Proceedings: First workshop on TRAFFIC CONFLICTS

OSLO 77
Foreword

Among the more interesting tools in the traffic safety work is the observation of traffic conflicts. The method was first recognized in the USA in the 1930's. But only in the latest years the method has also been evaluated on a larger scale. At this stage many countries are developing their own variation of the traffic conflicts technique.

To view the different methods a workshop on traffic conflicts was arranged in Oslo, September 1977. The initiative and the practical arrangements have been carried out by Christer Hydén of Lund Institute of Technology (Sweden) and Finn H Amundsen of the Institute of Transport Economics (Norway). The workshop was chaired by Bo E Peterson, National Swedish Road Administration.

We hope that these proceedings from the workshop will be of interest to researchers and public officials alike.

Oslo, Norway, November 1977

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Introduction

Indirect safety measures, as a complement to accident analyses, has been widely discussed during recent years. The engineer, trying to correct unsafe intersections, has worked with reported accidents which often constitutes an unreliable tool and are recorded in small numbers. Several countries have therefore initiated developmental work on methods to record supplementary and relevant data. Among the most promising methods is the recording of near accidents or traffic conflicts.

Researchers in this field have often felt that they have been working with the same problems but with different methods and often without knowing about each others work. There has also been a general feeling that a comparison between different projects should be interesting. The scope of this workshop has primarily been to assemble researchers but also some governmental officials and discuss the status of the development of the traffic conflict technique.

This report covers the introductory papers and the group discussions at the workshop. All the reports are presented in their full length and as they were presented.

We wish to thank the authors and participants for letting us publish their work.
The national papers

Traffic Conflict Studies in the United Kingdom by S J Older and J Shippey, Transport and Road Research Laboratory (TREL).

1. INTRODUCTION

This paper provides a brief survey of research into and use of Traffic Conflict studies in the United Kingdom and is intended to be supplemented in detail by material presented at the seminar.

Interest and research into the possible use of traffic conflict studies in the United Kingdom originated at the Transport and Road Research Laboratory and has developed both there and in associated research groups. As this paper will show, these studies are still mainly concerned with the development of the traffic conflict technique as a viable research and operational tool which it is hoped will be applicable in a variety of situations. This development work has caused considerable interest in the technique's use among organisations concerned with improving road safety, such as central government agencies, local highway authorities and police forces. There is however, at present, no recommended operational use of the technique in the United Kingdom.

2. INTENDED USES OF TRAFFIC CONFLICT STUDIES

During the course of work on traffic conflicts it has become clear that such studies can be for one of three purposes–

1. To obtain objective records of road user behaviour in "accident" situations for further analysis (and therefore of most interest to road safety research workers).

2. To provide a measure of safety to be used in "before and after" studies to evaluate accident countermeasures, (therefore of interest to traffic engineers and road safety officers, as well as research workers).

3. To evaluate the present state of a given location with respect to safety.
Work at the Transport and Road Research Laboratory started with the first purpose which was to use the conflict study technique to provide records of driver and vehicle actions in situations which could be described as potential accidents, i.e. near misses. (This work has concentrated on situations at road junctions as these are the locations where most road accidents occur.) To do this it was however realized that any such studies must produce valid and reliable data to be scientifically acceptable and most work at TRL has been directed towards establishing validity.

In obtaining validity data the possibility of using conflict counts to compare situations became clear and some work has been done using conflict studies in before and after experiments where some modification of junction design has been made.

The third purpose, that is of using traffic conflicts as a surveillance tool to determine if an accident problem exists, has not been pursued at TRL. The determination of accident black spots for example, is still considered best pursued by the routine collection of accident data over preceding periods of time. It is considered that traffic conflict studies are at present too expensive in terms of man power and time to make them a general survey tool. They could often be justified however if historical accident data were not available.

3. DEFINITIONS

At the present time in the United Kingdom the general definition used is that a traffic conflict is a situation involving one or more vehicles where there is imminent danger of a collision if the vehicle (or other road user) movements continue unchanged. This general definition has led to two practical interpretations in identifying such situations:

(1) A conflict is identified by the occurrence of an evasive manoeuvre by one or more of the vehicles involved; the manoeuvre being either braking or change of lane.

(2) A conflict is identified by the estimated times of arrival of vehicles at the possible collision point being within a given short time of one another.

The first type of identification derives from early work in the USA by Perkins and Harris, but the work at TRL uses an additional classification by severity of the evasive action. Table 1 lists the five categories used.

<table>
<thead>
<tr>
<th>Conflict Severity</th>
<th>Grade</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight</td>
<td>1</td>
<td>Precautionary braking or lane change (e.g., for vehicle waiting to enter junction) or other anticipatory braking or lane change when risk of collision minimal</td>
</tr>
<tr>
<td>Serious</td>
<td>3</td>
<td>Rapid deceleration, lane change, or stopping to avoid collision resulting in a near miss situation (no time for steady controlled manoeuvre)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Emergency braking or violent swerve to avoid collision resulting in a very near miss situation or minor collision</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Emergency action followed by collision</td>
</tr>
</tbody>
</table>
The severity grading implies different degrees of unexpectedness of the conflict event and a measurement of this by assessing the suddenness of the evasive action. Traffic law violations are not included under the definition of conflict in the TRRL work, because these do not by themselves indicate potential accidents. As will be seen later, the five categories of severity can be grouped into two, but requiring the observers or analysts to base their initial judgements on these detailed categories would appear, from other research in the use of subjective judgment scales, to contribute to their reliability.

Present work in progress at urban intersections has shown that there are difficulties in using the crude five-grade severity scale. The use of additional intermediate categories of severity appears to reduce these difficulties.

To be able to use the second type of identification, it is necessary to have information on the position and movement of all vehicles and road users in the area to be studied so that possible collisions can be predicted. In many cases, this approach reduces to the requirement of measuring how close in reality vehicles come in time and space to the point of collision. The particular time and space limits used to define that a conflict has happened, may well depend on the type of situation studied and may have to be determined empirically.

The difference between the two procedures is that the first relies on identifying that there is an imminent danger of collision by the evasive action which occurs and this implies that at least one of the road users in the situation has become aware of the danger. The second procedure does not rely on evidence of road user awareness but attempts to identify vehicles and road users that may come into very close proximity.

4. METHODS OF MEASUREMENT

TRRL are attempting to use two methods of measurement: the first, well tried, method relates to the observation of evasive action; and the second method, which is at present, undergoing road tests, is automatic detection. This relies on the 'proximity of vehicles' definition of conflicts given earlier.

4.1 Qualitative (subjective) assessment by observers of occurrence using severity of evasive action

The observation of evasive action may be made either on site or by means of film. TRRL has employed both methods successfully, but for different purposes. For a rapid assessment of the number and location of conflicts, a study using observers alone can give all the information required. For detailed analysis of events leading to, during and after conflicts, the use of film is essential.

In the first method of observation two observers for each major manoeuvre are usually required for complete assessment of the situation, particularly if conflicts occur in succession. If a second conflict occurs whilst the first is being recorded, the second observer is able to record it. Records are made on data sheets which are designed for the particular layout of the observed junction. A record made on a typical sheet (examples of which will be available at the seminar) includes: where and when the conflict occurred; the types and number of vehicles involved; avoidance behaviour taken; and an estimate of the severity of the event.

Similar, though more detailed, sheets are filled in as well as recording other parameters when analysing films of sites. The use of 16mm time lapse colour film taken from a mobile tower sited about 500m from the junction on the main road, allows comprehensive analysis of conflict situations. The steady film speed (2 frames per second) allows time measurements to be made directly from the film. Approach speeds and flow data may also be obtained. The use of colour film also makes brake lights easily visible and simplifies the identification and follow-up of vehicles particularly in complex situations, where there is multiple vehicle involvement.
4.2 Automatic detection of vehicle proximities from computer analysis of continuously recorded data from vehicle sensors

Automatic detection of the proximity of vehicles which relies entirely on complex arrays of sensors on the road and on sophisticated computer software systems for analysis, can identify the number and location of conflicts. The use of time lapse cine photography in addition is necessary if detailed analysis of events leading up to and resulting from conflicts is required.

The system used at present employs permanent sensors mounted in the road surface and lengthy computer analysis of magnetic tapes.

The sensors used are inductive loops and tribo-electric sensors arranged in configurations consisting of one loop surrounding two tribo-electric sensors. Diagrams of a typical sensor configuration will be available at the Seminar. The configurations are laid at intervals along the approaches to a junction and connected to a multi-track magnetic tape recording device, which searches every sensor every millisecond to determine vehicle presence. If a vehicle presence is found then the sensor identifier is recorded, together with a time provided by an internal clock, on the magnetic tape. The tape is then analysed on the laboratory computer in two stages. The first stage searches the data, sorting the individual sensor activations into sets each consisting of two tribo-electric sensor pulses and a loop 'in' pulse and a loop 'out' pulse for each vehicle crossing each configuration. This allows determination of vehicle speed and length, time of arrival and departure at each configuration, and gap between successive vehicles, as well as giving an idea of manoeuvres which are being performed.

The second stage of the analysis is then used to determine proximity or potential proximity of vehicles, by examining vehicle presence on adjacent sensor configurations within given time limits. This forms the true "conflict detection" part of the computer program.

5. STUDY DESIGN AND MEASUREMENT ACCURACY

This section considers four areas where problems exist in the methods already outlined.

5.1 Validity

Initially it was assumed that all accidents were preceded by an attempted evasive action, so that the number of evasive actions taken and the number of accidents were on a continuum. This implied a direct relationship between accidents and conflicts defined by evasive actions, and, indeed this was borne out by our early studies\(^1\) on staggered intersections at rural main road sites for the serious grades of evasive action described earlier. Subsequent studies have shown that the ratio between conflicts defined by evasive actions and accidents may vary for different classes of conflict. In addition there is filmed evidence that not all accidents are preceded by evasive action. These findings throw into doubt the assumed continuum between evasive actions and accidents.

We do not yet have any comparable data for proximity of vehicles compared with accidents at different sites, but our pilot studies using automatic detection equipment have been successful in identifying conflicts observed by the earlier method.
However, there is one aspect of measurement which may cause difficulties in examining the validity of both observer and automatic methods, and that is the method of accident reporting. In the UK only injury accidents are reported as a routine measure for national accident records and there is no doubt that collisions arising from certain manoeuvres are more likely to result in injuries. So it seems likely that whatever the conflict measure being used, the conflicts to accidents ratio will depend upon the types of manoeuvre being considered.

5.2 Reliability of observers

Two studies of observer reliability have been made.

The first compared the interpretation of events by two groups of observers at the same sites.\(^1\) This showed an agreement of 80% between the groups over all events classified as conflicts and of 85% between them when considering only serious conflicts. However the study only concerned 58 conflicts in total.

The second study compared the interpretation of two observers looking at six days' data from one site in the form of film records.

Both observers analysed the films independently and then made a combined assessment. The following comparisons were made taking the final combined assessment of the situation (agreed between the two observers) as being the correct interpretation:

1) The number of events correctly classified by both observers
2) The number of events correctly classified by each observer, and
3) The distribution of severities in each observer's classification compared with the agreed distribution.

The total number of events mutually agreed as conflicts was 899 which included

<table>
<thead>
<tr>
<th>Grade</th>
<th>Obs 1</th>
<th>Obs 2</th>
<th>Final Agreed Conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>75%</td>
<td>75%</td>
<td>72%</td>
</tr>
<tr>
<td>Grade 2</td>
<td>95%</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>Grade 3 and above</td>
<td>25%</td>
<td>35%</td>
<td>35%</td>
</tr>
<tr>
<td>Uncertain grade</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

There should be no problem with reliability using the proximity of vehicles definition as the automatic method will always record events involving a gap, or time measured to collision, below the chosen threshold as conflicts.

3 Day to day variability

No quantitative information is available for daily differences when studying passive actions. However it is obvious that precautions should be taken to avoid seasonal and time of day and week variations in comparative studies.

A study of day to day variations in automatically detected conflicts is at present underway, and we hope to be able to provide detailed findings from this work at the Seminar.

Data from the automatic detection of conflicts is available and, together, give large enough samples to study variability in terms of the sample variance compared with the sample mean. This indicated that sample variance increases with sample mean, and also that variance to mean ratio is different when considering different conflict types separately or collectively (about 1.4 and 2.2 respectively).
5.4 Conflict types and differences in accident/conflict ratios

Again there is little quantitative data on this topic, but, as outlined above, with the accident reporting system used in the UK there must be a variation in conflict to accident ratios for different conflict types. Some evidence for this is at present coming from analysis of conflicts at urban intersections. If one type of manoeuvre is more likely to produce an injury accident from a collision than another (eg a crossing manoeuvre resulting in collision is more likely to produce an injury than is a merging manoeuvre), then the collision to accident ratio will vary between different manoeuvres. This implies that even if conflicts are directly related to collisions the conflict to accident ratios will also vary.

This ratio has not yet been investigated for the automatic detection method because there is so far not sufficient accident data from the instrumented sites to make any kind of meaningful comparison. Any data available will be presented at the Seminar.

6. PRACTICAL APPLICATIONS

Although, as mentioned before in this paper, the main emphasis in traffic conflict studies so far made in the United Kingdom has been establishing their validity, this work has been combined with trial operational use of the technique wherever possible.

For example, work carried out by TRL has included the following "before and after" studies:

6.1 Rural dual carriageway junction (1)

From the study of a rural "staggered" junction of a minor road with a major dual carriageway it was possible to show that the majority of conflicts occurred in one carriageway and involved the two manoeuvres necessary to reach the central reserve area from the minor road entry. A partial traffic signal installation, controlling this minor road entry only, solved the major conflict problems and did not generate other types of conflicts.

1.2 Rural dual carriageway junction (2)

A similar intersection to the first one but with the "stagger" in the opposite direction showed a balanced pattern of conflicts with most occurring in manoeuvres where the main carriageways had to be crossed. In this case, movement from, as well as to, the central reserve produced conflicts. A full traffic signal installation resulted in a major reduction in conflicts within the intersection. In this case it was possible to show that the new design had generated a small number of conflicts of a type not originally present but which could have been eliminated by a further small design change.

1.3 An urban crossroads

A simple urban crossroads was studied where various classes of road user were involved in conflict situations. The result of a before and after conflict study when control at the intersection was changed from a 'give-way' priority to full traffic signalisation showed different levels of improvement for different classes of road user, see Table 2.
TABLE 2
Conflict frequencies before and after installation of traffic signals at an urban intersection

<table>
<thead>
<tr>
<th></th>
<th>Slight conflicts</th>
<th>Serious conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Vehicles with 4 or more wheels</td>
<td>255</td>
<td>7</td>
</tr>
<tr>
<td>2 wheeled vehicles</td>
<td>36</td>
<td>3</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>351</td>
<td>16</td>
</tr>
</tbody>
</table>

6.4 Introduction of a mini-roundabout at a simple priority intersection

A study was made of a suburban 3 way junction before and after the experimental installation of a "mini" roundabout. Conflict studies showed that "nose-tail" conflicts were eliminated but those between vehicles making intersecting manoeuvres had increased. An important factor was the unfamiliarity of drivers with the new priority rule (give way to the right) associated with the new layout.

6.5 Modification of entry layout at an intersection with a small island roundabout

Modifications to the layout of the entries of roads at an intersection with a small central roundabout have increased capacity at peak hours. Before and after conflict studies have shown that the number of serious conflicts has not decreased but their location within the intersection and the vehicle streams involved changed. The studies also showed some evidence of increased involvement of pedal cycles and motorcycles. The serious conflicts occurred outside the times of heaviest flow at the junction.

More details of these studies will be available at the seminar.

The knowledge of the work at TRL has prompted a few studies being made by traffic and highway engineers of county authorities and by one or two police forces. Both types of use have involved the subjective definition of severity of evasive action in identifying conflicts, as developed at TRL. The studies by local highway authorities have been concerned with specific road junctions where accident data have indicated a safety problem. The traffic conflict data have been used to provide additional information on the maneuvers of vehicles and the particular location involved in creating the accident problem. This work has caused some difficulty in interpretation of the conflict study results in that different accident/conflict ratios must be known for different types of conflict to make the results meaningful. Two of the local police forces in England are planning or have carried out trial conflict studies to assess the effect of police enforcement actions at particular sites.

7. OFFICIAL RECOGNITION

Traffic conflict studies are considered as an intermediate measure of safety which is still under development, and there is considerable recognition of the value of such a technique and support for its development. Knowledge of the existing use of the technique is available and research workers and practising traffic engineers are free to use it if they wish. There is however no official recommendation as to how and in what circumstances it should be used and no such recommendation is at present under consideration. It is felt that until the questions of differences in possible definitions of conflict are answered and the implications these have on methods of observation and the stability of the accident/conflict ratios are worked out, no recommendation is justified.

8. FUTURE RESEARCH

The main research planned is still the development of the technique rather than in its use in any specific area although work on the latter will be carried out as the
opportunity occurs. Planned work on technique development will include:

1. Further development of techniques of automatic recording and evaluation of objective conflict criteria against existing subjective criteria and accident data.
2. Investigating the possible amalgamation of the two existing means of identifying conflicts.
3. Using appropriate conflict definitions to build up data collection of accident/conflict ratios and identify conflict types for which the ratio is constant.
4. Studying the variability of conflict counts to provide empirical data useful for indicating accuracy of accident prediction.
5. Develop a training procedure suitable for use in instructing traffic engineers and road safety officers how to observe and record conflicts.

It is hoped to continue experimental use of the technique, using appropriate criteria, to study:

1. The influence of road design on safety at intersections.
2. The head movement patterns of drivers involved in conflicts at intersections and relate these to those of non-involved drivers.
3. The interaction of vehicles and child pedestrians on residential roads.

9. ACKNOWLEDGEMENTS

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10. REFERENCES


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Conflicts Observation Techniques in Traffic Situations, by V A Gütinger, Netherlands Institute for Preventive Medicine/TNO.

INTRODUCTION

In Holland great efforts are made to improve the safety of residential areas. In the past, townplanners gave too much priority to fast-moving traffic in residential areas' and gave less or no attention to pedestrians. One consequence of this one-sided thinking of the townplanners was an increase of accidents that involved pedestrians. To mention some figures: the number of pedestrians hurt or killed in traffic increased from 5000 in 1950 to 8000 in 1971. One half of these victims being children under 15 years; and about three-quarters of the accidents involving children occurred within 500 metres of the child's home.

With this concern about the unsafety of pedestrians, especially children in residential areas, our research on the conflict observation techniques began.

Although pedestrian unsafety, as indicated, is a big problem, accident in residential areas still are rare. The time needed to collect enough accident data for statistical processing is too long in these situations. Likewise, no short-term method can be said about the effects of measures taken to improve the safety of residential areas.

For this reason we turned to the conflict observation techniques. Some of the advantages of these techniques seemed to be:

1. Many measurements can be made in a short time.
2. Measures for improving road safety can be taken quicker on the basis of information from conflict methods provided the method is valid.
3. The conflict method is applicable with low-traffic densities where the accident level is likewise low.
4. Reduction of conflicts as a consequence of measures can be demonstrated quickly by means of before and after studies.
5. The supply of information to the authorities (police, traffic experts) and to road users themselves; it often happens that residents ask for action to be taken and the authorities cannot evaluate the traffic situation.

At the moment we started in 1974 with the conflict observation technique the few techniques that existed seemed to be strongly subject to as regards conflict scoring, especially as regards the severity of the conflict and the techniques had too little (or inadequately researched) correlation with accidents to be used as an alternative criterion to accidents.

Our first aim was to develop a reliable conflict-observation technique, reliability being the primary requirement for a measuring instrument. This implied that if we succeeded in developing a reliable instrument we could only use this technique to obtain information or to express opinions regarding road safety under the assumption of its validity. In fact we only would be able to express our opinions about measures in residential areas, in terms of conflicts.

THE CONCEPT "SERIOUS CONFLICT" AND ITS OPERATIONALISATION

We defined a serious conflict or near-accident as: a sudden motor reaction by a party or both parties involved in a traffic situation, towards the other, with a distance of about 1 metre or less between those involved.

Two variables are important: the motor reaction and distance.

Beside this concept "serious conflict" we distinguished 5 other possible combinations of the two variables mentioned.

For instance: a conflict: a sudden motor reaction by a party or both of the parties involved in a traffic situation towards the other with a distance of about 2 metres or more (maximum 20 metres) between those involved or

a contact: a non-sudden motor reaction by a party, or both of the parties in a traffic situation towards the other, with a distance of about 2 metres or more (maximum 20 metres) between those involved.

All together we called these six types of combinations of the two variables (motor-reaction and distances)

an encounter: a motor reaction by a party or both of the parties involved in a traffic situation towards the other, with a distance of 20 metres or less between those involved.

One should realise that any definition has its limitations.

This research has tried to give a definition of a serious conflict, which would on the one hand be as close as possible to a traffic
accident and be measurable, and on the other hand would provide sufficient number of serious conflicts to enable the problem to be investigated.

One might ask whether operationalization of serious conflicts with the aid of a sudden motor reaction is really the correct approach for a serious conflict, since sudden motor reactions do not always necessarily take place in order to avoid an accident! The point of departure in this research was the idea that an accident is the result of a reaction that was too late by one or more road users and not of no reaction at all. If accidents are the result of the wanting of reactions of the parties involved in a traffic situation, there is nothing to investigate with the conflict technique. The criterion of "sudden" has been determined empirically. With the aid of 27 video-recordings of encounters between pedestrians and other traffic, ten observers had to score reactions on a seven-point scale ranging from more to less sudden. A discussion resulted in a detailed list of criteria that could be used to identify three types of reactions (of different kinds of roadusers): sudden, in between, not sudden. Next the same ten observers evaluated the 27 video recordings on this three pointscale, using the list of criteria.

A second group of ten observers were given the same instruction as the first group for the second task, that is scoring on a three-point scale. In total, they scored the 27 video recordings three times each in a random sequence.

As regards the observers' external reliability (that is the reliability between the observers) with respect to pedestrians' reactions the average correlation between the observers in the 2nd group varied (over the three sessions) from .86 to .87. The average internal reliability (that is the reliability of the same observer for different sessions) was .91.

As regards the observers reliability with respect to other traffic, the average correlations for external and internal reliability are respectively .75 and .85.

It is noteworthy to mention that these results were based on the observations of unselected and untrained observers.

In later research with observers who passed a selection and then were trained, we found correlation for the external reliability of .91 for the pedestrians reactions, and .93 for the traffic reactions.

About the practical application of this conflict observation technique in field research we will be very short. We used the technique in a comparative study of two neighbourhoods designed according to a totally different point of view. One area designed according to the principle that gives all priority to wheeled traffic; the other one designed according to a new approach in Holland that gives pedestrians priority although traffic is allowed to enter this area. The aim of the latter type of design - we speak of residential yards - is both to give pedestrians, especially children more (play) facilities and at the same time reduce conflicts between pedestrians and wheeled traffic. With respect to this latter aim our research indicated that in contrast to the expectations the residential yard approach does not lead to fewer serious conflicts than the conventionally designed area. As mentioned earlier in this stage of our research we cannot express our opinions in terms of road safety.

In the light of this seminar more interesting than the results of this field study, perhaps, is the way we used the conflict observation techniques.

Female observers (students in social sciences) were trained in judging reactions of traffic and child pedestrians and in judging traffic situations.

In both neighbourhoods these observers made direct observations in two ways: by following children while moving through the area and by making observations of specially interesting areas as, for example, the entries of elementary and infants schools.

The reasons we choose for direct observation instead of using film or video recordings are:

- cameras have to be moved frequently in order to obtain a proper idea of the entire area; there were no opportunities for good sitting,
- following children with cameras would disturb their natural behaviour too much. Disturbances caused by the presence of an observer are less and according to our experience in the past, disappears after a few days,
- estimation of distance between the parties involved in a traffic situation from video or film recordings is difficult,
- the least important reason we choose for direct observations is that the costs of the field work would be twice as high.
when using video or film recordings: first you have to make
the recordings and after that make the observations.

Of course the big advantage of film or video recordings is that
you can run and rerun the recordings which gives the possibility to
more profound reliability research.

FINAL REMARKS.

At this stage the following can be said:

(a) our research has demonstrated that with the technique developed
an amount of information can be collected within a fairly short
period, which gives a good idea of what happens in a residential
area.

The reliability of the technique will have to be improved further
both experimentally and in the field.

(b) Since the research concentrated on developing a reliable tech-
nique, little can be said at present as regards its validity,
i.e. whether serious conflicts can also be suitably used to
predict traffic accidents. Any expression of opinion regarding
road safety is not therefore appropriate at this point.

(c) Instead of expressing any opinion on road safety, this research
does give a number of indications regarding certain types of
events in residential areas. This will enable town planners to
obtain more insight into the effects upon the various road users
They can modify their plans quickly and endeavour to improve
undesirable traffic situations.

The validity of our conflict observation techniques and comple-
tments reliability tests are the subject of our ongoing research. At this
very moment observations are made on 26 locations. The locations
of road in residential areas - are selected on base of the accident
reports over the past 5 years.

However, we must realize that this research has still the character
of a pilot study. There are severe limitations to profound reliability
research.

- the selection of the locations is based on accident reports. In
  Netherlands however approximately two-third of the road accidents
  are not reported. Although we try to meet this problem by inter-
  viewing the people in the surrounding neighbourhoods, we do not
  have the hope to get the exact accident figures.

- the accident data that exist are, as we noticed, not always
  reliable. For instance the exact place of the accident, the
  situation in which the accident took place, are sometimes
  badly recorded.

- and last but not least to get enough accident-data we have to
  work with figures based on a period of 5 years. Although we
  took into account changes that might have happened in those
  past 5 years (for instance locations where changes evidently
  took place in this period were not selected) we cannot take
  account for all possible changes: the socio-economic level of
  the population living in the neighbourhoods of the selected
  locations might have changed, or the number of children, not even
  mentioning changes in traffic-densities.

These are some direct problems we are facing at this very moment.

More fundamental questions are:

- Is our starting point in defining a serious conflict correct?
  Our basic assumption is that an accident is the result of a
  reaction that was too late.

If however accidents happen because of the wanting of reactions
of the parties involved, we better forget our approach.

Simple: if accidents happen because one party saw the other
party too late: then our approach can be correct. If
accidents happen because both parties did not see each
other: then our approach must be wrong. Perhaps both types
of accidents do exist. And if so in what ratio?

- With our method we hope to be able - in the future - to predict "changers"
in accident rates, in case measures are taken to improve road safety.

What are the chances to predict the magnitude of the accident rate
with the conflict methods? Even the estimation of the magnitude
of experimental accident rate made from actual accident-reports
seems to be doubtful.

- Is there a need for different conflict observation techniques for
different type of road users. That is: do we need a different type
of method for vehicle/vehicle conflicts, for pedestrian/vehicle
conflicts etc. etc.

- In conflict observation possible in case of what you might call
  "one-sided" accidents, that is, collisions of traffic with objects.

Of course there are only a few basic problems we have to face in
this research area.

I sincerely hope that this seminar will contribute to an answer to
some of those questions.
While easy to employ, the GM technique does not make sufficient distinction between severe and precautionary conflicts. This hierarchy was defined by the TRL researchers but the result was a very subjective definition whose relation solely to serious accidents has not been logically justified (2).

Many researchers have begun to seriously question the validity and ultimate usefulness of the traditional conflicts technique. Personnel involved with a recent project conducted for Transport Canada (3) have voiced serious misgivings about currently accepted definitions, and in fact have attempted development and testing of a new concept. Unfortunately, the work has identified more questions than answers, and a need to reassess the entire concept of traffic conflicts has been recognized.

To accomplish this, an attempt has been made to identify the requirements which a useful definition of the term conflict must satisfy. On that basis, a specific definition was attempted and some concepts for measurement were proposed. The following three sub-sections are taken from the unpublished report on this project by Dr. Brian Allen of McMaster University.

2.1 definition requirements

It is generally accepted that a direct measure of the level of safety is the average number of collisions which occurred during a period of time at a specified location. A conflict study is normally conducted so as to infer from a count of conflicts what the average number of accidents occurring during a period of time might be. A high conflict count is thought to be indicative of a high accident rate and vice versa.

The collision generation process on which the premise of such an association is based is represented schematically in Figure 1. According to that process, estimation of the rate at which collisions occur can only be made if two auxiliary estimates are obtained:

a. an estimate of the rate at which conflicts are occurring during the period of time for which the collision rate is to be estimated; and

b. an estimate of the probability "p" of a collision once a conflict has occurred.

A field survey on the site in question can yield an estimate of the rate at which conflicts occur. Thus, conflicts must be defined in such a manner as to allow estimation of a sufficiently accurate rate of conflict occurrence at a reasonable cost.
Estimates of $p$, the collision-to-conflict ratio, are not always needed. If the intent is to estimate a relative improvement (change) in safety, it is sufficient to conduct a "before" and "after" conflict survey provided that the value of the collision-to-conflict ratio did not change.

It follows that factors such as flow, driver behavior, etc. must be accounted for by the count of conflicts. Where the absolute and not the relative characterization of level of safety is sought, an estimate of the applicable collision-to-conflict ratio must be obtained. This is obviously difficult to come by, and obtainable only through research specifically conducted for this purpose. For research results to be transferable from place to place, the estimate of $p$ must be free of local factors. Therefore, the collision-to-conflict ratio must reflect an almost universally valid chance process of accidental occurrence subsequent to the materialization of a conflict. This division of labour between conflicts and the collision-to-conflict ratio agrees with the intuitive concept of near-miss, the conversion of which into a collision is an unpredictable matter of chance. In consequence, local conditions of flow behavior and environment must be reflected in the conflict survey.

An added implication of such definition of conflicts and the collision-to-conflict ratio should be noted. Namely, for research results to be transferable between locations and times, identical definitions and count procedures need to be accepted internationally as soon as possible.

The requirements which a definition of the term conflict must meet can now be summarized:

R1 - For the collision rate to be proportional to the rate of conflict occurrence, each collision must be preceded by a conflict. Thus, definitions which allow occurrence of collisions which are not preceded by a conflict are inadmissible.

R2 - A representative estimate of the rate of conflict occurrence can be obtained consistently at a reasonable cost.

R3 - Local conditions of flow, behavior and environment must be reflected in the count of conflicts. The value of the collision-to-conflict ratio must be independent of these local influences and thus reflect a universal chance process.
2.2 Implications and Observations

It should be noted that R1 implies that all conflicts, if properly defined, have a probability of resulting in a collision. This is essential if conflicts are to accurately reflect collision experience. Obviously, however, nothing in the requirements stipulates or implies that some form of evasive action is necessarily involved with a conflict.

On the other hand, observation of evasive action is the key to all methods presently used. Even the time-to-collision concept depends on evasive action as it is measured from the application of brakes to the extrapolated collision instant. However, many of the collisions recorded on tape for this project did not seem to be preceded by a discernible evasive action. To illustrate this point, Figure 2 schematically represents the accident generation process which includes evasive action as an event.

It is clear from the figure that to obtain an estimate of the accident rate, one must multiply the estimate of the rate at which evasive action (conflicts) occurs by the probability of collision occurrences, P, and add to this the product of the rate at which no evasive action occurs and the probability, q. It is quite apparent that the elements of the second product are not available. The neglect of collisions generated via the "No Evasive Action" path is in general only a matter of convenience, not of conviction. In fact, it might be argued that it is the absence of stimuli inducing evasive action which leads to collision. Thus, lack of evasive action may be a more important factor than its presence.

Finally, the importance of defining the term conflict so as to free the collision-to-conflict ratio from local factors can be illustrated as follows:

Consider a signal timing change which reduces by one-half the number of left turn conflicts. Ostensibly, the level of safety has doubled. This is so, however, only if the magnitude of the collision-to-conflict ratio remain unchanged. If, however, the conflicts after the change in timing are twice as likely to result in a collision than conflicts before the change, no safety improvement occurred. Consequently, it is extremely important that R3 be adhered to.

2.3 The Definition

As outlined in the preceding discussion, a conflict is a situation or sequence of events which has a finite expected (probability P) of developing into a collision. Similarly, due to R1, a conflict always precedes a collision and does not necessarily involve an evasive action.

To illustrate the notions inherent in the requirements let us first focus on left turn conflicts. We can define a left turn conflict as the presence of a through vehicle in the roadway segment AB shown in Figure 3, at the time t when a left turning vehicle encroaches on its lane.

Obviously all left turn collisions must be preceded by a conflict so defined, thus conforming to R1. However, the probability of a collision occurring once a conflict has developed depends also on the distance, d, of the through vehicle from the potential collision point, PCP, and on its speed, v, at the time, t, as well as on whether it has been decelerating at that time, the pavement conditions, its occupancy time in the lane, t' - t = Δt, etc.

If one considers the vehicle trajectory from point A at velocity v, the probability of collision occurrence is likely to be relatively low. Obviously, a vehicle proceeding from point C, however, is likely to have a much higher probability of becoming involved in a collision. One can conceive, therefore, a distribution of collision probability between A and C, dependent upon the through vehicle location at instant t. This immediately implies a degree of conflict severity, and the presence of evasive action (i.e., brake light observation) is not necessary to the definition.

To comply now with R3, the conflict definition must be further elaborated to render the probability of collision occurrence subsequent to a conflict, independent of the aforementioned location factors. This could be achieved by defining several conflict groups (severities) as a function of d, v, deceleration rate, pavement condition, etc. Thus, a LEFT TURN CONFLICT (d, v, etc., ...) occurs when a through vehicle is at a distance d from the collision point while going at speed v and decelerating at the time t when a left turning vehicle encroaches on its lane. Now the definition complies also with R3.

It remains to be seen whether with this conflict definition one can also satisfy R2 - the need to obtain conflict estimates at reasonable cost. Despite this uncertainty, one can conceive of a few potential data collection methods:

a. When the left turning vehicle encroaches the through lane, measure the speed and distance of the through vehicle, if it is in roadway section AB. To accomplish this, a remote activated time-lapse camera would take a minimum of two exposures at time t, another at t', with the distance CA measured from the film record.
b. A speed sensor would be placed across the roadway at B (computed from maximum t, v). Record speed of through vehicle if it appears that left turn may proceed. Then record time t of actual encroachment, yielding by extrapolation the distance CA.

3. Further Investigations

It can be seen from the above discussion that an analysis of actual accident sequences casts strong doubt on the relevancy of some traditional conflict definitions and would seem to lessen the possibility that meaningful data can result from a simple manual counting or observational procedure.

While the definitions described in 2., above, appear to have potential, they are difficult to apply to the rear-end or weave situation. A combination of human observation and subsequent detailed evaluation from video tape record was thus investigated in a study involving merging vehicles at freeway entrances. Conflicts were initially defined in the standard way by the presence of evasive action and were subsequently categorized by the least time-to-collision as recorded from the film (Figure 4). The distribution of minimum times-to-collision for a large sample of merging situations was then plotted. As Figure 5 shows, a threshold value of 1.5-2.0 seconds can be defined beyond which the number of observer-identified "conflicts" decreased while the total number of "incidents" continued to increase. Unfortunately, because of the difficulty involved in calculating time-to-collision for all vehicles it was impossible to assess how many subsequently defined conflicts would have been missed by the observers due to lack of obvious evasive action.

4. Conflicts and Accidents

The first study mentioned in Section 2, above, dealt only with a small sample of accidents since it involved the detailed film examination of a single intersection. Conflicts were collected periodically over a period of one year and compared to a four year accident history. Correlations were developed between accidents and various conflict definitions by lane position and time period.

Results of this analysis showed that serious conflicts correlated better with accidents than conflict definitions including those of a less serious nature. Of the various definitions evaluated, "post-encroachment time" (defined as the time from the end of a turning vehicle encroachment on a through lane to the time that the through vehicle arrives at the potential collision point) had the highest correlation at about R = 0.50 which was only marginally significant, given the sample size. Brake light applications had the same correlation, but
differences in the population and sample size make direct comparison difficult. It remains to be seen whether this correlation can be improved through further development of the methodology and application to a large accident data sample.

In terms of data consistency in day-to-day conflict counting, post-encroachment time had the second lowest standard deviation at 21% of the mean value.

The second study reported in the previous section gave rather disappointing results. Correlations between observed conflicts and accidents was low even when the most severe categories of minimum time to collision were used. A Spearman Rank coefficient was likewise of low order. These results confirmed earlier work by Transport Canada concerning merging behavior, where the number of small size gaps (1.5 seconds) accepted by merging vehicles was not found to have any discernible relation to the accident rate at the location. Figure 6 graphically illustrates the problem by comparing the location of accidents, evasive action initiation and minimum approach (time to collision) for the section between Bulloose and end of taper. It is evident that most of the events judged as conflicts by both observational and measurement definitions were in no way related to accident occurrence.

Two-thirds of the accidents at these locations were of the rear-end variety where a moving time-to-collision conflict definition would seem to offer some potential. One possible explanation for the failure of the TCT in this instance could be that many accidents occur at the tail end of a chain reaction initiated further down the acceleration lane. Instead of observing primary conflicts we should perhaps be more concerned with the secondary ones where the drivers perception of the original hazard may be greatly reduced and his reaction therefore slower. This concept could apply to rear-end conflicts in all situations.

5. Future Research

Future research by Transport Canada will concern the application of some of the new definitions and techniques developed in our recent studies. Only if a technique proves viable over a large and varied sample of traffic conditions and represents a significant improvement over volume-based accident diagnostic methods, will the necessary equipment and methodology be developed, if possible, to allow for easy data collection and to guarantee reproducible results.
6. Conclusions to Date

A number of logically developed definitions of traffic conflicts have been investigated based on analysis of actual accident occurrence. While the final judgement is not yet in, several tentative conclusions seem to be developing:

(i) observation of evasive action is not highly correlated to accidents and, in fact, represents a demonstrably poor concept for prediction;

(ii) to date, no other definitions show high promise of significantly improved performance over the counting of brake light applications. Some new concepts have, however, recently been developed by Transport Canada and others and only further testing will determine their usefulness;

(iii) all conflicts are extremely volume-dependent and, in many cases (especially rear-end accidents), a simple consideration of traffic volume and speed can give a better, more consistent assessment of accident potential.

(iv) accidents are a highly variable phenomenon; in fact accidents themselves are often not a particularly good predictor for future occurrences; this may result from the large human factors component inherent in the estimation of the collision probability "p";

(v) in terms of engineering warrants, conflicts thus may well be of use only as indications of operational problems or deficiencies which may, or may not, lead consistently to accident occurrence depending on a number of indeterminate factors;

(vi) the concept of traffic conflicts is a very appealing one from the point of view of the traffic engineer and the road safety researcher; while the above tentative conclusions are largely negative, it is still hoped that some useful definition and application of the TCT can be found.

7. Bibliography


(3) Unpublished reports on two recent Transport Canada studies


Traffic Conflicts Technique - Status in Norway, by Finn H Amundsen and Hans O E Larsen, Institute of Transport Economics (TVI).

1. USE OF THE METHOD
The method is intended to be used to supplement traffic accident data, where few accidents are recorded, where there is no accidents yet and for before and after studies of short term effect. We further hope that the mere observation of the traffic in the intersection will help to decide the correct traffic safety measure. We do not, however, use conflicts as we would use accidents, i.e. to decide where corrective measures should be adopted.

2. THE DEFINITION OF CONFLICTS
The conflicts are separated in three severity groups; moderate conflicts, dangerous conflicts and critical conflicts. Any traffic accidents and unlawful movements are also included, but the last group is not counted as conflicts.

Moderate Conflict:
A situation that could develop into an accident if one or both parties had not decelerated, turned or changed their path faster than usual. One or two vehicles (or pedestrians) pass or stop within a certain distance.

Dangerous Conflict:
A dangerous situation that counteracts with rapid deceleration or yielding manoeuvre. One or two vehicles (or pedestrians) stop or pass near each other.

Critical Conflict:
A critical situation that almost develops into an accident. The deceleration or yielding manoeuvre is out of control.

To guide the observers the distance in meters between the passing or stopping vehicles are given in a table:

<table>
<thead>
<tr>
<th>Severity grade</th>
<th>In built up areas</th>
<th>Outside built up areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low traffic</td>
<td>3 - 5</td>
<td>5</td>
</tr>
<tr>
<td>Heavy traffic</td>
<td>1 - 3</td>
<td></td>
</tr>
<tr>
<td>Dangerous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low traffic</td>
<td>2 - 3</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Heavy traffic</td>
<td>0,5 - 1</td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low traffic</td>
<td>0 - 2</td>
<td>0 - 3</td>
</tr>
<tr>
<td>Heavy traffic</td>
<td>0 - 0,5</td>
<td></td>
</tr>
</tbody>
</table>

The definitions of conflicts used in Norway are verbal and therefore subjective. The observer is therefore an element in the study and he needs very extensive training with skilled observers. The table with distances was added later with help from observers and we feel that it makes the data a little more quantitative. We do not, however, add conflicts from different observers or compare intersections from different observers. Therefore, before and after studies have to be made by the same or the same group of observers. In addition to record conflicts the observers are urged to comment on the intersection, traffic, signing etc.
We have discussed developing a more objective set of definitions but have decided that the advantage is that observations can be made without technical equipment (video tape etc). We do, however, plan to record an instruction film or tape.

3. METHOD OF CONFLICT MEASUREMENT

The measurements are made as described by TRRL with one or more observers, but without filming.

4. MEASUREMENT ACCURACY

As we use the method as a more qualitative measure we have not made too many studies of quality. In 1974 we evaluated the method on 31 intersections in Oslo.

In the first test we recorded accidents (3 yr), conflicts (7 hr) and traffic (7hr) in 12 intersections with signed priority and 19 with right hand rule. The Spearman rank correlation was used as a significance test. For the 12 intersections the partial correlation between accidents and serious conflicts (constant traffic) was higher (0.49) than between accidents and traffic (constant conflicts) (0.19). For the 19 intersections the partial correlation between accidents and serious conflicts was lower (0.25) than between accidents and traffic (0.42). The Spearman rank correlation shows a significant correlation between accidents and conflicts (p = 5% for the 12, p = 1% for the 19 intersections).

The conflict- and accident situations were also recorded. The Spearman rank correlation between the groups was significant (p = 1%). We have concluded that there exists a relationship between accidents and observed conflicts in these groups of intersections.

To check out the definitions we have made two small studies: where four observers recorded conflicts in the same intersections and by recording in the same intersections for several days.

PRACTICAL APPLICATION

The method has been used extensively in the last three years for research purpose in determining the "safety" of at-grade intersections and separated-grade intersections. The use of yellow signal lights during hours of low traffic intensity has also been studied.

In addition it has been used in before and after studies and to correct unsafe intersections.

The results are reported in Norwegian.
We would like to show two examples of simple before and after studies made in Oslo.

In a signalized intersection a special left hand turn was installed. Conflicts were recorded before and after the change.

<table>
<thead>
<tr>
<th>SUM</th>
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<tbody>
<tr>
<td>41</td>
<td>4</td>
<td>21</td>
<td>5</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The left turn conflicts were reduced from 21 to 3. The number of left turning cars increased from 1018 to 1363 (34%). The number of straight through cars was reduced from 4040 to 3680 (9%). The second intersection used to be right hand ruled but a priority sign was installed on one of the intersection legs (see drawing).

Even if the number of conflicts has decreased the number of conflicts per car from Haukeland has only been reduced from 0.017 to 0.011.

OFFICIAL OPINION

There are different opinions on the use of the method. Although many are sceptical the method has been used by local and governmental authorities, often with success. In Oslo they usually make conflict observations if they are in doubt what to do with an intersection.

FUTURE RESEARCH

No research is planned. We want to use the method in practical work and see how it works and gain experience from this.
1. Introduction

Since the later half of 1976, National Swedish Road and Traffic Research Institute (VTT) has been working with a development of a traffic study technique adapted to rural intersections. The primary aim is to receive knowledge of accident producing mechanisms working at intersections.

The traffic flow in the majority of the rural road network intersections in Sweden is not especially high and therefore we have not designed our investigation as an ordinary traffic study with intentions to measure what usually is meant by traffic conflicts, e.g. traffic situations classified as "near accidents". In the following text, the concept of traffic measurements includes traffic conflicts in ordinary sense as well as situations with low potential for accidental risks.

Definitions of traffic measurements

Conflicts, operationally defined by occurrence and seriousness of the corresponding overt conflict situation, are - specially the serious ones - very rare events in rural areas according to our opinion, based on screening a substantial amount of video taped traffic situations. In order to define measurements which can be assumed to be related to traffic conflicts, but more informative than e.g. simple flow variables, we have looked for more comprehensive traffic measurements, some of which are exemplified below.

The vehicles, observed in different traffic streams at an intersection, are grouped together according to certain time criteria. Within every group, the vehicles belonging to the main stream, are ordered in pairs. For such pairs we define a leading and a following car by use of arrival time at first passage.

The high accuracy of estimated coefficients in the functions which describe individual trajectories makes it possible to use different measurements and to follow intra-traffic relations in every combination of cars in terms of differences in position, velocity and acceleration.

We will give some examples of such intra-traffic relation measurements. For two cars, belonging to the main road stream we could have a situation like that in figure 2 with an observed "rear-end" situation. We introduce a simulated sudden stop for the leading car at some instant. After some time, equal to the reaction time of following car, we simulate a response-trajectory corresponding to an avoidance maneuver defined as a heavy deceleration. If the hypothetical collision, will be a fact or not, depends on the relations between the trajectories and the point of time for the simulated sudden stop. The critical moment in that respect gives for every pair of cars a "minimal safety distance" (MSD). We define a MSD-phase with help of observed time and road position for the leading car, which is the conflict generating element. The definition should be clear from the figure. The MSD-phase is terminated when approaching condition is changed, i.e. when passing occurs.

In the example above, the velocity of the leading car was drastically changed to zero. Another case could be a situation where the leading car retained its velocity but through a lane-shift prevented an initiated passing process. (figure 3.) We introduce the concept of "point of no return" (PNR). If the following car isn't able to adapt to the new condition, we will say that it has passed PNR. As in the MSD-example, we can define a PNR-phase. This concept is somewhat more complicated. Road position is not, as for MSD, the same for the generative event and the corresponding consequence. The PNR-phase has two parts, one generative and the other consecutive (look at the figure).

If we are interested in the conflict-generative properties of an intersection we would study the generative part of PNR. If we on the other hand are interested in a comparison with accident outcome we should concentrate on the consequence part.

The passing process itself can be divided into subsequent parts defined e.g. by positional relations like "leading car back to following car front", "side by side" and "leading car front to following car back". For each state we then estimate initial and terminal road positions and duration.

Relations between the left turning main stream and the oncoming traffic is of course of great importance. We have here classified observed interactions according to a disturbance category scheme.
A short list of output measurements

For individual cars:

1. Direction (traffic stream category)
2. Type of vehicle
3. Trajectory parameters
4. Position
5. Velocity at relevant points of time
6. Acceleration
7. Durations in intersection parts

For relations in combinations of cars:

1. Direction combination
2. Type combination
3. Distance between cars
4. Relative velocity at specific points of time
5. Relative acceleration
6. Total time in the intersection for cars
7. Common time in different parts
8. Initial and terminating positions for different phases
9. Corresponding durations
10. Disturbance categories
11. Passing categories

2. Method of traffic measurement

Information of the traffic process has been obtained by way of a video tape recordings-method. In a first step we have collected data from about 10 rural intersections, corresponding to about 50 hours effective recordings of traffic (approximately 5000 observed cars).

The general design is demonstrated in figure 1. The actual intersection together with a portion of about 100-150 meters of the connected main road are covered by 4 video cameras. By painted markings on the road the investigated area is divided in relevant sections. The video system includes a time generator and so we can estimate passage times between these sections. From the recordings we get informations about direction, type and sidposition.

Our main interest has been focused on the left turning traffic and its interaction with other potentially conflicting streams. The observation team has selected those situations for recording, which include at least one left turning car. According to some criteria, based on time assumed to be sufficient enough to not imply interactions between the left turning cars and other traffic streams, groups of cars have been formed.

3. Systematic and random errors

A great amount of work has been used to develop estimation methods with the purpose to reduce the influence of random errors and to correct for systematic errors. For systematic errors, for example road distance errors, we use a method for correction based on estimation of the true velocity in two different ways and then comparing these values for a small sample of our recorded cars.

After correction for systematic errors we still have to take random variation into consideration. In spite of efforts to make accurate readings of passage times we have had some problems with disturbing influence of random nature. As the reliability of our difference measures is very sensible to that fact, we have used an approach based on a regression model with a polynomial of somewhat less degree than what could optimal be used regarding number of observations. Thus, we are smoothing out the initially observed course, but still expect our model function to allow most forms of true variations. Thus, for every car in the primary direction of the main road we estimate 4 regression coefficients, which in the following analysis are used to compute road positions, velocities and accelerations at every requested instant. In one of the checking programs we have a method based on the sum of squared residuals.
FIG. 2 THE CONCEPT OF MINIMAL SAFETY DISTANCE (MSD)
A Conflict Technique, by G Malaterre and R Muhlrad, France.

Work on a traffic conflict technique has been carried on at ONISR since 1973. We have drawn on past work as a basis for our study, but the technique which is presented here differs from others in taking into account not only the recognized concept of urgency, but also other factors which determine the severity of individual conflicts (closeness to an injury-producing accident) such as speed, manoeuvres and type of road users involved.

GENERAL ORIENTATIONS:

The object of the exercise undertaken at ONISR is primarily to provide an instrument for measuring danger suitable for evaluation studies in urban areas; it is in this field that the need for a conflict technique appears to be the greatest: urban traffic conditions do change quickly and it usually proves impossible to carry out before-and-after studies based on injury-producing accidents as they involve long periods of data collection; also, in towns, personal injury is rare in terms of the number of breakdowns in the traffic system: damage only accidents play a much more important part than on rural roads: hence the need for a new way of appreciating "danger"; we can add to this that it is difficult to find comparable urban locations as the number of characteristics that can differ is enormous and therefore that evaluation studies can be of any use only if they are qualitative as well as quantitative and show how a countermeasure works as well as how much it works: hence the value of a thorough description of the conflicts as they occur.

Although our conflict technique is primarily designed for evaluation studies and for comparisons between various locations in terms of risk, we have also tried to see if such a technique, or a slightly modified version of it, could be any use in safety diagnoses on hazardous locations, i.e. if it would help in a major way finding out the factors of danger and designing the corresponding countermeasures.

THE TECHNIQUE:

1. Definition of conflicts: urgency, severity, and risk values:

   Between an analytical definition of conflicts including measurements of some factors (distance, speed, etc...) or elements which require personal interpretation (brake noise, brake lights, etc.) and a more general definition depending on an evaluation of the situation by trained and experienced observers, we finally chose the second approach as possibly conveying more information. So, the final definition is the following:

   "A traffic conflict is a situation where the interaction of several road users (or of a vehicle and the environment) would result in a collision unless at least one of those involved takes evasive action; it is the success of this action that determines the final result - conflict or collision".

   Conflicts have been rated from one to five on an urgency scale designed to give an indication of the closeness between the conflict and an actual collision. The meaning of the five values is as follows:

   1. Slight conflict: an evasive action was actually necessary to prevent a crash, but the protagonists had the time and distance necessary to achieve the manoeuvre without much difficulty.
2. Moderate conflict: The evasive action was more difficult than in the first case; an observer might have thought an accident would happen as a result of the initial conflict situation.

3. Serious conflict: The evasive action was very violent and only just

4. Conflict resulting in a minor collision: The evasive action was unable to prevent a slight accident; in some cases, there might not have been time for the evasive manoeuvre to be effective.

5. Conflict resulting in a serious accident (vehicle badly damaged or personal injury).

As defined here, the urgency scale is indicative of the risk between conflicts and any kind of collision; in towns in particular, know that damage only accidents occur with a much greater frequency and injury-producing ones; if we want to obtain an index of danger relative to our traditional measure or danger (i.e. the number of injury-producing accidents), we then must weigh each conflict according to its characteristics, with the various weights built as a function of the probability of collision being an injury-producing one.

To this purpose, we have constructed what we call a "seven matrix", based on the following characteristics:
- urgency (the five values are used in a logarithmic progression)
- speed of the fastest road user at the very beginning of the evasive type of road users involved (used as a function of their aggressiveness, vulnerability),
- angle of the collision that would have taken place if the evasive action had not been successful (or angle of the real collision if it actually occurred).

The calculation of the matrix coefficients has been based on national accident statistics and on behavioural analysis. We have not, in particular that in mixed conflicts (i.e. involving two different types of road users), the severity is to be found lower when it is the road with the greatest facilities for braking or swerving the one who has to take action to avoid the other one; in many cases, the latter has been in taking a calculated risk, thus creating the conflict situation.

The coefficients are such as follows:

- **Urgency**:

<table>
<thead>
<tr>
<th>Value of urgency</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient γ</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

- **Type of road-users involved**:

<table>
<thead>
<tr>
<th>Type</th>
<th>VL</th>
<th>PL</th>
<th>2R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient γ</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

P: conflicts involving one pedestrian
2R: conflicts involving at least one two-wheeler, but no pedestrian
PL: Conflicts involving at least one heavy-weight vehicle (but no pedestrian or two-wheeler)
VL: Conflicts involving only cars.

- **Angle of the would-be collision**:

<table>
<thead>
<tr>
<th>Angle</th>
<th>0</th>
<th>0.2</th>
<th>1.5</th>
<th>0.1</th>
<th>0.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient γ</td>
<td>1</td>
<td>1.5</td>
<td>0.1</td>
<td>0.35</td>
<td></td>
</tr>
</tbody>
</table>

The severity of each conflict is calculated by multiplication:

\[ S_i = \text{max} \{ \text{2R} \times Y_{2R} + \text{PL} \times Y_{PL} + \text{VL} \times Y_{VL} \} \]

In mixed conflicts with the most "mobile" road-user involved having to take evasive action, severity is divided by two.

One problem has appeared after use of this severity matrix: when we compare injury-producing accidents and severity values, one category of conflicts remains quite under-represented: the conflicts with one road-user turning left. So we had to apply a 1.5 multiplicative factor...

(1) When more than two road-users are involved in the conflict, speed and type of road-users apply to the "principal one" (the two of them between whom the collision would have occurred)
coefficient to all the conflicts of this category. This is the only way when we intervene directly on the type of conflict.

The risk on a given intersection is calculated by adding the severity values of all the conflicts occurring at this intersection: 

\[ R = \frac{1}{n} \sum S_i \]

It is between the risk values and the corresponding number of injury-producing accidents that we must verify a significant correlation to validate our conflict-technique; we have also been looking into the variations between the distributions of accidents by type of road-users involved and by type of manoeuvres and the corresponding distribution risk values.

2 - Method of conflict measurement:

So far, we have not been using technical aids (such as cine or video cameras) to collect conflict data because of various problems that arose:

- high cost: in urban areas, the camera must be continuously in action because of heavy traffic and the vagaries with which conflicts occur;

- impossibility of systematically finding a suitable position for the camera for a good coverage of the intersection studied: there are a frequent problem of the view being blocked, (by large lorries for instance) at times of heavy traffic;

- impossibility of filming the intersection and also the approach of the conflict with only one camera: if several cameras are used, the analysis of the results becomes much too long and complicated.

- difficulties in the analysis of the films: this operation calls for judgement on the part of the researcher just as direct observation; however film is a poor substitute for reality, especially the positioning of the camera is usually high up, and it appears difficult to "collimate" observers for conflict detection and evaluation of results from different locations might become difficult to compare.

So we eventually opted for the method of reporting conflict by direct observation, which has the advantages of being relatively inexpensive, providing immediate information, and hopefully producing more results, assuming that the observers are properly trained at the outset. However, we have not given up using cameras completely since films of conflicts suitably chosen as "typical examples" must ultimately help us improve the training of observers and test the accuracy of their judgment, also the use of cameras will be tested as a complement (and not a replacement) to direct observation.

Several teams of observers (two or three of them according to the size of the intersection) are working simultaneously on a given location. Their task includes:

- the detection of conflicts and the rating of severity;

- the notation for each conflict of the variables used for the calculation of risk: type of road-users involved, speed of the fastest one at the beginning of the conflict, angle of the would-be collision...

- the notation of other variables descriptive of the conflict: time, weather conditions, description of manoeuvres, total number of each type of road-users involved (if more than two), road-user creating the conflict situation, and if necessary indications of the local regulations (traffic lights, etc...).

A standard report-form has been issued for use by the observers, which makes the operation quite fast, except in the case of a very complicated conflict.

Before starting the actual work, the observers are submitted to a two-to-three day training period, including explanations and exercises carried out in the laboratory, and guided observations on busy intersections adequately chosen. A first series of tests of the reliability of their judgement was carried out during that period, and more tests follow after the beginning of the actual data collection.

VALIDITY:

Three main campaigns of measurement have been carried out.
The first one (Antony, 1976) was aimed mostly at testing the method for data collecting and improving the technique. The two others were used for the tests.

Here are the results as far as validation of the technique is concerned:

1 - Antony, 1976: (Eight intersections)

<table>
<thead>
<tr>
<th>Type of road users</th>
<th>VL</th>
<th>PL</th>
<th>2R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>% conflicts</td>
<td>31</td>
<td>15</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>% total risk</td>
<td>20</td>
<td>10</td>
<td>44</td>
<td>25</td>
</tr>
<tr>
<td>% accidents</td>
<td>21</td>
<td>6</td>
<td>42</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of manoeuvres</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>% conflicts</td>
<td>31</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>% total risk</td>
<td>15</td>
<td>4</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>% accidents</td>
<td>10</td>
<td>10</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

Application of the severity matrix improves a lot the correspondence between conflict data and accident data. The results are in effect reasonably good, apart from the fact that pedestrian-conflicts have been
reduced a bit too much.

The correspondence between risk values and total numbers of accidents is not so good.

<table>
<thead>
<tr>
<th>Intersections</th>
<th>Risk</th>
<th>Rank</th>
<th>Accidents (2 years)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.6</td>
<td>7</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>12.6</td>
<td>1</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3.5</td>
<td>8</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>8.9</td>
<td>4</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>12.2</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>9.3</td>
<td>3</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>7.8</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>5.8</td>
<td>8</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

The correlation between risk index and injury-accident figures to be quite low. However, the most serious faults can be explained:

- The intersections 1 and 3 which have a very low risk value have not been transformed recently during the period between accident collection observations in the previous campaign (Antony, 1975) which had taken place before the transformations, we had found a very high risk value for these two intersections (ranks 1 and 3 respectively).
- On intersection 5, a third of the total risk is related to a very close contact of a sort which occurs rarely; this conflict is more given the great an importance, considering that the observation period is quite short (one day long).

The problem of the optimum length of the observation period has not yet been solved yet.

2 - Lille, 1977 (5 intersections)

<table>
<thead>
<tr>
<th>Type of road-users</th>
<th>VL</th>
<th>PL</th>
<th>2R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>% conflicts</td>
<td>38</td>
<td>4</td>
<td>20</td>
<td>38</td>
</tr>
<tr>
<td>% total risk</td>
<td>87</td>
<td>4</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>% accidents</td>
<td>38</td>
<td>4</td>
<td>40</td>
<td>12</td>
</tr>
</tbody>
</table>

Type of manoeuvres

<table>
<thead>
<tr>
<th>Type of manoeuvres</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% conflicts</td>
<td>21</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>% total risk</td>
<td>5</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>% accidents</td>
<td>7</td>
<td>28</td>
<td>48</td>
</tr>
</tbody>
</table>

Here again, use of the severity matrix has greatly improved the correspondence between conflict data and accident data; this improvement is particularly spectacular where types of manoeuvres are concerned; however, the risk amount corresponding to conflicts with a left-hand turn is still a little too low.

If we examine the ranking of the five intersections:

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Risk</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>8.9</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>14.2</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>5.4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>10.3</td>
<td>7</td>
</tr>
</tbody>
</table>

As far as injury-accidents are concerned, our five intersections are more or less on the same level. The risk-index tends to differentiate them a bit more, but there is no contradiction between risk values and accident figures.

3 - Bordeaux, 1977:

The experiment here differed from the others in that it was constituted by a relatively long period of observation on only one intersection. It is in fact the before-after period of a before-and-after study which is not yet finished. Also, the intersection studied is situated in a suburban area, not quite urban, but not quite rural.

The distributions of accidents and risks are the following:

<table>
<thead>
<tr>
<th>Types of road-users</th>
<th>VL</th>
<th>PL</th>
<th>2R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>% conflicts</td>
<td>36</td>
<td>0</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>% total risk</td>
<td>47</td>
<td>11</td>
<td>42</td>
<td>7</td>
</tr>
<tr>
<td>% accidents</td>
<td>38</td>
<td>0</td>
<td>60</td>
<td>5</td>
</tr>
</tbody>
</table>
The improvement due to the severity matrix is neat. However, the risk-matrix related to conflicts with a left-hand turn is still very low.

Finally, the severity matrix that we have been using seems to work in a positive way in all the cases that we have not so far had.

**RELIABILITY - TRAINING OF OBSERVERS**

1 - Antony, 1973:

The observation periods at Antony were divided into two parts; a series of them took place in June, and a second one in October. All the two, the observers were submitted to a complementary training.

The four observers were divided into two teams working simultaneously on the same intersections, and we compared the reports brought up by each of them on the following characteristics:

- Rate of detection of conflicts (frequency of the conflicts reported)
- Accuracy of the conflict reports

<table>
<thead>
<tr>
<th>JUNE</th>
<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team A</td>
<td>1.28</td>
</tr>
<tr>
<td>Team B</td>
<td>0.88</td>
</tr>
</tbody>
</table>

In June, team B had a detection rate much lower than team A; a closer look into the types of conflicts detected shows that the difference is mainly due to a lower frequency of reported pedestrian conflicts. After discussion on this fact and more training, the detection rates of two teams have reached the same level.

- Evaluation of urgency and detection rate:

<table>
<thead>
<tr>
<th>Urgency</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team A</td>
<td>41%</td>
<td>10%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>51%</td>
</tr>
<tr>
<td>Team B</td>
<td>30%</td>
<td>15%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
<td>49%</td>
</tr>
</tbody>
</table>

The two teams have detection rates which are not too different. But team A reports more light conflicts: a look into the distribution of conflicts into types of road-users involved shows that the excess light conflicts involve VL only:

<table>
<thead>
<tr>
<th>Types of road-users</th>
<th>VL</th>
<th>PL</th>
<th>2R</th>
<th>P</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team A</td>
<td>23%</td>
<td>2%</td>
<td>9%</td>
<td>17%</td>
<td>51%</td>
</tr>
<tr>
<td>Team B</td>
<td>15%</td>
<td>3%</td>
<td>10%</td>
<td>20%</td>
<td>49%</td>
</tr>
</tbody>
</table>
The light conflicts reported in excess by team A appear to be in speed ones. There is not great difference between the two teams as far as appreciation of speed is concerned.

Some of the observers working on the Lille experiment had already been involved in the Antony one. It seems here that one of the problems faced is the determination of the right amount of training:

- a minimum period of training is necessary to get the observers accustomed with all the notions they will have to use, to calibrate their judgments, and to get them used to the report forms and the practical work they will have to do on the field.
- too much training or working too long at a time on intersections makes observers weary, and also tends to give the feeling that things are so well-known as to cause a deterioration of the results.

The training method we have adopted and formulated includes explanations, discussions, and actual periods of observation in the field. We certainly feel at this stage that training films of conflicts would be a great help. They would also allow us to control better the consistency of judgment of each observer at time intervals.

**Analytic Use of Conflicts:**

The question is to know what part the conflict technique can play in safety diagnoses on hazardous locations, either with conflicts replays in injury-accident data, or with conflict descriptions used as a complement.

A study is presently being carried out in Lille on four locations to examine accident factors and design countermeasures: it is based on injury-accident analysis or on conflict analysis or both.

It appears immediately that direct interpretation of conflict forms does not show the real safety profile properly, and that it is necessary to consider the severity value of each conflict. Even then, the correspondence with accident data is not perfect. We'll give here the example of one of the intersections studied:

We have represented in the diagram the conflicts with the highest severity value. It appears that the left-hand turn from rue Carrel to rue Belfort is the most dangerous movement on the intersection, followed by right-angle conflict at the opposite corner. But none of that latter type of maneuver appears in the real accidents; on the other hand, three accidents
involve a left-hand turn from rue de Belfort to rue de Douai, while this doesn’t appear in the major conflicts.

So it looks like the safety diagnosis based on injury-accident should be slightly different from one based on conflict data.

However, the question remains whether we must stick to accident data accumulated during past years as a reference when we know that the traffic situation might be moving quite fast, or whether the risk index might be a much more adequate indicator.

If we are to use the conflict technique as a help in safety diagnosis, it seems necessary to develop a little more descriptive parameters in the conflict report, without however making the whole process too heavy for the observer.

FUTURE DEVELOPMENTS:

1. In the short term:
   - development of a variant of our technique for use in safety diagnosis
   - gathering of new data for further validation of the technique
   - experiments of before-and-after studies (one has already started).
   - test of the use of cameras as a complement to direct observation and for training observers.

2. In the long term:
   - training of teams of observers for systematic use of the conflict technique in before-and-after studies on a local scale.
   - practical evaluation of various experimental countermeasures.
   - others ....


By very broad sense, the Traffic Conflicts Technique is not really anything new—only newly titled. For many years, highway engineers have observed problems in an effort to detect what operational characteristics were contributing to either safety or operational deficiencies. Over the years, it has become more common for experienced engineers to at least mentally note or even verbally record events such as vehicle-vehicle or vehicle-pedestrian maneuvers, "near-misses", and "near accidents". The advent of an activity characterized by brake-light activity. There were at least one documented brake-light study that was done in the late 1960's.

These efforts, however, were rarely documented with standard definitions or search to verify that what was being observed and counted was, in fact, indicative of either safety or operational deficiencies. "Engineering judgement" and the guide as a result, those interruptions to the traffic stream that are the easiest to observe, such as single vehicle erratic maneuvers, were most hot counted. This data was then utilized, along with actual recorded accident information, as justification for implementing engineering changes. More often than not, it was assumed that the correct solution had been determined and there was no follow-up after the location had been "improved."

1966, two engineers at the General Motors Research Laboratories were assigned a task of observing traffic at intersections to see if, by observation, it would be shown that General Motors cars performed differently than other manufacturer's cars. After months of observation, it became clear that at least the untrained observer, there was no discernible difference in operational characteristics. What they did report, however, was that most drivers, regardless of their make of car, reacted to potential conflicts of path conditions; either braking or swerving to avoid a possible collision course. They reasoned that it did not matter if, in fact, there was the real danger of collision. Only a perceived danger was necessary since the braking or swerving maneuver itself did cause an accident.

A set of definitions and procedures was developed, and it was envisioned that the "new" traffic conflict technique, was to be used primarily as a tool for measuring the traffic accident potential at intersections. In fact, in 5 years to follow, the Traffic Conflicts Technique was to be used mostly as a diagnostic tool as opposed to a predictive tool.

According to the very broad General Motors definition, a Traffic Conflict occurs if one driver takes evasive action by braking or swerving to avoid what he believes to be an impending collision with another vehicle. The objective evidence of a traffic conflict is a brake-light indication or a lane change affected by the second driver. The brake-light indication or the lane change, as well as the following vehicle, must be observed before a Conflict can be recorded. Criteria are defined for over 20 specific conflict situations at intersections and are described in GM Traffic Conflicts Technique - Procedures Manual.

According to the Procedures Manual, when a Traffic Conflicts count is taken, observations from two opposite intersection approach legs are recorded in 1 day by a two-man team using a single vehicle. One observer is responsible for noting conflicts, while the other is responsible for recording volume data. 10-minute data samples are taken alternately on each intersection approach.
lag from the observation vehicle, which is parked on the side of the roadway about 150 to 300 feet back from the intersection. The observer waits 15 minutes after each sample to count the data and move to the opposite approach. The team alternately surveys the two approach legs throughout the day.

It should be noted at this point that the General Motors counting procedures and definitions were not the result of extensive research. Very little effort was expended in determining reliability (i.e., consistency among observers for the same types of conditions). The only attempt was made to define the time at a given location under different traffic conditions) and sample size.

Although the General Motors work was subsequently presented at the annual Highway Research Board (now the Transportation Research Board) meeting in 1971, it was evident that highway agencies were reluctant to undertake programs to test the applicability of the Traffic Conflicts Technique as an operational research tool. The U.S. Department of Transportation, Federal Highway Administration contracted with three States to conduct a Traffic Conflicts demonstration program. The contracts provided funds for the counting of conflicts at a minimum of 400 intersection approach legs in each State. In addition, the counts were to be made both before and after a "spot improvement" type of engineering change had been made. Special training was provided by one of the General Motors engineers who developed the technique.

The States' role in the overall evaluation of the Traffic Conflicts Technique was to determine whether conflicts data provided the kind of information from which the need for safety improvements could be determined. The States were responsible for making the counts comparing it to actual accident data, determining whether the Traffic Conflicts Technique was advantageous to use.

It was beyond the scope of the studies to require that the improvements be made only on the basis of conflicts counts because this would have necessitated the funding of the improvements themselves. Instead, each State was to make counts at intersections that were already scheduled for improvement as the result of accident analyses based on accident experience. Because the Traffic Conflicts Technique was developed as a tool for measuring accident potential, it was hoped that the conflicts counts would reveal the same safety deficiencies as did conventional accident analysis.

II. Current Activity

Primarily because of the three-State demonstration project, which was completed in 1971, the Traffic Conflicts Technique has gained popularity as a diagnostic tool. In two of the three States involved in the demonstration project, the Traffic Conflicts Technique is employed as a diagnostic tool in day-to-day operational procedures. In addition to diagnostic applications at both interstate intersections and freeway spot locations such as gore areas and weaving sections, it is being used as warrants for justifying special signalization projects or in some cases as a traffic control device evaluation tool in research studies.

Currently, there are four States that use the Traffic Conflicts Technique on a regular basis. The use in these States varies from extensive to occasional. A number of other States continue to experiment with conflicts and occasionally use the data as an evaluation tool on research projects or as a supplement to accident data in justifying certain expenditures of safety funds.

While the General Motors definitions and procedures are utilized exclusively, certain variations have been introduced by some of the users. Specifically, as a result of work by the Transport & Road Research Laboratory in Great Britain, the regular users of Traffic Conflicts data in this country have included a severity scale in their procedures. In addition, the Traffic Conflicts count time has been reduced to as little as 2 hours per day for certain types of locations. One State has developed its own normalizing data so that traffic conflicts can be estimated as to what constitutes a "good" or "bad" number of traffic conflicts. This is particularly important for a specific location with specific design and operational characteristics.

The introduction of severity measures into the procedures has resulted in Traffic Conflicts counts being more judgmental in nature and has served, in part, to focus attention on the issues of reliability and repeatability. This problem, together with variations in the Traffic Conflicts definitions has rendered the data incompatible from one user to another.

Other forces at work that tend to inhibit the use of the Traffic Conflicts Technique include the requirement by the Federal agencies that all transportation safety projects be justified on the basis of reported accident experience. As a result, the State highway agencies have developed, with Federal funding, extensive accident record systems and rely heavily on computer generated accident data to diagnose and evaluate safety problems. The interest in the use of techniques such as Traffic Conflicts, however, remains high because of the obvious problem of using reported accident data.

As can be seen from a review of the published reports on the Traffic Conflicts Technique, a number of attempts have been made to model the relationship between Traffic Conflicts and accidents. The results of most of these efforts have not been satisfactory. A study by Glennon and Todorovich of the Traffic Conflicts literature in an accident countermeasure evaluation. They conclude that the current reliability of the Traffic Conflicts Technique is highly questionable. A number of potential uses of Traffic Conflicts data, such as traffic control, are in need of additional data.

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III. Proposed Research

Because of the focus of the Traffic Conflicts Subcommittee, increased interest among highway agencies, and the discussions evolving from the Thorson-Glenrock paper, a major research project entitled "Application of Traffic Conflicts at Intersections" was generated through the National Cooperative Highway Research Program (the National Cooperative Highway Research Program is a part of the Transportation Research Board that administers a national, State-funded research program).

The objective of the present project is to develop a standardized set of definitions, procedures that will provide a cost-effective method for measuring Traffic Conflicts Required is a Traffic Conflicts Technique method that is both reliable and repeatable for diagnosing safety at hazardous road intersections; and effective for reducing effectiveness of improvements at intersections; and yet be capable of use by personnel without extensive training or expensive equipment. The product of this research will be a ready-to-use procedures manual that clearly and concisely describes the recommended training procedures, data collection methodology, techniques, and evaluation methods.

Although the relationship between Traffic Conflicts and traffic accidents is a valid and important research area, it is not the major thrust of this project. Rather, the major question to be addressed is how well can Traffic Conflicts predict traffic crashes? There are two major parts to this question: (1) At a given site under specific traffic and environmental conditions, how much variability in the recorded Traffic Conflicts is expected from one observation period to another? (i.e., are Traffic Conflicts repeatable?); and (2) for a given set of observed Traffic Conflicts, how much variability in the observations is expected between trained observers (i.e., traffic conflict counts reliable?).

The research plan consists of five logically sequenced tasks.

In Task 1, all information on the state-of-the-art and the extent of current practice on Traffic Conflicts analysis will be drawn together. This activity will help define the scope of the remaining research.

Task 2 involves using the information gained in Task 1 to select candidate Traffic Conflicts Technique definitions and procedures to be tested in the Task 3 studies. This will be done by weighing data and estimates of the efficiency, practicality, accuracy, reliability, repeatability, and applicability needs of each candidate.

Task 3 will consist of comprehensive field studies testing the candidate definitions and procedures to determine their reliability (observer variance) and repeatability (site variance) for a variety of intersection conditions and characteristics. Task 3 includes seven subtasks to (1) develop a general work plan, (2) select sites, (3) develop field study procedures, (4) design experiments, (5) recruit observers, (6) train observers, and (7) conduct the field studies.

Task 4 involves the exhaustive analysis of the field data, and the application of the findings in generating final recommendations on Traffic Conflicts Technique definitions and procedures. The task will include (1) developing the field files (2) statistically analyzing the data to determine for each candidate Traffic Conflicts Technique procedure, its repeatability, reliability, and applicability for a range of site configurations, and (3) selecting those highly rated from the standpoint of both reliability and repeatability and also practical economic efficiency.

References

Use of the Traffic Conflicts Technique in Finnish Road Conditions, by M. J. Merilinna, National Board of Public Roads and Waterways.

1. General

The traffic conflicts technique was introduced in Finland in 1972 when the first study on it was carried out by the National Board of Public Roads and Waterways (NBH). After that NBH has developed it further by setting up a goal to make it usable for safety studies on intersections of public roads, mainly in rural areas. Three reports have been published as a result of this work [1, 2, 3]. Presently there is a vast study going on that comprises conflict counts from 100 intersection approaches, which was required 2400 working hours during the field surveys. The results are being analysed now.

2. Definitions of Conflicts

The General Motors Research Laboratories in the United States had developed conflict definition which were used by NBH in their technique. Even the first field study proved the technique of GMRL too complex for Finnish road and traffic conditions. It had to be simplified. At the present phase of studies a conflict at an intersection is defined as

(a) Evasive action, when a driver with the right-of-way traveling straight through an intersection, stops or weaves due to obvious interference by other traffic.

(b) Breaking is considered to have happened if the lights are lit.

(c) Weaving is considered to have happened if there is a clear change in travel course (e.g. crossing solid yellow line in no-passing zone).

In this connection traffic law is violated on:

- Traffic violation

Conflicts in Group a) are further grouped as to their cause:

- right-of-way conflicts
- rear-end conflicts
- pedestrian conflicts

Right-Of-Way Conflicts

Right-of-way conflict is the situation where a driver, traveling straight through an intersection, is threatened as to his right-of-way by another vehicle and must therefore brake or weave. These conflicts are grouped according to the direction of the threat. They are named as:

- right-of-way conflict from right
- right-of-way conflict from opposing left turn
- right-of-way conflict from left

Rear-End Conflicts

Rear-end conflict is the situation where two vehicles following each other approach an intersection into the direction with the right-of-way, and the vehicle following behind is obliged to brake or weave because of the vehicle in front. These conflicts are grouped as to the movements of the first vehicle: making a left hand turn, driving straight through or making a right hand turn. They are named as:

- rear-end conflict to left
- rear-end conflict straight through
- rear-end conflict to right
Pedestrian Conflicts

Pedestrian conflict is the situation where a driver with the right-of-way, travelling straight through an intersection is forced to brake or weave because of a pedestrian on the road.

There are altogether eight separate types of conflicts. A division into "severe" and "other" conflicts is necessary, as it turned out that in Finnish road conditions (excluding city areas) a "severe conflict" (e.g. time for braking ≤ 2 seconds or less) is a very rare occasion.

3. Field Studies

Two observers record conflicts and traffic volumes at an intersection counting simultaneously the conflicts from both main intersection approaches. The observations are in periods of half an hour. A total of eight counting hours per day and two to three counting days are used. The presentation of the observations are presented in Figure 1: Arrangements for field studies of conflicts.

Some Results of Studies So Far

LQ. Correlation between Conflicts and Accidents

As the first conflicts study [1] was carried out in Finland in 1972, the traffic conflicts technique was tested by observing 25 intersection approaches. The conflicts observed during relatively short periods of time were converted into average daily conflicts (ADC). The correlation coefficient between ADC's and reported accidents within three years was found to be $R = 0.87$, which is significant at the one per cent level of significance. The definitions of conflicts slightly differed from those used at the moment.

Reliability of the Traffic Conflicts Technique

In 1974...75 a study on the reliability of the technique was carried out [2]. The following two separate conflict studies were conducted.

- Repeated conflict counts at three intersections during three weeks.
- Two one and a half hours' conflict counts at the same intersection approach with thirteen and sixteen observers.

Conformity of observations between individual observers was found insufficient if their training for observing conflicts was very short (only about half a day). In this case 95 per cent of all observations about the same conflicts are approximated to fall within the limits of the mean ± 42 %, thus the range is fairly wide. However, it was also noticed that a longer training would improve conformity of observations.

It was suggested that experiments involving several observers simultaneously at different locations must absolutely be preceded by a test. All the observers count the same conflicts at the same location and the results are compared.
The length of a counting period may vary from 2 to 3 hours. If the standard deviation of all observations is:

\[ s \leq \frac{0.05\bar{x}}{t_{1-\frac{\alpha}{2}}(N-1)} \]

where

\[ \bar{x} = \text{mean of the observations} \]
\[ \alpha = \text{level of significance (.05 suggested)} \]
\[ N = \text{number of observers} \]
\[ t_{1-\frac{\alpha}{2}}(N-1) = \text{corresponding upper percentage point of the t-distribution} \]

the survey may begin. Otherwise the observers need more training. This test can be run, depending on the situation, either with the total number of conflicts or only with the specific types of conflicts. When this test is used a sample size of \( N=5 \) observers is recommended.

Before a new observer is allowed to start actual counting, it was also suggested to arrange a conflict counting test with another experienced observer. For instance the following test procedure can be applied. The observers are required to count the same conflicts during ten half hour periods on an intersection approach during one day so that a good variety in traffic volumes will occur. A sample correlation coefficient is to be calculated between their observations and if

\[ r_{\text{observed}} \approx 0.975 \]

the new observer may start working, otherwise more practical training is needed.

The unsteadiness of conflict numbers between different observation days proved rather severe problem because most of all observations were approximated to fall within the limits of the mean \( \pm 21\% \) (the range relatively from \( 0.79 \) to \( 1.21 \)), and the only means to improve the accuracy was to increase the number of counting days. The mean of the observations obtained through two counting days will fall within the relative 95 per cent confidence interval \( 0.85 \) to \( 1.15 \), and about twenty counting days are required to reach the 95 per cent confidence interval of the mean from \( 0.95 \) to \( 1.05 \). One counting day in this estimation meant two to three hours' effective conflict counting.

The study showed that the best possible result can be obtained from conflict observations distributed evenly during a whole day at one location as conflict observations are being made from traffic conditions of all volumes.

**Practical Applications**

The Traffic Conflicts Technique is being further developed in Finland. A detailed traffic safety study was carried out on a road section (Main road 4, section Jämijärvi-Jyväskylä) and different methods were compared that suggest certain arrangements aiming at decrease in accident numbers. The comparison also included the Traffic Conflicts Technique.

The results show that the Traffic Conflicts Technique is rather a useful method, in some cases even better than an analysis of accident statistics, for determining suitable traffic safety arrangements. However, interviews of local authorities, professional bus, lorry and taxi drivers give very similar information at lower costs, although their recommendations can partially be misleading.

**Official Opinion and Future Research**

The results of the before mentioned project that is being analysed will show to what extend the usability of the Traffic Conflicts Technique is believed in and if it will be given any weight in decision making.

The final results of the project will also determine if the technique will be regarded useful for traffic conditions on public roads in rural areas of Finland. If the results are positive, further studies are very likely to be made.
REFERENCES

/1/ Matilimaa, M.J: "A Study on the Reliability of the Traffic Conflicts Technique", The Ohio State University, USA. Columbus 1975.


INTRODUCTION


Hazardous situation, near miss, near accident and traffic conflict are all synonyms describing traffic situations with a potential accident risk. These situations show up as irregular events in the traffic stream without resulting in accidents. Most studies carried out on this subject have used different definitions to define the irregular events that represent a deficient situation from the safety and traffic operational point of view. This investigation suggests that a study of the regular flow of vehicles through an intersection should be included as part of the study of the irregularities, or the hazardous situations that may arise from them.

The various studies on this subject can be broadly divided into:

...
1. Investigations that observe groups of drivers and vehicles under various traffic situations. These studies are mostly of a psychological-sociological nature, and include studies by Forbes (1957), Zuercher et al. (1971), McFarland & Moseley (1954), and others.

2. Investigations that observe certain location or group of locations (generally an intersection or a bend). At such locations, the behavior of drivers and vehicles is observed.

This category includes studies such as the "General Motors Traffic Conflicts Technique", first developed by Harris and Perkins (1959, 1969), studies by Campbell and King (1969), Baker (1972), Pugh Halpin (1974), Paddock (1974), and others. Also included in this category are traffic conflict studies as developed by the TRRL, Spicer (1971, 1972, 1973), Amundsen (1974), studies by Guttinger and Kraay (1976) on conflicts in residential neighborhoods, Hayward (1971, 1972), who was the first to introduce the concept of "Time to Collision (TTC)" and Hyden (1973, 1976), who further developed this concept.

Studies attempting to relate driving errors and violations, such as by Harvey, Jenkins and Summer (1975), also belong to this category.

Most of the above studies are oriented towards engineering applications. Many were carried out at intersections, and attempted to locate deficiencies at those intersections by determining a correlation between conflicts and accidents.

THEORETICAL BASIS FOR THE PRESENT STUDY

The present study belongs to the second category of studies, investigating the behavior of vehicles at a certain type of location - intersections.

A number of basic assumptions formed the foundation for the present study, and determined its design and research method.

1. The engineering approach necessitates the study of the normal driver and vehicle population passing through the type of location under investigation (i.e., intersections).

2. In order to develop objective criteria, the analysis should be quantitative and not merely qualitative.

3. Any unusual traffic event forms the basis for a traffic operational and safety deficiency.

4. A relationship exists between the driving stimuli that exert themselves as deficiencies and the driver-vehicle system reaction.

5. The system's reaction consists of two possible parts: a change in velocity and a change in direction of travel. Reactions are possible as acceleration or deceleration and as a change in angular velocity, or as a combination of the two, and they are inter-changeable to some extent.
According to the above principles, it was decided to study the reactions and manoeuvres of vehicles on the approach to an intersection. Manoeuvres were recorded continuously, so that a microscopic model of the traffic flow could be defined in the following way:

reaction = f (stimulus; sensitivity)

Most car-following models of this kind deal with single lane traffic on an undisturbed straight section of road, and define the reaction as a change in tangential velocity. The present model, however, deals with the interaction of pairs of vehicles on the approach to and through an intersection, in which case, two dimensions of motion have to be considered, and all terms of the model-reaction, stimulus and sensitivity are defined accordingly.

The present study defines reaction as the resultant velocity change (deceleration), and is a function of both velocity change and directional change over time:

\[ \ddot{a} = \sqrt{\ddot{a}_T^2 + \ddot{a}_R^2} \quad \ldots \ldots \quad (1) \]

where:
\[ \ddot{a} = \text{resultant change in velocity} \]
\[ \ddot{a}_T = \text{change in tangential velocity} = \ddot{a}_T = \frac{\Delta \dot{a}_T}{\Delta t} \]
\[ \ddot{a}_R = \text{change in radial velocity} = \ddot{a}_R = \frac{\Delta \dot{a}_R}{\Delta t} \]
\[ s = \text{tangential velocity} \]
\[ \omega = \text{radial velocity} \]
\[ \Delta s = \text{velocity change} \]
\[ \Delta t = \text{time interval} \]

Whereas the expression for the reaction can be written in a general form for any kind of traffic activity or disturbance, the terms for sensitivity and stimulus have to be defined separately for each activity.

When treating, for example, the approach to an intersection, it is suggested to use the following terms:

for stimulus:
\[ s_{n+1} - s_n, \quad \omega_{n+1} - \omega_n \]

for sensitivity:
\[ \lambda_{o1} (x_{n+1} - x_n)^{-1} + \lambda_{o2} (s_{n+1} - s_n) \]

where:
\[ n = \text{leading vehicle} \]
\[ n + 1 = \text{following vehicle} \]
\[ s = \text{velocity} \]
\[ \omega = \text{radial velocity} \]
\[ x = \text{location} \]
\[ \theta = \text{angle} \]
\[ \lambda_{o1}, \lambda_{o2} = \text{parameters of sensitivity} \]

It follows that the complete expression for the motion of two vehicles becomes:

\[ \ddot{a} (t+T) = \lambda_{o1} (x_{n+1} - x_n)^{-1} (s_{n+1} - s_n) + \lambda_{o2} (s_{n+1} - s_n) (\omega_{n+1} - \omega_n) \quad \ldots \ldots \quad (2) \]

\[ \ddot{a} (t+T) = \lambda_{o0} + \lambda_{o1} (x_{n+1} - x_n)^{-1} (s_{n+1} - s_n) + \lambda_{o2} (s_{n+1} - s_n) (\omega_{n+1} - \omega_n) \quad \ldots \ldots \quad (3) \]
The tangential expression is identical to those used in normal car-following models, whereas the angular expression is analogous and symmetrical to the tangential one.

Two formulations are offered and studied. Eq. 2 without a free term, and Eq. 3 with a free term λ_{00}. The justification for each type of equation will be discussed later.

Other formulations to this theoretical model could probably be presented and developed.

DEFINITION OF THE DEVIATING REACTION

According to the theoretical basis developed, a potential situation of risk in traffic will form the stimulus for the driver-vehicle system, and will result in a reaction. The reaction will therefore be a subjective estimate of danger, but will be related through the equation of motion to the stimulus, which is an objective estimator.

The question arises as to what can be termed as a reaction which exceeds confidence limits of "normal" reactions, which could be defined as the white noise resulting from normal traffic conditions. At this stage, two alternative formulations of the model are considered in Eq. 2 and 3. Eq. 2 is consistent with the normal car-following theory, and implies that no reaction results when there is no stimulus. The free term in Eq. 3 implies, however, that a certain reaction may result even without stimulus. This reaction can be termed "white noise".

It is suggested to use the free term as an estimate of the "white noise". When the reaction to a certain motion exceeds the limits of "white noise" by a certain amount of n standard deviations, it can be termed deviating.

A deviating reaction \( a > \lambda_{00} + n \sigma_{\lambda_{00}} \)

It will be shown that according to this definition, unusual events in the traffic stream can be identified.

STUDY METHOD

To evaluate the situation defined above, a stream of traffic approaching an intersection was monitored continuously. Vehicle manoeuvres were measured and evaluated. Continuous filming was considered as the most suitable method of recording. Vehicles approaching an intersection were filmed from a high building adjacent to the intersection at a rate of 24 fps. with a 16 mm. Bolex H16 camera. Before filming started, the intersection and its approaches were marked with an orthogonal grid of 1x1 meter stripes. This grid formed the basis for the analysis of the film.

The film was analyzed on a photoroptical Hadland-Vanguard film-analyzer, whereby for each film frame the coordinates of the front and rear of each vehicle were recorded. Also recorded were a sequential number for each vehicle, its type and its manoeuvre.

By means of a polynomial regression of the form \( a^n y^n \), \((n,n = 0,1,2,3)\), the film coordinates were translated into real coordinates. In this way,
calculations could be made for each vehicle, each group of vehicles, each manoeuvre, etc. The characteristics for each vehicle manoeuvre, such as velocity, direction of travel, deceleration and angular velocity could all be accurately calculated.

Two urban intersections were selected for detailed analysis, both with similar daily traffic flows. One was a T-intersection, with reasonable geometrical layout, channelization and sight distances, and with few accidents. The second intersection, a cross-road, had many accidents during the past years. It had no traffic control, no channelization, no lane markings, deficient sight distances and parking on the approaches. It was argued that if intersection geometry has an influence on driving behaviour, it should show up in the comparison of these two locations. At the present, the study is not completed, and this paper brings results from the T-intersection only. At this intersection, 248 vehicles were filmed over 32,000 frames of 16 mm. colour film. At the second intersection, 179 vehicles were filmed, also over some 32,000 frames.

DATA ANALYSIS

The first results included a listing of the characteristics of motion for each vehicle from the moment it reached the approach until it left the intersection.

The second stage of the analysis consisted of a study of the relationship between two following vehicles, according to the models described.

Each pair of vehicles was analyzed and an equation of motion was fitted with the aid of a linear regression equation. It had to be determined what value of delay \( T \) between leader and follower should be chosen. For each pair of vehicles, 10 values of \( T \) were studied, ranging from between 0.25 to 2.5 seconds. The value of \( T \) selected for each pair of vehicles was taken at the point where the residual value of the regression equation was smallest. The two models, with and without a free term, were both investigated.

The third stage of analysis was to group all pairs of vehicles according to the optimal values of \( T \) obtained for each pair, and to fit a regression equation to all vehicles according to the type of manoeuvre. This stage also included calculation of the free term of the regression equation, and its standard deviation. Excessive reactions and unusual events were also determined at this stage.

RESULTS

At the intersection studied, 248 vehicles were filmed at 24 fps and analyzed accordingly. 32 vehicles were travelling in platoons, interacted with each other, but travelled straight ahead, without turning movements.

For these vehicles, the car-following model was:
\[
\ddot{a} = 4.257 \Delta s/\Delta t + 0.0022 \Delta \dot{a} + \Delta \ddot{a}
\]
\( r = 0.92 \) .... (4)

\[
\ddot{a} = 0.096 + 3.587 \Delta s/\Delta t + 0.0189 \Delta \dot{a} + \Delta \ddot{a}
\]
\( r = 0.72 \) .... (5)
where:
\[ \Delta s = s_{n+1} - s_n \quad ; \quad \Delta d = x_{n+1} - x_n \]
\[ \Delta 0 = \theta_{n+1} - \theta_n \quad ; \quad \Delta w = \omega_{n+1} - \omega_n \]

The definition of the coefficient of correlation is calculated differently in the regression equation without a free term from the normal BMD procedure. This results in a higher correlation coefficient in eq. 4 than in eq. 5, which is, of course, unreasonable. This is one of the reasons why previously the best fitting equation was selected according to the value of the residual and not according to the correlation coefficient.

On the other hand, the two equations are not very different from each other, and produce results consistent with theory. The free term in eq. 5 contributes only little to the calculated reaction. The two other terms in each equation are statistically significant, but the first term (\(\Delta s/\Delta d\)) contributes significantly more to the correlation coefficient than the second term.

According to the average value of the free term, and the standard deviation of this value, an excessive reaction was defined at two levels:
1. \[ \bar{\Delta s}_1 > \lambda_{00} + 2\lambda_{00} \] excluding 84% of the vehicle population
2. \[ \bar{\Delta s}_2 > \lambda_{00} + 2\lambda_{00} \] excluding 98% of the vehicle population

This estimate was used for a number of applications of the results, as described below.

a. To identify the vehicles that contributed the excessive values. A list was prepared for those vehicles, including their type, manoeuvres, and the values of their driving characteristics (speed, headway, etc.). These vehicles were also observed separately on the film analyzer to study their behaviour in detail.

b. To determine average values for the "manoeuvre coefficient" of each type of manoeuvre, such as a left-turn exit from the main road, a left turn entry from the side road, stopping for a pedestrian crossing, etc.

The manoeuvres were defined according to the different types of disturbances, and are as follows:

<table>
<thead>
<tr>
<th>Type of disturbance</th>
<th>Average value of sum of resultant braking values greater than one</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Undisturbed free flowing vehicles</td>
<td>2.9</td>
<td>42</td>
</tr>
<tr>
<td>2. Disturbance from vehicle parked on the right</td>
<td>3.0</td>
<td>20</td>
</tr>
<tr>
<td>3. Disturbance from preceding vehicles (platoon)</td>
<td>4.3</td>
<td>32</td>
</tr>
<tr>
<td>4. Disturbance from platoon and parked vehicle</td>
<td>5.4</td>
<td>29</td>
</tr>
<tr>
<td>5. Disturbance from left turning vehicle</td>
<td>9.5</td>
<td>28</td>
</tr>
<tr>
<td>6. Disturbance from vehicle waiting to enter from side road</td>
<td>8.6</td>
<td>16</td>
</tr>
<tr>
<td>7. Disturbance from vehicle entering from side road</td>
<td>33.2</td>
<td>20</td>
</tr>
<tr>
<td>8. Disturbance from crossing pedestrian</td>
<td>86.2</td>
<td>10</td>
</tr>
</tbody>
</table>
Each type of manoeuvre can be evaluated according to its contribution to the average value of the "braking" reaction. It can be seen that left turning vehicles contribute relatively much to the disturbance (at a channelized intersection), but entering vehicles and pedestrians contribute much more. This type of analysis may form the basis for the development of more sophisticated models, calibrated for each type of intersection and type of manoeuvre, which could then be evaluated according to their contribution to the "resultant braking" reaction.

c. The preparation of charts of "iso-deceleration" at the intersection. Such charts may provide information on deficient locations within the intersection area which produce the largest contributions to the values of resultant deceleration. Such locations, once identified, can be studied on the film taken. An engineering evaluation may lead to a determination of the geometrical and traffic control improvements that could be introduced to eliminate the "black spot". (see Fig. 1).

SUMMARY AND CONCLUSIONS

This study presents a basic research effort to determine a methodology for objective analysis of traffic behaviour at an intersection. A methodology is presented to describe the motion of each vehicle, and to determine its travel characteristics. Excessive values of reaction to driving stimuli have been defined and calculated.

Fig. 1: Graphic presentation of "iso-deceleration" at intersection.
The development of two-dimensional equations of motion, the
definition of unusual events, excessive reactions for each type of
manoeuvre at each intersection may enable an objective analysis of
vehicle manoeuvres through an intersection.

The definition of additional variables in the model and application
on a wider scale may turn this method into a research tool for evaluating
engineering deficiencies at intersections.

Further analysis of the data obtained, including a comparison of
the "good" and the "bad" intersections, may provide further information.

It should also be studied whether similar results may be obtained
by simplifying the data analysis procedures, which are, at the present,
very time and labour consuming.

LIST OF REFERENCES

Method and an Analysis of the Correlation with Traffic Accidents.
Transportakademisk Institutt, Norway.

H.R. Rec. 384, Highway Research Board, U.S.A.

Campbell, R.E. & King, L.E. (1969). An Investigation of Two Rural Inter-
sections Utilizing the General Motors Traffic Conflicts Technique.
Highway Research Board, Second Western Summer Meeting, U.S.A.

No. 152, Highway Research Board, U.S.A.

Guttinger, V.A. & Krenz, J.M. (1976). Development of a Conflict Obser-
vation Technique.

Accident Potential at Intersections. H.R. Bull. 225, Highway Research
Board, U.S.A.

Automotive Safety Seminar, General Motors Corporation, Warren, Michigan,
U.S.A.

Report 149 UC, Transport & Road Research Laboratory, Crowthorne, England.

Hayward, J. (1971). Near Misses as a Measure of Safety at Urban Inter-
sections. The Pennsylvania State University, Department of Civil Engineering,
Pennsylvania Transportation & Traffic Safety Centre Report, U.S.A.

Hayward, J. (1972). Near Miss Determination through Use of a Scale of
Dangers. The Pennsylvania State University, Pennsylvania Transportation &
Safety Centre Report, U.S.A.

Planfor Group, Report Lund University, Sweden.

Pedestrian Safety Research. International Conference on Pedestrian Safety,
Dec. 1976, Road Safety Centre, Technion, Haifa, Israel.

Long-Haul Truck Operations, (2) Studies of Near Accidents in Long Distance
of Public Health, Boston, Mass., U.S.A.
REFERENCES Cont'd.


A Traffic-Conflicts Technique for Examining Urban Intersection Problems, by Chr Hydén, Lund Institute of Technology. (Sweden)

1. INTRODUCTION

This paper primarily describes a three-year project which was completed 1976.

The aim of this project was to develop a traffic-conflicts technique which should be useful when studying all kinds of safety problems in urban intersections. One of the criteria when starting this project was that the technique should be simple to use both in research work and in practical planning. The traditional use of accident-analysis in traffic safety planning creates great problems in some areas. This conflicts- technique is primarily meant to be an alternative to accident analysis within the following main areas of interest:

1/ What are the main safety problems in urban traffic to-day?
2/ What kind of events/hazardous behaviours lead to accidents?
3/ What are the real accident causes and what part plays the different factors involved, such as the different road users involved, the physical layout, the traffic situation, the vehicle and the external conditions (light, weather, etc.)?
4/ What is the optimal combination of different countermeasures totally or in a part of the network at a given time?
5/ What are the estimated safety benefits from different solutions according to item 4/ and what are the actual effects of the countermeasures implemented?

A natural approach to to solve the problems associated with the use of accident analysis is to define a kind of event that fulfills the following criterias:

1/ The event shall be much more frequent than accidents.
2/ The degree of seriousness of an event must be clearly defined so that the accident probability is obvious.
3/ The full history of the events must be easily and reliably recorded.

2. DEFINITION OF A SERIOUS CONFLICT

Based on the criterias mentioned in section 1 we define a conflict as a situation which had led to an accident if none of the road-users involved had taken any evasive action. We believe that the degree of seriousness of conflicts may be determined by focusing on the moment when the first of the conflict-involved road-users
starts taking evasive action. The degree of seriousness may be defined as the remaining time to an accident (in the following TO) if both road-users involved had continued with unchanged speeds and directions. By watching video-taped conflicts, we however found out that there were clear indications that some of the road-users consiously lowered their TO-value by braking (swerving or accelerating) as late as possible according to their opinion of a safe behaviour. It became quite clear that a threshold level exists at approximately 1.5 seconds.

This means that a conflict with a TO-value below 1.5 seconds is characterized by the fact that (almost) no road-user voluntarily puts herself in such a situation. This therefore forms the natural basis for a definition of a serious conflict:

A serious conflict occurs when the time to accident (TO) is below 1.5 seconds.

A conflict definition of this kind has the following advantages:

1/ The accident probability is quite obvious. The different actions and possibilities to avoid an accident are quite limited because most of the psychological part of the process may be disregarded (e.g. the perception and reaction times of the road-users involved). The situation also requires an immediate action which also limits the number of possible further actions.

2/ The definition may be applied on all kind of urban intersection conflicts (i.e conflicts between all kind of road-users in all different kinds of situations).

3. THE RECORDING OF SERIOUS CONFLICTS

One of the basic items in the development of this conflicts-technology was to develop a recording technique which was easy to use. The best way of accomplishing this is to use human observers for ground-level observation. However this makes great demands on the operationalisation of the conflict-criterion in order to achieve a certain reliability.

In this project the observers are trained to determine the TO-values of conflicts in an indirect way. The training of observers is based on studies of video-taped, TO-classified conflicts. The observers learn to relate the suddenness and violence in a certain situation to the actual TO-value obtained by calculations from the video-taped situations.

In this way the observers are trained to discern the "threshold level" defined by the TO-value 1.5 seconds and to separate serious conflicts from non-serious ones.

Tests of the observer reliability have been carried out in the following way:

A number of trained observers performed, at the same time, conflict recording in the same intersection. The observers worked quite independently each other. Simultaneously the intersection was covered by a continous video-recording. Figure 1 shows an example of one of the tests that is carried out.

Another way of studying the consistency in conflict-counts is to compare counts carried out at different occasions in the same intersections and where the expected number of serious conflicts is estimated to be as equal as possible at the different occasions. This was done in a number of intersections in the city of Malmö. The intersections were studied in two different years (1974 and 1975). The studies were carried out at the same time of the year (may), the same weekdays (mondays, tuesdays) and at the same time of the day (11.30-13.00). Other factors influencing the expected number of serious conflicts, such as traffic volume, weather and light conditions, were to be considered approximately constant between the two studies, except for a small increase in traffic volumes. In the 1974-75 study the number of serious conflicts per minute was 0.034 (40/11855) while the corresponding figure for 1975 was 0.037 (44/1176). The small difference, approximately 8%, is quite acceptable and may also be partly explained by the increase in vehicle traffic.
4. RELATION BETWEEN SERIOUS CONFLICTS AND ACCIDENTS

The fundamental problems encountered during the formulation of an analytical model for the relation between serious conflicts and accidents caused us, at an early stage, to concentrate on an empirical model. To accomplish this, studies were carried out in a total of 115 intersections. At each intersection conflict-recording was carried out for seven hours on average. For each intersection accident-data (injury accidents only) were collected for seven to eight years, starting 1968 (the year after the change to right hand traffic in Sweden).

The study was divided into the following three steps:

1A/ 50 intersections in Malmö were studied in 1974 to differentiate which variables were important for the relation.

1B/ The same intersections were studied again in 1975. The purpose was to study the stability in the conflict frequency and to increase the data-base.

2/ 15 new intersections in Malmö were studied in 1976 to clarify the relations' variation within the same urban area.

3/ 50 intersections in Stockholm were studied in 1976 to study whether the relations vary with the characteristics and size of the urban area.

In a first preliminary analysis a computer program for stepwise linear regression (BMD02R) was used on data collected in the 50 intersections in Malmö. According to the results of the regressions, the relation between the number of observed conflicts per time period and the number of accidents per time period should depend mainly on 3 variables for the kind of road-user and 4 variables for the vehicle speeds. The following descriptive chart was compiled:

<table>
<thead>
<tr>
<th>Traffic class 1</th>
<th>Car - Car</th>
<th>Car-Bicycle</th>
<th>Car-Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic class 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic class 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic class 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

where

Traffic class 1 = All situations in low speed intersections and situations with only turning vehicles involved in high speed intersections

2 = Situations with only turning vehicles involved in signalized intersections

3 = Situations with at least one straight forward going vehicle involved in high speed intersections

4 = Situations with at least one straight forward going vehicle involved in signalized intersections

Low speed intersection = Non-signalized intersection with a median speed for passing vehicles below 30 km/h in all directions of flow

High speed intersection = Non-signalized intersection with a median speed exceeding 30 km/h in one or more of the direction of flow

For each of the twelve elements a conversion factor = number of accidents/number of serious conflicts per time unit was calculated. The change in traffic volumes, from the time covered by the accident analysis (an average for all years) to the time of conflict-recording, was also considered in the calculations. The results indicated a small number of accidents or conflicts in some of the elements. This creates a great uncertainty in the estimated ratios. A merging of some of the elements therefore was considered. It is seen by studying the traffic class division, which mainly describes the speed differences of the involved road-users that class 1 and 2 may be considered equal as can class 3 and 4. It should be possible then, to combine into 2 classes. A division by kind of road-user is mainly done to describe differences in the probability of a personal injury occurring in a serious conflict. From this point of view, it should be possible to merge classes where unprotected road-users are involved.

The merges can be described by the following figure with the twelve elements as a base:
If we consider the $t$-estimations of the Stockholm data, we find that this corresponds very well with that of Malmö's for the car-car cells. However in the cells that concern unprotected road-users the Stockholm $t$-estimations are lower. The most probable explanation of the differences between Stockholm and Malmö is the special difficulties for bicyclists in Stockholm due to the heavy vehicle traffic and the relatively small number of bicyclists. It is possible that a more thorough analysis than this project allowed could explain these differences. So far we can not establish that the differences are so large that a unification is not considered appropriate.

5. PRACTICAL APPLICATIONS

One of the main application areas is evaluation studies. Under assignment of the Road Safety Office the Department has carried out before- and after-studies on four locations where local speed limits of 30 km/h were enforced. The goal was to expose whether the school-children's safety improved, and if so, what this improvement was dependent upon. The speed limit was posted on two types of signs:

1/ Ordinary sign that stated that the speed limit was valid only Mondays-Fridays 07.30 - 16.00

2/ Adjustable sign automatically controlled indicating 30 km/h during the time the children were on their way to and from school.

In each test, one before- and two after studies were completed. Each study covered five weekdays except for one test where the study time was doubled because the conflict-frequency was too low. This decision to double the length of the time was already determined during the before-study.

In each study conflict recording, traffic counting and speed recording was done. The speed was measured with the use of a "datalogg" developed at the Department. Two tubes stretched across the road recorded in the datalogg the passage time of each vehicle. The collected data was registered on tape, which then were computerized. Besides the vehicle speed, the number of vehicles and pedestrians in different flows was also recorded with use of the datalogg.

The vehicles passages were divided with regard to whether children were on or close to the street or whether no children were visible and also which speed limit was enforced. The results of the conflict studies are given in the following table, which concerns the number of conflicts with pedestrians (children) involved:

<table>
<thead>
<tr>
<th>Traffic class</th>
<th>Car - Car</th>
<th>Car - Bicycle</th>
<th>Car-Pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic class 1</td>
<td>Cell 1</td>
<td>Cell 3</td>
<td></td>
</tr>
<tr>
<td>Traffic class 2</td>
<td>Cell 2</td>
<td>Cell 4</td>
<td></td>
</tr>
</tbody>
</table>

The reasonability of the proposed merge from 12 elements to 4 cells has been tested statistically for all three selections of intersections. The results indicate that in all three cases a merge is reasonable.

Conversion factors for the three different selections were calculated. Figure 1 and 2 give the results of these calculations. The results from the two Malmö-studies show a very good correspondence regarding the estimated ratio between accidents and serious conflicts ($t^*$. However this doesn't mean, with total certainty, that the real $t$-values are identical. If we, having the maximum bad luck, have received the estimations of $t$ which are far from the real $t$-values for respective data and in different directions, the $t$-estimations for the groups of data can eventually give the same value even though the real $t$-values are different. This is shown in the following figure:

![Diagram](image)

It is impossible to establish the existence of this situation.

It could be stated though, that there is a 5% risk of the one groups of data's real value to fall outside the estimated $t$-value's confidence intervals limit on one side. The risk that the other group of data's real $t$-value will fall outside of its confidence interval is equally large. The probability that this would be the case simultaneously for both estimations is very unlikely.

The only way to establish whether two groups of data can be unified, through the reasoning of this kind, is to decrease their confidence intervals in order to collect more conflict- and accident data, until it can be considered certain that the two groups of data's real $t$-values lie close enough to each other. It is a question of judgment whether this is the case for the Malmö-15 and Malmö-50. We do believe this to be the case.
Location Before After I After II
KommendBrsgatan, Stockholm 3/ 22 13 8
Abrahamsbergavagen, Stockholm 3/ 8 4 6
Nyagatan, Vetlanda 4/ 10 4 2
Erik Dahlbergsg, Sderalje 4/ 22 14 7
Total 52 35 23

1/ Carried out appr. one month after the introduction of the speed limit
2/ Carried out one half-to one year after the introduction of the speed limit
3/ Ordinary signs
4/ Adjustable signs

The number of conflicts have decreased significantly in all four tests. Besides, in three of the four tests, the number of conflicts continued to decrease by the second after-study. This is true for both tests with adjustable signs.

It can also be mentioned that the conflicts before and after the introduction of the speed limit are of the same type except that the speed of the vehicles involved was constantly lower in the after studies. The relations between accidents and conflicts illustrated earlier in this paper clearly show that the relations are dependant on the speed meaning, the lower the speed, less the probability that an accident should occur. The positive effects in terms of a decrease in the number of conflicts, thus is strengthened by the fact that the conflicts have also become less seriosus.

Through the counts of traffic volumes and control of weather conditions in the different studies, it could be established that the decrease in the number of conflicts must be explained by the decrease in the vehicle speeds. The speed recordings can be summarized as follows:

On locations with ordinary signs the average speed decreased by 3.2 km/h while the adjustable signs gave a reduction of 8.9 km/h. The presence of children caused a constant decrease of yet one km/h.

A conclusion drawn from the speed recordings is that the drivers demonstrated a fairly good understanding of the need for the speed limit through the adjustment of their speed with consideration to the risk of conflicts.

6. OFFICIAL OPINION ON THE USE OF THE TRAFFIC-CONFLICTS TECHNIQUE

In Sweden there has been a growing interest in using the traffic-conflicts technique during the last years. One example of this is the project described in section 5. The results obtained formed the basis for new official guidelines concerning the use of special speed limits at schools.

At present the Public Roads Administration reflects on funding a project which aims at modifying the existing technique for rural intersection studies. Two pilot studies are already completed.

The governmental Transport Research Delegation, who has sponsored the development of the existing conflicts-technique, now sponsors research projects in the area of pedestrian and bicycle safety in urban traffic, where the traffic-conflicts technique is applied.
<table>
<thead>
<tr>
<th>CONFlict SITuation NO</th>
<th>TIME OF DAY</th>
<th>KIND OF ROAD User INVOLVED</th>
<th>SERIOUS CONFLICT ACCORDING TO VIDEOTAPEs 2/</th>
<th>SERIOUS CONFLICT ACCORDING To THE OBSERVERs' RECORDING 2/</th>
<th>SCORes POSSIBLE ERRATIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.00</td>
<td>C - B</td>
<td>1</td>
<td>1 1 2 1 -</td>
<td>5 1</td>
</tr>
<tr>
<td>2</td>
<td>16.11</td>
<td>C - P</td>
<td>3</td>
<td>3 3 3 3 -</td>
<td>5 1</td>
</tr>
<tr>
<td>3</td>
<td>16.17</td>
<td>C - C</td>
<td>-</td>
<td>- - 1 - -</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>16.20</td>
<td>C - P</td>
<td>3</td>
<td>3 3 3 3 3</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>16.30</td>
<td>C - P</td>
<td>4</td>
<td>4 4 4 4 4</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>16.54</td>
<td>C - C</td>
<td>-</td>
<td>- - 3 - -</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>16.55</td>
<td>C - B</td>
<td>1</td>
<td>- - 1 1 1</td>
<td>5 2</td>
</tr>
<tr>
<td>8</td>
<td>17.01</td>
<td>C - N</td>
<td>-</td>
<td>1 1 1 1 1</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>17.03</td>
<td>C - C</td>
<td>4</td>
<td>4 4 4 4 2</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>17.35</td>
<td>C - C</td>
<td>2</td>
<td>2 2 1 2 2</td>
<td>5</td>
</tr>
</tbody>
</table>

**Total:** 7 9 8 8 6 40 6

**Number of errors per observer:** 1 3 0 0 2

1/ KIND OF ROAD USER INVOLVED: C = Car driver, B = Bicyclist, P = Pedestrian, N = Moped driver.

2/ The figures concern the degree of seriousness in four classes of the serious conflicts.

Location: No 13 in Malmö, Amiralsgatan-Spånderhusvägen. Wednesday, 1974.06.05, 16.00-18.00

**Table 1**

**Figure 1**

**Estimation of the Ratio Between Accidents and Conflicts (\( \pi_2 \))**

Confidence interval with 95% degree of confidence for Malmö.
The Development of the Traffic Conflicts Technique in the Federal Republic of Germany, by G Zimmermann, BAST, E Kimolong and H Erke, Braunschweig Techn University.

1. Intended tasks of TCT

The traffic conflicts technique is intended for application in a large number of problems, especially

1.1 Diagnostic instrument

- in-depth analysis of locations with a concentration of accidents, especially at urban junctions, in order to evaluate the possible effects of planned countermeasures
- determination of the accident proneness of junctions and highway sections with a low rate of accidents which nevertheless can be overproportional with respect to the traffic volume
- evaluation of facilities for nonmotorized participants in traffic
- assessment of safety measures

1.2 Experimental evaluation of traffic facilities, traffic signs and other measures

- observation of driving behaviour at level railway crossings with alternative traffic safety measures
- observation of driving behaviour at changeable traffic signs

1.3 Instrument for traffic observation and control

- training of policemen for traffic observation, development of systematic control techniques, actions with relevancy to safety
- observation of the quality of traffic flow in order to derive improvement measures
2. Definition of conflicts

A traffic conflict is conceived as a hazardous situation in which road users approach each other in space or time to such an extent that there is an increase in the risk of collision.

Indicators of a conflict are the critical driving manoeuvres intended to reduce the collision risk:
- braking
- accelerating
- evasion
- or a combination of these

Traffic violations without the consequence of an accident are an additional indication of a conflict, because conflict situations could have been the result (e.g., not stopping when the traffic lights are red). Traffic violations without any consequences generally have none either because there are no other road users nearby or because other road users are not affected by the traffic violation. Thus the violation remains without consequences.

2.1 Operational definition of conflict type according to three sets of criteria in relation to
- road features, section, approach to the junction, inner area of junction, pedestrian crossing, level railway crossing, deceleration lane, etc.
- driving (walking) manoeuvres, choice of lane, change of lane (weaving), joining or leaving traffic, crossing, etc.
- the accident causes register (which needs to be revised as far as its psychological and traffic engineering aspects are concerned)

2.2 Operational definition of the degree of severity of conflicts in relation to
- distance between cars or car and pedestrian
- different speeds
- rate of acceleration or deceleration
- kind of reaction of the road users involved

Finally, 4 degrees of severity were defined.

1. Controlled braking, resp. change of lane to avoid collision. The driver has just enough time to execute a deliberate manoeuvre (time enough to look into the rear-view mirror). The manoeuvre is initiated because of an unforeseen traffic occurrence.

2. Vehement braking and/or abrupt change of lane to avoid collision. The driver has not enough time for deliberate reactions. Brake sounds and skid-marks frequently are associated with such manoeuvres.

3. Emergency stopping and/or avoidance in "last second". The driver only manages to avoid an accident by means of a quick reaction (near accident). In general, intensive noise from brakes and tires accompany such events.


2.3 Preparation of special records for specific locations or tasks in order not to overtax the limited capacity of the observers

3. Methods of conflict measurement

3.1 Definition of road sections and driving/walking manoeuvres to be observed according to structural criteria (e.g., road with parallel lanes, from the beginning to the end of the development of additional lanes, stopping area before stopping line)
3.2 Definition of direction of observation

3.3 Direct classification according to type and severity of conflicts, records on special lists. In special cases also records with graphic symbols, films or video recording

3.4 Simultaneous measurement of relevant traffic volumes (also pedestrians)

4. Study design and measurement technique

4.1 Training of observers

The observers receive a training manual in form of programmed instructions. Conflict types are graphically represented. Traffic situations and traffic conflicts are played from video-film and must be grouped into conflict categories. The interrater reliability has been studied. At the beginning, the agreement among the observers is $r = 0.67$. After performing the training manual and presenting the second video-film the reliability raises up to $r = 0.67$. In the final training observers will have to record conflicts at junctions. This showed an agreement of $r = 0.84^*$ and $r = 0.94^*$ among the trains which were divided into two groups (Erke a. Zimolong 1977).

4.2 Analysis of accidents

All accidents that occurred at the junctions under investigation during the last 3 years are compiled on the basis of accident records and collision diagrams. These are all the accidents (inclusive accidents without personal injuries and damages up to 1,000 DM) which were registered by the police. The accident retest reliability for all accidents is $r = 0.68^{**}$, for weaving accidents $r = 0.60^{**}$, rear end accidents $r = 0.42$. This quite satisfactory result depends mostly on the nearly complete accident records of the local police.

4.3 Conflicts and accidents

The conflicts are assigned to the accident types. Simple linear and multiple correlations are computed to assess the relation between types of conflict, degrees of severity and the corresponding accidents. Forecast elements are the three degrees of severity and the traffic volume. In the multiple regression analysis results are cross validated on the basis of accidents and conflicts from a random sample. The conflict to accident ratios have been investigated as well as the confidence intervals from the accident and conflict regression lines to identify junctions with high accident and conflict risks.

4.4 Before/After studies, pedestrian conflicts

To control the effect of traffic measures, traffic and pedestrian conflicts are counted after structural alteration had been carried out. Changes in conflict frequency and types are significant.

5. Practical applications of the TCT

5.1 First TCT study was performed at the approach roads of 6 signal-controlled junctions in Braunschweig ($n = 10$) (Zimolong a. Erke 1977). There exists only a poor relation between Rear End Conflicts and Rear End Accidents ($r = .20$). Weaving accidents and the Total of accidents can be better predicted on the basis of conflicts ($r = .67, .82$).
By a weighted combination of the independent variables: degrees of severity of conflict types and traffic volume much more variance of the criterion can be accounted for (Table 1).

Table 1 Multiple Correlations of Types of Accident and Types of Conflicts. Independent Variables are degrees of severity K1 and K2 of Types of Conflict, Traffic Violations K0 and Traffic Volume (VOL). (*p .05, **p .01).

<table>
<thead>
<tr>
<th>Type of Conflict</th>
<th>Type of Accident K1,K2</th>
<th>K0,K1,K2</th>
<th>VOL,K1,K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAR-END</td>
<td>.31</td>
<td></td>
<td>.76</td>
</tr>
<tr>
<td>WEAVING</td>
<td>.65*</td>
<td>.80*</td>
<td>.68*</td>
</tr>
<tr>
<td>TOTAL</td>
<td>.62**</td>
<td>.81*</td>
<td>.86**</td>
</tr>
</tbody>
</table>

5.2 The second TCT study was conducted at six signal-controlled junctions in Braunschweig and Hannover, including all approach area roads (n = 24) and 72 observation areas in the junctions proper (Erke a. Zimolong 1977).

The correlation coefficient of traffic volume, types of accident and all degrees of severity of types of conflict are shown in table 2. The coefficients are computed together from the junctions and the approach roads.

Table 2 Correlations between Traffic volume, Accidents and Conflicts

<table>
<thead>
<tr>
<th>Types of Variable</th>
<th>REAR-END</th>
<th>WEAVING</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume/Accident</td>
<td>.40*</td>
<td>.36*</td>
<td>.46*</td>
</tr>
<tr>
<td>Volume/Conflict</td>
<td>.67**</td>
<td>.45*</td>
<td>.54**</td>
</tr>
<tr>
<td>Accident/Conflict</td>
<td>.52**</td>
<td>.47**</td>
<td>.63**</td>
</tr>
</tbody>
</table>

The different degrees of severity of conflicts (K1 = slight, K2 = medium, K3 = serious) generally are recorded in the ratio of 80 to 19 to 1. The relationship depends on the site and type of conflict. The best correlations of accident and conflicts are found for slight conflicts K1 (Fig. 1).

The correlations between accidents and types of conflict computed for the inner area of junctions and the approach roads are shown to be different. A well established relation has been found for the approach roads (Fig. 1), but for the inner area especially the left-turn accidents cannot be predicted by means of left-turn conflicts.

The multiple correlation coefficients computed for all accidents and the forecast elements, degrees of severity of all conflicts, traffic violations (K0) and traffic volume (VOL), are shown in table 3. The correlations have been computed separately for the approach roads (segment 2, segment 3) and the observation areas at the inner junctions (right, left, through).

Table 3 Multiple correlations of accidents and various independent variables

<table>
<thead>
<tr>
<th>Approach</th>
<th>K1-K3</th>
<th>K0-K3</th>
<th>K1-K3,VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 2</td>
<td>.72**</td>
<td>.73**</td>
<td>.74**</td>
</tr>
<tr>
<td>Segment 3</td>
<td>.73**</td>
<td>.76**</td>
<td>.73**</td>
</tr>
<tr>
<td>Segment 2 + 3</td>
<td>.86**</td>
<td>.88**</td>
<td>.87**</td>
</tr>
<tr>
<td>Junction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>.29</td>
<td>.30</td>
<td>.38</td>
</tr>
<tr>
<td>Left</td>
<td>.77**</td>
<td>.80**</td>
<td>.77**</td>
</tr>
<tr>
<td>Through</td>
<td>.23</td>
<td>.24</td>
<td>.71**</td>
</tr>
</tbody>
</table>
5.3 A pedestrian conflict study (PCT) at five locations in Braunschweig [pedestrian crossings and adjoining road sections].

5.4 Before/After study with TCT and PCT to study the effect of an installation of light signals at four junctions.

5.5 Driving manoeuvres at changeable traffic signs. Observation of lane choice, joining traffic, weaving and the corresponding conflicts under conditions of normal signal operation and signal-directed change of direction; additional interviews with drivers; validation on the basis of the accident criterion is planned.

5.6 Traffic safety week and competition with respect to carpedestrian-conflicts
- Series of articles on conflicts and accidents in newspapers
- Competition with 60,000 participating school children
- Competition resulting in 204 proposed improvement measures from the public, these suggestions are in part so well considered that they will be put in practice, if possible.

6. Application possibilities of a traffic conflicts technique from the point of view of the Federal Highway Research Institute (BAST)

When it was recognized that an evaluation and selection of structural or traffic control measures in order to improve traffic safety, which is based on the evaluation of accident data alone, does not lead to satisfactory results, the BAST started in 1973 with investigations into the safety-relevant behaviour of road users. The objectives of the research projects were the following:

(1) Determination of evaluation criteria for the safe design of structural traffic facilities. The nature of the criteria should be so as to be able to be

Fig. 1 Regression lines for All Accidents (Gesamtunfälle) and three degrees of severity of All Conflicts (Gesamtkonflikte) K1, K2, K3.
collected in a short time unlike accident data which require long periods of observation.

(2) Determination of an evaluation standard for the change of certain forms of road user behaviour with time. The great number of different public and private traffic safety measures, whose individual effectiveness can hardly be any longer evaluated, requires that behavioral trend studies be made at certain intervals.

These criteria should place the responsible authorities in a position to assess the extent to which all the measures taken really have the desired effect, the effect which, e. g., is described in the Traffic Safety Program of the Federal Republic of Germany.

The main methods used were interviews, observation of behaviour while being with road users, and field observations and the results indicated that primarily the last method mentioned should be based on a more sophisticated footing.

The available information on appropriate and target-oriented possibilities of standardizing observation techniques induced the BAST to continue its efforts in order to arrive at a fully developed traffic conflicts technique ready for application.

In comparison to other techniques this technique of observation also involves the advantage that, given standardization of application has been achieved and guidelines for the training of observation personnel can be made available, practical aids for the evaluation of measures and the observation of traffic can be offered to the responsible bodies of communities and to the police.

6.1 Aids with respect to the decision making of community authorities (highway construction authorities, public authorities financing construction works, police departments)

- Additional evaluation techniques for the support of economy-oriented decision-making techniques with respect to alternative suggestions for structural and traffic control measures affecting specific locations within the traffic network. (A traffic conflicts technique test is being planned by making use of suggestions in order to reduce the danger of left turn movements inside built-up areas).

- Control methods as part of before and after studies of structural and traffic control measures affecting total road networks, parts of networks or stretches of roads. (Traffic conflicts technique tests in comparatively quiet city areas, from which particularly through-traffic has been banned, among others on streets which are jointly used by all types of road users).

6.2 Control and survey techniques with respect to the tasks performed by the traffic police

- Standardization of police training with respect to traffic observation, conflict and accident survey as well as evaluation routines. (Harmonization of survey lists, in particular with respect to "accident causes" and "type and severity of conflicts"; manual for the survey personnel to be trained; guidelines for instructors and teaching personnel).

6.3 At present the BAST does not possess any information according to which traffic conflicts techniques have been or are actually used on the Federal, State, or Community level.
7. Future research

- definition and validation of conflicts at urban junctions
- studies on TCT at road sections with a low rate of accidents but overproportional to the number of vehicles/pedestrians
- development and evaluation of a conflict survey technique for pedestrians in residential areas
- development and evaluation of a cyclist conflict survey technique inside built-up areas
- analysis of the origin and development of conflict by taking into account the communication processes on the traffic scene.

8. Publications


What Task is a Traffic Conflicts Technique intended for?, by S Oppe, Institute of Road Safety Research/SWOV (The Netherlands).

In general it can be said that the basic purpose of the traffic conflicts technique is to determine the safety at different points or under different conditions; when there is no information about accidents or when the information is unreliable.

One of the questions which are often raised when the conflicts technique is proposed is: can future accidents be predicted better on the basis of many conflicts or based on few accidents? Essentially this is the question about the relation between the predictive validity of the conflicts technique and the reliability of this technique and of the accident history. One of the problems regarding the reliability of the conflicts technique has to do with the precision of the operational definition of a conflict. If there is any ambiguity in the definition then it is difficult to identify an occasion as a conflict. A second problem has to do with the length of the sample period and the representativeness of this period for the whole period under consideration. However a perfectly reliable technique does not need to be valid. It is in fact the problem of the validity that causes the change in attention in recent research from conflicts to serious conflicts.

The question stated above can be rephrased in terms of reliability and validity as follows:

Is the validity of a reliable conflicts technique high enough to predict accidents better than the unreliable accident data? This problem about the reliability – validity relation is well known in psychological test theory (see Lord & Novick, page 69 pp). We shall use some of the results of this theory to formulate a decision rule for the choice between two measures.

Let us define unsafety operationally as the expected number of accidents. "Expected" means here something like: conditions being the same (stochastic variables like traffic flow, whether conditions etc. equally distributed over the whole period of investigation), the mean number of accidents per
year converges to some value if the number of years tends to infinity.

Call this number, $A_{oo}$, the criterion of unsafety, then the 
value of this criterion can be estimated from the number of 
accidents in a certain year, like generally a population mean 
is estimated from a sample mean.

Moreover, let us define the reliability coefficient of a 
measure $M$ as the product-moment correlation coefficient $r_{mm}$ 
between two series of measurements, the series being 
independent measurements of the same objects at two occasions.

Now, if we have two series of accident counts, then $r_{aa}$ tells 
us how reliable the safety criterion is measured. If we have 
two series of conflicts, then $r_{cc}$ tells us how reliable the 
conflicts are measured. We know nothing from the conflicts 
about the criterion yet.

The correlation between a series of accident counts and 
conflict counts $r_{ac}$ regarding the same situations gives us this 
kind of information.

This value $r_{ac}$ however is not the correlation of $C$ with the 
criterion values but with estimates of these values. If we 
define the correlation between $C$ and the criterion ($r_{acc}$) as 
the validity coefficient then this value can be estimated from 
$r_{ac}$ and $r_{aa}$ as follows:

$$r_{acc} = \frac{r_{ac}}{\sqrt{r_{aa}}}$$

Then the correlation between the accident counts and the 
criterion is

$$r_{ac} = \sqrt{r_{aa}}$$

The ultimate coefficient of validity, which is reached when

$C$ is measured completely reliable will then be:

$$r_{acc} = \frac{r_{ac}}{\sqrt{r_{aa} \cdot r_{cc}}}$$

Example:

If $r_{aa} = .50$ and $r_{acc} = .80$, then

- if $r_{cc} = .90$, $r_{ac}$ will be .76
- if $r_{cc} = .70$, $r_{ac}$ will be .67

In the first case it is preferable to use the conflict counts, 
however if $r_{cc} = .70$ then the accident counts will predict the 
accidents better.

To get an idea of the practical implications an example will 
be added with an analysis of real data. The data are taken 
from the SWOV-investigation into road safety in De Beamsterpolder 
(SWOV, 1975, table 24 and SWOV, 1976, table 8).

The data refer to accidents at intersections during the two 
The following data are gathered: accidents with material damage 
only, injury accidents, fatal accidents, traffic volume for 
each leg of the intersection.

In this analysis the following data of the first and second 
period are used.

- $T$: total number of accidents
- $N$: number of accidents with material damage only
- $I$: number of accidents with casualties (fatalities + injured)
- $F$: product of volumes on main road and cross road
- $V$: sum of volumes on main road and cross road.

Although knowledge about conflicts would have been preferable,
we use $F$ and $V$ because this is the only data available.

Let us predict the total number of accidents $T$ of the second 
period from the data of the first period and use the correlations 
as an index of predictability.

From the first column of Table 1 it can be seen that $T$ is the
best predictor, N is second, F is third, I is fourth and V is last.

At first sight it may look somewhat strange that F predicts T better than I does. An explanation for this may be found from column 2. F turns out to be very reliable, while I is not. The correlations in column 1 are not the correlations with the criterion, but with an estimate of that criterion. To correct for this fact, we have to divide the correlations by the square root of \( r_{xx} \). These values are given in column 3. To see if F predicts T always better than I does, we have to divide the values in column 3 by the square root of the values in column 2. Now we get the ultimate possible prediction of T by completely reliable predictors.

This results in the validity coefficients of column 4. From this column it can be seen that T has a higher ultimate validity than F although F predicts the total number of accidents better.

As a final note it may be stated that accidents do not predict accidents much better than the product of volume in this case and that the sum of volumes is a useless measure.

It seems from these data that conflicts can do hardly better than the product of volume. The reason for the small difference may be the homogeneity of the intersections. If the intersections are completely identical in layout and traffic flow, then the ratio between the number of accidents and the product of volumes will tend to be equal for all intersections as is the ratio of accidents and conflicts.

In most cases the assumption is however that some locations are more dangerous than other and A, I or N will predict much better than F does.

So far we did speak only about a decision between two measures (e.g. few accidents and many conflicts). Another possibility is to combine these measures in order to get a better prediction.

If we apply multiple linear regression to the data mentioned before in such a way that the total number of accidents of the second period \( T_2 \) is estimated from the value of \( T_1 \) of the first period and if we try to improve this solution by adding the product of traffic volumes \( F \) then we find as regression weights \( b_T = 9.999 \) and \( b_F = 4.709 \).

Given the variance of T in the second period = 234.5 we see that \( 9.999^2 / 234.5 \times 100\% = 42.3\% \) of the variance in \( T_2 \) is explained by \( I_1 \) (which follows also from the fact that \( r_{T_2}^2 = 0.652^2 = 0.423 \)).

An additional 9.5\% will be explained from the values of F.

The variance of \( b \) is \( \text{VAR}(b) = 5.14 \).

Thus under the assumptions of normal distributed variables we find that \( b_F \) differs significantly from zero at 5\% level.

As a result it can be stated that \( T_1 \) and F predict \( T_2 \) better than \( T_1 \) does alone.

The same line of investigation can be followed according to accidents and conflicts, conflicts and serious conflicts, conflicts of type a and b and so on.

<table>
<thead>
<tr>
<th>( r_{xx} )</th>
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<tbody>
<tr>
<td>T</td>
<td>.650</td>
<td>.650</td>
<td>.686</td>
</tr>
<tr>
<td>N</td>
<td>.594</td>
<td>.670</td>
<td>.736</td>
</tr>
<tr>
<td>I</td>
<td>.493</td>
<td>.684</td>
<td>.614</td>
</tr>
<tr>
<td>F</td>
<td>.508</td>
<td>.978</td>
<td>.730</td>
</tr>
<tr>
<td>V</td>
<td>.301</td>
<td>.991</td>
<td>.373</td>
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</table>

Table 1.

Validities with regard to an estimate of the unsafety criterion, reliabilities, validities with regard to the criterion and ultimate validity with regard to the criterion for total number of accidents (\( T \)), accidents with material damage only (\( N \)), accidents with casualties (fatalities + injured) (\( I \)), product of traffic volumes (\( F \) and sum of traffic volumes (\( V \)).

\( x \) stands for \( T \), \( N \), \( I \), \( F \) and \( V \) respectively. These values are measures from the data of 24 intersections over two periods.
Danish "Traffic Conflict" Definition, by N.C. Jørgensen, Danish Council of Road Safety Research.

(Abstract of a Master Thesis from the Technical University of Denmark)

Only rural roads studied. Heavy and fast traffic

Conflicts defined through the simultaneous occurrence of:

1) Narrow gap acceptance from secondary road
2) High speed on main road
3) Braking on main road

Headways on main road studied but turned out to be insignificant.

It was impossible to establish accident/conflict correlation with only two of the three parameters mentioned above.

The following parameter values produced the best possible correlation to accidents:

1) Accepted gap < 4 sec
2) Speed > 80 km/h
3) Braking (g > 0)
Reports from group discussions

GROUP A

The participants to the discussion were Mr Erko, Mrs Engel, MM Gorder, HHFrier, Larsen, Lindroth, Mrs Muhrad, MM Oppe, Peterson and Shippey.

The discussion was very animated, and here are the main results that came out of it:

Purposes of a traffic-conflict technique

It was considered that a conflict technique can serve two categories of aims:

1. Being used as a basis for before and after studies, or, generally speaking, evaluation studies, and also for ranking intersections or locations according to their level of danger.

2. Being used as a tool for safety diagnoses, to help finding out the causes of a dangerous situation and designing the appropriate countermeasures; also as a tool for behavioural studies, that could lead for instance to the development of educational or training programs for road-users, to a better assessment of regulations, or to a critical analysis of enforcement methods.

In the range of possible aims for a conflict technique, its use as a surveyance tool and a danger detector has been considered and finally abandoned, as it leads to too much work and expense.

To reach Aims 2, the conflict technique required must be a good analytical tool and produce a good quantity of descriptive data.

Such a technique, once developed, might turn up to be very expensive or rather heavy to use, and a simplified version of it could then be more adequate when we are concerned with Aims 1. It does not follow that a before - and - after study should be a pure count of conflicts, but the qualitative data required is certainly reduced compared to what is needed to reach Aims 2.

So we come to the following diagram:

It has been pointed out that conflicts are generally considered as a substitute for accidents; however, a conflict technique can be validated with reference to accidents only for the small proportion of urban or rural roads on which accidents are frequent and concentrated at particular locations. In other areas, such as residential ones, a direct relationship between conflict data and accident data can't really be established.

So the group has considered, that in residential or similar areas, a valid aim for a conflict - technique is to use conflicts as a measure of the deficiencies of the traffic-system. This notion includes safety, but appears wider. It is recommended that a conflict technique used to this aim should however be validated on the basis of data at accident locations.

Definition of conflicts - Conceptual basis

To work out what a definition of conflicts should be, the group felt that it was necessary to go through the chain of events preceding a possible accident. From the road-user point of view, the chronological events can be expressed on the following diagram:
In all studies that we know of, the working definition of conflicts has been established at one or the other of two levels:

1. Taking into account only the fact that there is a collision course. The necessary threshold beyond which conflict data is actually collected is then always defined as an objective measurement; for instance, maximum time and/or distance to collision.

2. Taking into account the facts that there is a collision course and also that there has been an evasive action. The area in which the action observed can be considered as an evasive one must be defined; the threshold is here defined in what is usually known as a "subjective" way, which means without including precise measurements. The severity of conflicts, related to the amount of success of the evasive action, can either be measured, or estimated.

Both types of working definitions have their advantages and disadvantages:
- Advantages:
  - Definitions based on appreciation of the collision course have the advantage of not taking into account the actual behaviour of the road-users involved; the variability of this behaviour is such that it is very difficult for an observer to evaluate it properly; therefore avoiding this problem is a positive point from an operational point of view.
  - Another advantage of these definitions is that they include as a conflict the situation in which an accident occurs without any evasive action or change of manoeuvres. They thus meet the requirement that "any accident should be preceded by a conflict" (E. Hauer).

- On the other hand, definitions of conflicts at the level of the evasive action have an opposite advantage: they take into account the actual behaviour of the road-users involved, which is often an accident-prone factor and the conflicts observed can therefore be considered as closer to a real accident; hopefully such conflict techniques should then be easier to validate.

The group has also been discussing working definitions including situations where there are violations of the traffic-laws with only one road-user involved. These situations have finally been ruled out, as all past experience in this field tends to show that conflicts defined that way bear only little relationship with accidents.

The group has agreed that levels of severity or seriousness of conflicts should appear at some stage in the technique and perhaps be part of the working definitions. However, we regret that time has been too short for the discussion to go further into the different variables, that could be used to assess severity and should therefore be collected as part of conflict data.

**Methods of conflict observation**

Both methods of observation, either by human observers, or using technical aids, can be used whether the working definition of conflicts belongs to category 1 or 2. If direct observation is chosen,
observers must be trained, in the first case to estimate values of
time or distance and compare them to a given threshold, and in the
second case to appreciate a situation including a collision course
and an evasive action.

Both methods have specific advantages and disadvantages (purely
technical problems for which technical solutions can be found have not
been considered):

- Direct observation is relatively cheap and yields immediate results.
  However, the reliability of the observers has got to be checked
  regularly.

- Technical aids enable the researcher to go back to basic data and
  review the event as often as necessary. However, any method based
  on the use of cameras or video-cameras is relatively expensive and
  produces results with a delay as the films have to be analysed
  afterwards; also, the observer in front of the screen is not in
  the usual situation in which he can use wholly his experience as
  a road user, and films being a poor substitute for reality, his
  appreciation of a conflict situation might become inadequate
  (this is a disadvantage mostly when working - definitions of the
  second type are used, as a comprehensive judgement of the situation
  is then required).

Validity studies and accuracy

The group has agreed that conflict-techniques should be valid-
dated with reference to accidents in all areas where accident data is
adequate. It has been emphasized that the choice of statistical methods
for validation is important and might influence the results. In parti-
cular, accident samples must often be corrected to become comparable
with the relevant conflict data.

The group points out that what is required is not a perfect
tool; the desired level of accuracy of measurements and adequation
to accident data has got to be chosen, taking into account the opera-
tional requirements of a conflict-technique. We must also remember
that reported accidents have been so far a very imperfect basis for
all safety studies....

If we go back to the two categories of aims that can be
accepted for the development of a conflict technique, it is obvious
that Aims 1 require a higher level of accuracy and validity than
Aims 2; a conflict technique can lose some of its descriptive
value when used for Aims 1 instead of for Aims 2, but this loss
must then be compensated by an increase in accuracy.
The participants in the discussion were Mr. Clauss, Mr. Hakkert, Mr. Hansen, Mr. Nydén, Mr. Kraay, Mr. Kritz, Mr. Malaterre, Mr. Sakshaug, and Mr. Schützenhöfer.

INTRODUCTION

What is the need to think that we better can use conflicts in studying road safety than accidents themselves?

The drawbacks of accident analysis are:

1. Accident statistics only contain information on recorded accidents and not, therefore, on the unrecorded ones. But only part of all accidents are recorded.
2. Since accidents are relatively rare, it is often impossible to obtain reliable accident data.
   The time needed to collect adequate numbers of accidents for statistical processing is too long in many cases. Furthermore, different conditions and circumstances may occur during a lengthy period of collecting accident data.
3. The present standard records do not comprise any detailed information about manoeuvres.

And some possibilities of analysis with conflict techniques seem to be:

1. Man measurement can be made in a short time.
2. Conflicts can be classified according to manoeuvring behaviour.
3. Reduction of conflicts as the consequence of measures can be demonstrated quickly by means of before and after studies.
4. The supply of information both to the authorities (police, traffic experts) and to road users themselves. It often happens that residents in a given area ask for action to be taken and the authorities cannot evaluate the traffic situation.

**Question A**

What tasks is a traffic conflicts technique for?

We want to use the traffic conflict technique in specific situation for studying the safety of locations and where no sufficient accident data are available. As is stated traffic safety of a specific location can be defined as the average number of accidents per year. But since (very) few traffic accidents occur at specific locations, e.g. a junction, and in different kind of areas, e.g. residential areas, in a year it is impossible to use this criterion for short term research.

**Task 1**

In studying traffic safety, conflict-behaviour may be a predictor for accidents and or in accident causation.

In respect to this the traffic conflicts technique can be used particularly at low-volume locations where the accidents reporting level is likewise low:

- as a diagnostic tool to determine unsafe locations, and to study the features in depth.
- in evaluating countermeasures in terms of traffic safety with before and after studies, but for a good evaluation you need sometimes more after studies (3 months after and again 6 months after).
- as a priority ranking criterion for programming the order for the implementation of spot improvements.

There is an argument locations can be ranked as well using traffic volume measures.
But ranking locations can be done in that way that on road stretches you can use the conflict technique and on intersections you can use the traffic volumes. May be you can use both measures together.

Task 2
Conflicts are an indicator for road user’s well-being, or as you want road user’s discomfort. In this way the technique concerns the subjective and not the objective unsafety. The feeling of safety is mostly based on conflicts and not on accidents.

In this way there is no direct relation between conflicts and accidents, only an indirect one. E.g. parents have a good feeling of safety because there happen very few serious conflicts in their streets, consequently they accompany their children less to school as before the children are becoming more involved in traffic accidents.

Task 3
The conflict technique can be used in the operation of the quality of traffic flows. To study operational problems like traffic congestions.

An additional argument to use the conflict technique is an ethical one, there is no need to wait for accidents to happen before the hazards are pointed out.

No tasks of a traffic conflict technique
The traffic conflict technique does not necessarily concern traffic law violations. Traffic law violations are mostly not included under conflicts, because they do not always by themselves indicate potential accidents. Some violations are related to accidents and some not.

Question 3
The definition of conflicts.

1. The basis for the definition is, that a conflict is a situation or sequence of events which has a finite expectation (a probability p) of developing into an accident in all situations which are investigated. But different probabilities for different kind of road user’s and for different groups of situations. Which elements are common to all situations to which the conflicts technique will be applied?

2. There are many definitions in use. The elements in these definitions are:
- the kind of manoeuvres
- the estimated times of arrival of vehicles
- the proximity in time and in distance
- the speed of vehicles and speed changes
- the direction and changes in direction
- environmental elements
- the different traffic participants (also pedestrians)
- the traffic mode
  (and combinations of these elements).

In most studies the conflicts are classified by severity from slight to severe.

These are the common elements and type of conflicts. The foregoing means that the aim is to find a good definition for different conflict types with observable events.

In the future we have to look for agreement in using definitions.
Question C

Techniques of conflict measurement, the reliability.

1. The most useful techniques are often still strongly subjective as regards conflict scoring, especially as regards the severity of the conflict.

2. The different techniques of measuring conflicts are:
   - by means of film
   - by means of video (objective measures
   - by means of observers
   - by means of automatic detection of vehicle proximities.

   in areas
   - by means of observers following persons through the area.
   - using observers, how it is an accepted technique.

3. In spite of the mentioned subjectivity the internal and external reliability of observers seemed to be rather good (about 80-90 percent agreement). But this reliability research was only on a very limited scale.

Training of selected observers with video recordings and in the field can improve the reliability of measuring the severity of conflicts. Only some countries have manuals for training observers.

Question D

Study design and measurement accuracy, the validity.

In finding the absolute level of safety an accident-to-conflict ratio must be obtained (say, one accident on thousand conflicts) to estimate the magnitude of the safety problems. Therefore even with a totally reliable conflict measure the absolute level of safety will only be estimated by conflicts. Of course the ratio between conflicts and accidents may vary for different classes of conflict. Some kinds of conflict are rather good correlated to the same kind of accidents. But so far research on this has been on a limited scale.

To know the relative level of safety the ratio of expected accidents must be calculated.

Some problems in validation conflicts to accidents are summarized below.

1. In the predictive validation one choose situations with many accidents, and then the question is:
   Can an estimate of expected accidents be made from actual accidents? In some studies it is shown that this is possible.

But we want to use the conflict technique in situations where are very few accidents, and then the question arise:

Can conflicts be used to make an accurate estimate of expected accidents?

A possibility is that we assume that the same relationship in heavy accident situations exist in low accident situations.
And in the reliability-validity relation. When is the validity of a reliable conflict technique high enough to predict accidents better than the unreliable accident data?

Beside these main problems there are other ones.

2. In most studies analysis showed that serious conflicts correlated better with accidents than conflict definitions including those of a less serious nature. Even with significant correlations it is reasonable to suppose that both accidents and conflicts are positively correlated to traffic volume.

3. Conflicts are related to the reported accidents (mostly injury accidents) and it is well known that only one-third of all accidents are reported.

4. Conflict studies are carried out mostly under normal conditions. What to do with variations in seasons, in speed, weather conditions, in traffic flows, etc. Till yet there are no correction figures.

5. Sample size. How many accidents are needed in order to obtain a representative picture of e.g. an intersection such that every type of accident that may happen at such an intersection has occurred? The same problem applies to conflicts. The answer is not known.

6. In cases in which only serious conflicts are taken the information about the validity is scarce compared with studies taken into account all conflicts.

7. Conflicts do not explain all of the accident variability. There is evidence that not all accidents are preceded by conflicts.

8. The fundamental question beyond all these problems still is: should a conflict be regarded as an alternative to the road accident indicator, or is it a different or supplementary indicator of the concept of traffic safety or as an useful measure for road users well-being.

Joop H. Kraay
The participants in the discussion were Mr Amundsen, Mr Baker, Mr Cooper, Mr Gütinger, Mr Jørgensen, Mr Lindholm, Mr Morillina, Mr Nettelblad and Mr Nilson.

1. THE TASKS FOR THE TCT

The Traffic Conflicts Technique is not a general surveillance tool. It is, rather, a tool for evaluation of locations or spots previously identified through other warranting procedures.

The TCT has application as a research tool in that it can shed light on the relationships between geometric conditions, driver behavior and accidents. This in turn can lead to specifications for new design where the proven detrimental effects of certain constructions can be warned against.

The TCT has application as an operational tool. Accident data are insufficient in both quantity and quality to permit the minute evaluate of safety deficiencies within hazardous locations. Traffic conflicts can be more plentiful and impart greater information to the engineer. They can be useful not only in identifying hazardous situations but also in defining the countermeasures to be used against them. The TCT can also be employed in situations where a very low accident rate is expected but a safety assessment is needed to counteract public or political pressure.

The above considerations lead to two important criteria to which it was agreed that conflicts should confirm:

1. Traffic conflict categories should be described or recorded in such a way as to relate to the behavioral process which in turn identifies the nature of the accident problem and the area in which countermeasures should be sought.

2. Traffic conflict techniques should be formulated such that sufficient quantities of data can be readily obtained so as to make possible the division of this data into as many subsets as required to perform meaningful correlations involving relatively small areas of interest.

2. THE DEFINITION PROBLEM

A cursory look at the literature suggests that traffic conflict techniques can be compared on a scale of "objectivity", that is, the degree to which the initial identification of the conflict is based on subjective or objective criteria. This prompted an attempt to begin by grouping all the various methodologies on such a scale. The results were as follows:
It should be stressed that there is no implied rating involved in the above. Subjective is not considered "better" than objective and vice versa. What the comparison reveals, however, is that many of the techniques involve both subjective and objective components. In other words, the different techniques are conceptually very similar, only their execution is different.

In light of this, it was concluded by the discussion group that traffic conflict researchers have been the victims of semantics. In fact we are all trying to measure the same thing – a traffic conflict – which we all define similarly. Only the means of training observers to recognize this phenomenon is different. For example in some countries observers are trained to record speed and "time to collision" while in others, they are trained to recognize visually a set of circumstances which corresponds to the same critical parameters. That is to say that a traffic conflict is described by a certain small set of variables, all of which are combinations of position and time. Combinations of these critical values produce recognisable situations.

Now we find that we can quite easily agree upon the proper definition of a conflict:

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

This definition omits single vehicle erratic manoeuvres since their relation to accidents is questionable. It limits conflicts to observable situations while not dictating the method of observation. Finally it implies that some degree of accident risk is necessary, which eliminates normal or precautionary manoeuvres.
The method of training people to recognize conflicts so defined is now a separate consideration and the existence of different procedures is no longer so great a problem. Certainly, some procedures may prove easier or more efficient than others and research should attempt to assess this. In order to facilitate an optimum choice on the part of each user agency of what we can now term “identification techniques” the following recommendation is made:

“That any country currently planning the evaluation of a particular technique should also consider evaluations, under the same conditions, one or more of the other available techniques.”

Once this has been done we should be in a position, each of us, to weigh the advantages and disadvantages of each technique as it applies to our own particular situation and make a decision as to which one to use. We will thus have uniformity of definition coupled with optimum techniques for conflict identification depending upon the nature of the resources available to us. This may sound too easy and, in fact, some modifications to all techniques may be required in order to ensure that we are, in fact, measuring the same conflicts. The main point, however, is that the existence of different identification techniques can be supported under the same conflict definition.

Peter Cooper

**Brief summary of discussions**

After each chairman had presented the results of the group discussions a general discussion was arranged.

The first question that was brought up was whether a collision should be counted as a conflict. The majority of the participants felt that this should not be necessary as most collisions are preceded by a conflict. A collision should, however, be recorded as an accident if it was reported as such.

The proposal from group C (Cooper) for a general definition was then discussed. The participants agreed on the definition but two questions were raised. The first question referred to whether single car conflicts should be recorded. The results of the discussions were not conclusive, but one felt that it was natural to include single vehicle conflicts at rural intersections but probably not at urban intersections. The participants agreed that this problem should be studied further.

The second question referred to the definition of a serious conflict. The figure below illustrates the problem.

![Diagram showing the relationship between accident, serious conflict, exposure, and conflict](image)

Even if an agreement had been reached on a general definition, the operational aspects and the definition of classes of seriousness need more work.
Final remarks

Abbreviated from a summary of the workshop given by Mr W T Baker, Federal Highway Administration, USA

Mr Baker stated: "The most positive aspects of the workshop have been that we learned to know each other, we know about each others work, and we have got some information about each others line of thoughts. Even if we have not solved any problems we have agreed upon a general definition of a traffic conflict."

He also proposed to establish a mailing list and appoint one or two persons to be responsible for distributing literature and to arrange another workshop.

The participants appointed Mr P Cooper, from Transport Canada, to act as a clearinghouse for literature. He will send summaries or the little page of every report he obtains to every country that participated in the workshop.

There was also agreement on arranging a new workshop in 1979. Kunde man antyde f ox:

The TRRL was suggested as a suitable place and Mr S J Older promised to examine the possibilities for such an arrangement.

Program

First international seminar on Traffic Conflict Techniques
OSLO, NORWAY, September 26th/27th

Monday 26th

0800 - 0900: Breakfast

0900 - 0915: Introduction
Karsten Kroghganger, Director
Institute of Transport Economics

Be Peterson, Chief Engineer
National Swedish Roads Administration
has kindly accepted the chairmanship of the seminar

0915 - 1200: Each country presents its paper:

0915-0925: Great Britain
0920-0935: The Netherlands (TNO)
0935-0945: Canada
0945-0955: Norway
0955-1005: Sweden (LTH)
1005-1015: France
1015-1025: USA
1025-1035: Finland
1035-1050: Break
1050-1100: Israel
1100-1110: Sweden (VTI)
1110-1120: Denmark
1120-1130: Germany
1130-1140: The Netherlands (GNOV)

Each country must appoint one speaker

1200 - 1300: Lunch

1300 - 1400: "Indirect or Direct Safety Measures"
Paper by E Hauer, Canada
Presented by S J Older TRRL

1400 - 1700: Group discussion
The participants will be divided into three groups:
Group A will be chaired by Nicole Muhlrad, France

Group B will be chaired by J Kray, The Netherlands

Group C will be chaired by P C Cooper, Canada

The discussions will cover the following four topics:

a) What task is a Traffic Conflicts Technique intended for? How does it accomplish these tasks?

b) The definition of Conflicts. What are the advantages and disadvantages of present definitions? What is a good definition? What is the conceptual basis for a definition?

c) Methods of Conflict Measurement. Human observers versus automatic (directly or indirectly through film/video)

d) Study design (validity studies) and measurement accuracy.

1800: Dinner

Tuesday 27th

0800 - 0900: Breakfast

0900 - 1115: Discussion of the group work
Short presentation by the chairman of each group

1115 - 1200: Practical application
Prepared examples from
Great Britain
Sweden

1200 - 1300: Lunch

1300 - 1400: Practical application II
Prepared examples from
USA
France

If any other country wants to present examples (max 15 minutes) they must contact Mr B Peterson

1400 - 1600: Final discussion - Conclusions
Prepared introduction by Mr W T Baker, USA

The seminar will be held at LYSEBU. You can reach LYSEBU by Holmenkollbanen to Voksenkollen station from Nationalteatret station in the centre of Oslo.

On Sunday 25th of September at 9 pm you are invited to a cocktail party at the Hotel Grand (Courtesy 3M - Norway). We hope you all will be able to attend.

To recover the expenses for the seminar we plan to publish the national papers, a short summary of the discussions and the conclusions. Please tell Mr Amundsen as early as possible if you want to make any changes in the papers.

We look forward to seeing you at the seminar!
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