1983).

The study of the literature over the development and application of the conflict method reveals the following application possibilities:
A. In general it can be stated that in applying the conflict method, those aspects of the road users' behaviour with regard to one another or with regard to their surrounding in traffic have to be determined which are relevant to traffic safety.
The conflict method is based on the assumption that unsafety increases in proportion with the interaction between the involved persons (behaviours) becoming more and more conflicting, with of course an increasing number of accidents.

B. In addition to application possibilities mentioned under A and mainly referring to outlining the scope of traffic unsafety, it can be expected

that by means of various analysis techniques, traffic safety aspects related to conflicts can be analysed as well, thereby revealing the actual causes of unsafety. It is also expected that the conflict method could be used in studying the traffic safety of certain special locations (black spots) and of areas with insufficient accident data for statistical analysis.

As a rule the traffic safety of a given location is characterised by the average annual number of traffic accidents, (if possible) in relationship with a certain measure of traffic exposure. However, since only (rather) few accidents happen on some places, for ex. intersections, in various types of areas, accidents cannot be accepted as criteria of traffic unsafety in short-term investigations. In view of such restrictions of accident investigations, it is necessary to look for other data, which in some way are related to traffic safety. In other words, it has to be found out whether an accident investigation can be complemented with additional studies in order to reveal the causes and circumstances of accidents.

For this purpose the conflict method can be used on locations and/or in areas with a low annual accident figure and also with a low traffic intensity
- as a diagnostic means for determining unsafe locations;
- as a means for the in-depth study of various unsafety aspects, in which case the method is of a theory-forming character;
- in evaluating measures and their effect on traffic safety, by means of pre- and post-studies;
- as a criterium for establishing priorities in a programme of traffic safety investigation, aimed at improving the safety of certain locations and/or areas.

The classification of certain locations with regard to unsafety could also be established on the basis of traffic intensity. However in this case the chance of correctly identifying dangerous locations becomes still more problematic. The available manpower and money, furthermore the amount of data which are at the disposal of the investigators, will be the decisive factors in making the choice.

A practical mode of classifying dangerous locations could also be carried out by
- using the conflict method in residential districts, road sectors and "quiet" intersections, and by
- using the number of accidents on intersections with heavy traffic. A combination of both methods is, of course, also possible.
If accidents are regarded as the most serious form of conflicts, they will have to be treated with more emphasis in the description of unsafety, than near-misses, which, in general are classified as less serious conflicts.

The conflict method can also be applied to establish one of the indicators of the well-being of traffic participants. In this connection we conceive of conflicts in terms of panic reactions. Other terms which can be related to the idea of well-being are: the livability of traffic and the discomfort of the road user. However, in this case the investigation is concerned with the subjective way in which the road user experiences traffic events, without finding out anything about the (simultaneous) relations with objective traffic unsafety. The subjective feeling of traffic unsafety often originates from experience with the conflicting behaviour of traffic participants and not from experience with traffic accidents proper. People may have a certain feeling of traffic unsafety which corresponds to objective unsafety. However, these two aspects: the subjective feeling of traffic unsafety, and the objective one are not always in accordance with one another. Whathever the case may be, the feeling of (un)safety may have a direct influence on the behaviour in traffic of the involved persons. In addition to a direct relation, there may also be an indirect relation between the subjective feeling of traffic unsafety and objective traffic unsafety. We shall illustrate this with an example.
After the designing of their residential area a strong feeling of safety may grow in parents because there are hardly any conflicts between road users in the street where they live or in their neighbourhood. If, however, encouraged by this feeling of safety, parents will accompany their children less rigorously to and from school, their slackening vigilance may lead to situations, far more likely to involve the children in accidents than before the restructuring.

C. Advantages of the conflict method are:
- A great number of measurements can be carried out in a short time, thereby permitting a quick evaluation of traffic situations and traffic measures, also on locations with low traffic intensity.
- The measuring programme can be adjusted to specific requirements of the investigation, like type of transport means, vehicle flow, type of manoeuvre, etc.
- General traffic data can be collected simultaneously so that all the data will refer to the same period of time, which usually is not possible when accident data and general data have to be related to one another.

D. Drawbacks of the conflict method are:
- The observations are expensive and for this reason they have to be carried out during short, non-representative periods of time (day/night, work day/weekend, season, etc.).
- Quite often the observations are evaluated and scored in a subjective manner. This, of course, requires a thorough training of the observers and observation teams of unchanged composition, capable of collecting the observations in a comparable and consistent manner.
- A conflict is not always defined in the same terms by various teams, which complicates the comparison of observation results.
- The conflict method assumes a relationship with unsafety in terms of accidents. This relationship has to be present to an adequate extent. The first three drawbacks raise questions as to the reliability of the method, while the last one concerns its validity.
The unreliability caused by the subjective mode of evaluating and scoring can be reduced by using film and video apparatus. An exact, operational definition of classification possibilities is also indispensable.

Finally, it can also be mentioned, that for complementing the observations, traffic offences can be noted as well. As a rule, traffic offences are not classified as conflicts. However, depending on the traffic situation, some traffic offences may have something to do with traffic unsafety. In general, no unambiguous relationship can be established between traffic offences and traffic unsafety.
In view of the advantages ensured by the conflict method in carrying out traffic-safety investigations, it is evident that this method, after

further development, in a few years, will be applied on a large scale. Following this chapter, some marginal notes will be made on this assumption.

4. Reliability of conflict observations

Most observation techniques still apply rather subjective modes in scoring the conflicts, mainly as regards their severity. As an example an observation technique will be quoted, according to which the observers have to assess the time from that moment when a vehicle carries out an evading manoeuvre, until the moment, when a theoretical collision could have occurred, if no evading manoeuvre would have been effected in time. In case the assessed time is less than $1\frac{1}{2}$ seconds, the event is scored as a conflict (Hyden, 1976).

The various observation techniques can be classified as follows:
-Observations on locations, for ex. intersections, using film or video apparatus, as objective measuring devices. Observations may also be carried out by observers. A recently developed technique permits the automatic detection of the proximity of vehicles and changes in their speed.
- Observations in areas like residential districts, carried out by observers, following selected persons on their way. A general survey of conflicts occurring in a given area cannot be carried out by means of film or video techniques. As a rule, there are not enough suitable places for setting up the apparatus, neither is it possible to find enough locations, which would permit a complete coverage of the entire investigation area.

The employment of observers has been accepted on account of the problems involved in the application of objective measuring techniques. The observers' subjectivity can be reduced by suitable selection, training with the aid of video apparatus and field studies. Only a few countries have text books for the observers at present.

In spite of the indicated subjectivity of the observers in scoring the conflicts, the reliability of observations can be rather high, if they

make their evaluations after several reruns of the video films. The scores made by the observers display, as a rule a satisfactory accordance as well, with correlations as high as 0.80-0.90. It has to be pointed out that only small-scale investigations have been carried out into the reliability of this technique.
On removing from the collected material traffic conflicts involving pedestrians, the correlations for external and internal reliability of the observers was found to be lower in comparison to evaluations, taking into account pedestrian conflicts as well. This seems to indicate that pedestrian conflicts can be more distinctly recognised (and consequently scored) than conflicts between other road user categories.

Up till now not much has been done to establish the extent to which evaluations carried out during a rather short period of time, may give a dependable prediction for a longer period and with a great diversity of traffic possibilities and conditions like darkness, slipperiness, rain, etc.

5. Validity of the conflict method

As mentioned above, one of the aims of the conflict method is to act as a substitute measuring tool for accident analyses in traffic safety studies. This means that conflicts are expected to predict reliably traffic accidents.

The first requirement is effectiveness. Even if the (annual) number of conflicts can be evaluated consistently, it still has to be seen whether the number of accidents can be evaluated adequately as well. Should this be possible, we can expect a high validity of the method.
In case of a 100% validity, the number of conflicts could simply be multiplied by a constant factor, thus establishing an accident/conflict ratio. However, in practice we have to be content with less than 100% validity. The only question now is, to what extent can demands be lowered without discrediting the reliability of the method. Of course, the accident/conflict ratio will be different for various types of conflicts, while at the same time, some types of conflicts will correlate better with the same type of traffic accidents, than other combinations of

conflicts and accidents. This problem has only been studied on a small-scale up till now.
The relative level of traffic safety can be evaluated without having to calculate the constant factor. However, also in this connection the problem of validity must be taken into consideration.

We shall now discuss some problems of validating the conflict/accident relationship.
In order to determine the effectiveness of conflicts in predicting accidents, accident-prone locations have to be selected. The problem we are confronted with in this instance is to what extent can the number of ancicipated accidents be evaluated on the basis of accidents which actually happened. Such accidents are also subject to random fluctuations and consequently they give no true picture of the safety of the location in question. In case, however, the circumstances did not change considerably, a correction of the unreliability of actual accident figures certainly seems possible.
The next problem is that observation techniques are intended just for locations with low accident frequency. It has to be studied, whether the method can be adapted to such situations, in other words, whether it is possible to make accurate evaluations of anticipated accidents on such locations on the basis of conflicts. It would be rather difficult to find out whether the relationship between conflicts and accidents is the same for locations (situations) with a high number and also with a low number of accidents. The problem in the relationship between reliability and validity is, whether the validity of a dependable observation technique is high enough to predict accidents more accurately on the bases of conflicts, than with the application of unreliable accident data. A decision model, adopted from the psychological test theory and (assuming its reliability and validity) with a possibility of choice, has already been developed (Oppe, 1977).

In addition to the aforementioned problems, the following difficulties have to be faced:
- According to most of the studies, there is a closer correlation between severe conflicts and accidents than between less severe ones. However, less severe accidents are, as yet, not scored with the required reliabi-

lity. Even in case of high correlations, it can be safely assumed that both conflict and accident will be in positive correlation with traffic intensity, but it still has to be found out, to what extent conflicts are more dependable in prediction than traffic intensities.
- Conflicts are related to recorded accidents (mostly accidents involving injuries), but, as mentioned earlier, not more than one third of all accidents is being recorded.
- Conflict observations, as a rule, are carried out under normal weather conditions and for rather short periods of time. However, what should be done with variations in the type of accidents, caused by seasonal effets, weather conditions, changes in speed, various traffic intensities, etc.? At present there are no correction factors for these variables.
- How many accidents have to happen on a location in order to get a representative picture of traffic safety, for ex. on an intersection and in order to prove that each type of possible accidents actually occurred there? The problems relate also to conflicts and there is no answer to either of them.
- Studies only concerned with severe conflicts supply less information about validity, than those taking all possible forms of conflicts into consideration.
- Conflicts do not explain all aspects of the variability of accidents. Not all accidents are initiated by a conflict.

6. Aims of the international calibration study

In several countries conflict techniques have been developed and applied to field studies, without an adequate investigation into the reliability and validity of the techniques in question. The various techniques applied also produce different effects. In order to reveal the value of the various techniques, an international comparative study has been carried out, with the participation of ten different observation teams in Malmö (Sweden), in June 1983. This "calibration study" had the following objects:

A. To carry out a detailed comparison of the agreeing and differing issues in various observation techniques on the basis of data obtained from a field study. This meant that the following questions waited for an answer:

- Which are the agreeing and differing points in scoring a conflict and the severity thereof by the various observation teams;
- in case there are differences in the observation data supplied by the various teams, in which manner can these differences be explained by the type of location, the manoeuvring of the vehicle, the traffic behaviour of traffic participants, etc.
- which are the application possibilities of the various techniques?

B. To establish the scientific value of the calibration study and to make recommendations for a validation study.

The calibration study can be regarded as an important step towards a better understanding of the relationship between various observation techniques and actual traffic issues.

Literature

Hydén, C. (1976). A traffic conflicts technique for determining risk. Tekniska Högskolan, Lund, 1976.

Kraay, J.H. Review of traffic conflicts techniques studies. Third edition. R-83-9. SWOV, Leidschendam, 1983.

Malaterre, G. & Muhlrad, N. (1976). Les conflits de trafic; Une technique au service des études de sécurité. ONSER, Arcueil, 1976.

Older, S.J. & Shippey, J. Proceedings of the second international traffic conflicts technique workshop, Paris, 1979. TRRL Supplementary Report 557. Transport and Road Research Laboratory TRRL, Crowthorne, 1980.

Oppe, S. (1977) Some notes on: "What task is a traffic conflicts technique intended for?" Contribution to the International Seminar on Traffic Conflicts, Oslo, 26-27 September 1977. R-77-13. SWOV, 1977. Also in: Proceedings First Workshop on Traffic Conflicts, Oslo, September 1977, pp. 111-116. T.Ø.I., Oslo & L.T.H., Lund, 1977.

Perkins, S.R. & Harris, J.I. (1968). Traffic conflicts characteristics: Accident potential at intersections. In: Highway Research Record 225, pp. 35-43. Highway Research Board, Washington, D.C., 1968.

SWOV (1976). Evaluatie-onderzoek met betrekking tot de verkeersongevallenregistratie (VOR); Beschrijving en resultaten van het Vooronderzoek Carnets en de Proefregistratie Verkeersongevallen in de Provincie Utrecht. R-76-6. SWOV, 1976.