VALIDITY OF THE TRAFFIC CONFLICTS TECHNIQUE

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Abstract—The traffic conflicts technique was developed as a tool for estimating accident potential at intersections and for indicating methods of reducing hazardous conditions. A review of evaluation studies fails to confirm that the method can perform these tasks. This results partly from methodological problems in the studies. Differences in the definitions of both accidents and conflicts have produced results which often are incomparable simply because different pairs of variables have been used in the analyses. Other theoretical inconsistencies appear to limit the likelihood of predicting accidents from conflicts. It is suggested that a hierarchy of traffic events ranging in severity from slight conflicts to fatal accidents exists. Certain fundamental characteristics of these events (including time of occurrence, type of manoeuvre, location and probable cause) differ so markedly that the prediction of one from the other may not be possible. Evidence is presented which indicates that neither accident nor conflict data, recorded using present methods, is of much value in predicting future accidents or conflicts, respectively. It is suggested that a new method of recording conflicts which overcomes the conceptual problems of previous definitions may be useful in evaluating countermeasures at least as an experimental tool. This would require a change in the criterion used for assessing the benefits of countermeasures from one of the reduction in accidents to one of eliminating predetermined improper driving behaviour or operational problems.

INTRODUCTION

An important part of the task of the highway and traffic engineering professions is to ensure a reasonable level of road safety. This requires a knowledge of the relationship between traffic accidents and the road and traffic environment in particular, and some knowledge of the influence of driver behaviour and vehicle characteristics on accident causation. The earlier attempts by practising highway engineers to diagnose operational or safety deficiencies included the simple technique of observing erratic driving, unsafe manoeuvres and "near misses" at problem locations [Baker, 1977]. This method was first formalised by McFarland and Moseley [1954] who observed "near misses", judged as "emergency situations or critical incidents which could easily have led to an accident" experienced by intercity bus and truck drivers. Forbes [1957] also collected, after the events, data on "near misses" or "accidents that nearly happened" from 200 drivers reported to be interested in traffic related matters.

It was not until 1966 that the first attempt was made to record "near miss" events between vehicles (described as traffic conflicts) in a systematic manner. Two General Motors engineers, sent to observe traffic at intersections, found that most drivers reacted to potential conflict of path conditions by either braking or weaving [Perkins and Harris, 1969]. The objective evidence of a traffic conflict was a brake light indication or a change in lanes made by the offended driver. These conflicts seemed to be very similar to accidents, they appeared to have the same characteristics except for the final component, an impact. It seemed that the engineers had found a surrogate measure for accidents, a link between accidents and the roadway features which contributed to them. Not only did it appear to be an indicator of real danger in traffic it also seemed to give some insight into a driver's perception of danger, real or imaginary, which could cause him to make unexpected manoeuvres.

Perkins and Harris [1969] believed that the technique was ideal for objectively measuring accident potential at intersections, for rapidly testing the effectiveness of traffic engineering countermeasures and for gaining insight into the basic causes of traffic accidents. It also appeared to circumvent the principal problems associated with using normal records of traffic accident data, namely that accident numbers at individual sites are often low, that traffic conditions can change greatly during the several years needed to collect sufficient quantities of data to make statistically sound judgements and that accident reports are imprecise and are not reliably collected [Perkins and Harris, 1969; OECD, 1976].

Realisation of these desirable aims has been more difficult to achieve than might have been expected from this early speculation. While many later studies appeared to substantiate the
The supposed value of the traffic conflicts technique is that the basic hypothesis that conflicts are related to accidents has never been proven beyond reasonable doubt. A review of reports shows that the results are inconsistent. Techniques for analysing the relevant data either are lacking altogether or differ markedly from study to study and successive reports omit a critical assessment of earlier work. The technique appears to have been accepted wholesale on the basis of its face validity despite the fact that many results indicate that conflicts are not related to accidents. The outcome of this uncritical acceptance is that the traffic conflicts technique has progressively come to be regarded as the panacea for traffic management problem diagnosis when in fact it is still in the experimental stage of its development.

In the first assessment of the technique Perkins and Harris [1969] presented data gathered at five intersections and compared, in tabular form, recorded conflicts per hour with accidents in a previous year. They claimed, and a cursory examination of their tables seems to suggest, that high accident frequencies are always associated with high conflict frequencies but no statistical analysis was performed to indicate whether significant correlations actually existed between these variables. Shortly afterwards, Campbell and King [1970] produced the contrary result that conflicts per vehicle and accidents per vehicle are not associated using a Spearman rank correlation test. The conflicting nature of these pioneering studies and the lack of statistical analysis in the report of Perkins and Harris [1969] appears to have been overlooked in most subsequent studies.

Baker [1972] described the results of an FHWA project in which a large sample of intersections in Washington, Virginia and Ohio were observed before and after traffic engineering improvements were made (392 intersections before, 173 after). The author found an association between accidents and conflicts at both the signalised and unsignalised intersections. Glennon et al. [1977] criticised this analysis on the grounds that it did not account for the significant influence of traffic volume on accident variability. Paddock [1974] expanded the Ohio data base used by Baker [1972] from 196 to 410 intersections. Accident prediction algorithms were developed which provided a mean accuracy of ±1.1 accidents per year based on traffic volume, conflicts and accidents per two years for signalised and unsignalised intersections. Glennon et al. [1977] claimed that in this study the influence of traffic conflicts on accidents was not sufficiently differentiated by these relationships because they were more sensitive to conflict opportunities (traffic volume) than to conflicts. Pugh and Halpin [1974] described a study of 240 hazardous sites in Washington. Conflicts per hour were related to average accidents from a three year total using a regression method but the correlations were found to be rather low. The authors concluded that conflict data could be used to pinpoint relatively dangerous groups of intersections.

In comparison to these uncertain results a series of studies in England seemed to indicate a strong association between conflicts and accidents. Spicer [1971] described a conflict study of a rural junction near Winchester. Conflicts, as defined by Perkins and Harris [1969], were not related to accidents but so-called serious conflicts, as defined by Spicer, were related to serious [personal injury] accidents even in terms of location within the intersection and time of day. In a similar study, Spicer [1973] compared three years of accident data with conflicts per 10 hour day at six rural intersections and reported very high rank correlations between serious accidents and serious conflicts. These studies were questioned by Glennon et al. [1977] who pointed out that the method of selecting serious conflicts was highly subjective in nature, unlike the Perkins and Harris [1969] definitions, and that no justification was given for comparing serious conflicts with serious accidents to the exclusion of other forms of accident.

Favourable results were reported in several other studies. Amundsen and Larsen [1977] reported that a study of 31 intersections in Oslo indicated that serious conflicts [as defined by Spicer, 1971] related to three year accident data [Spearman rank coefficient correlation]. However, at 19 uncontrolled intersections where right hand priority applied [with no signing] accidents were more strongly correlated to traffic volumes. Amundsen [1974] reported that in a study of 34 junctions in Oslo and Akershus serious conflicts [as defined by Spicer 1971] correlated well with three year personal injury accident data [Spearman rank correlation] but at the uncontrolled junctions traffic volume was as good an indicator as conflicts. Finally, Zimmerman et al. [1977] studied 12 signal controlled intersections in Braunschweig and Hannover in Germany. Multiple regression techniques indicated that slight conflicts correlated better with all accidents (including property damage only) than more serious conflicts.
In contrast, another group of studies showed poor relationships between accidents and conflicts. A study of 50 unsignalled intersections in four Canadian cities by Cooper [1973] indicated that conflicts were very dependent on volume and could not account for differences in accidents when corrected for volume exposure. In a similar vein, Cooper [1977] reported that a study of merging vehicles at a freeway entrance in Canada indicated that serious conflicts correlated poorly with accidents [four years of data]. Al-Ashari [1976] made a study of five intersections (before and after improvements) in Grand Rapids, Michigan which indicated that the percentage variations in conflicts per 10,000 vehicles and two year accident numbers were not correlated. The data were not analysed statistically. Malaterre and Muhrad [1977] reported that conflicts did not relate to accidents particularly well unless the conflict counts were weighted according to a subjective risk factor which was intended to account for the speed of vehicles, the types of road user involved and the angle of collision. Yauch and Parsonson [1978] studied five high speed signalised intersections in Georgia. They found no correlation between accident rate [17 months of data] and conflict rate. The authors concluded that either accident data is unreliable or conflicts cannot predict accidents.

The results of these studies vary so much that it is difficult to judge the validity of the traffic conflicts method yet the technique has gained widespread acceptance from practitioners who appear to be unaware of this uncertainty. A recent workshop on traffic conflicts (Amundsen 1977) produced exaggerated lists of possible uses for the technique including the following: (i) to rank locations for improvement (ii) to determine causes for danger at blackspot locations and design countermeasures (iii) to determine the actual effect of countermeasures (iv) to indicate road users well being or level of discomfort (v) to study behaviour and thus produce educational programs for road users (vi) to assess regulations, analyse enforcement methods and train policemen (vii) to measure danger in urban areas where traffic conditions change quickly (viii) to perform before-after studies where injury accident data is unavailable or unreliable (ix) to evaluate facilities for pedestrians and bicyclists (x) to provide non-specialist community groups and the police with a practical aid for the evaluation of countermeasures and the observation of traffic.

Given the uncertainty of the many evaluative studies it is by no means certain that the traffic conflicts technique can perform these tasks.

Some explanation of the variety in research results can be obtained from a careful examination of the various operational techniques used by different authors. It can be seen that such great differences exist in the definitions and methods of recording of the variables traffic conflicts and accidents that few of the studies are comparable. Typically the authors have attempted to relate different pairs of variables from one study to the next.

DEFINITIONS OF TRAFFIC CONFLICT

In their original work Perkins and Harris [1969] defined traffic conflicts as evasive actions (brake light indication or a lane change) by drivers, or a violation of the uniform traffic code. Specific definitions were developed to describe road-user manoeuvres which resulted in weave, cross-traffic, rear end, and red light violation conflicts. Data for a particular intersection was gathered by two observers in alternate 15 min count periods during three 12 hour periods from 7 a.m. to 7 p.m. on Tuesday, Wednesday and Friday. Similar techniques were used by Baker [1972] Paddock [1974] Al-Ashari [1976] and Blunden and Munro [1976].

No other authors have kept strictly to this original definition. Initially alterations were comparatively minor. Varying the time and period for counting probably had little effect but eventually major changes were made to the definitions and methods of recording conflicts until virtually every new author produced a unique definition of a traffic conflict to suit the special conditions of his test sites.

Campbell and King [1970] reported that they used the techniques defined by Perkins and Harris [1969] but were unable to record a particular cross traffic conflict and introduced conflict counts at night from 8.00 p.m. to 1.00 a.m. on a Wednesday and Thursday. Cooper [1973] expanded the study period to two 14 hour days (7.00 a.m. to 9.00 p.m.) but excluded weekends and increased the number of observers to four, one for each leg of an intersection. Pugh and Halpin [1974] reported that by taking counts during the most critical time period (presumably for accident occurrence) they could reduce count times to between four and six hours. These
authors were the first to introduce a severity scale for conflicts. It included routine conflicts, moderate hazard and near miss. Zegeer and Deen [1978] collected data for 15 minutes each hour in an 11 hour count day and multiplied each count by four to estimate each hourly count. They found that conflict data could be limited to peak hours because other periods were uneventful. Conflicts were classified as routine, moderate or severe and modified conflict types were recorded for each of signalised and unsignalised intersections.

Spicer [1971] made major changes to the original technique used by Perkins and Harris [1969] and applied these new methods in later studies [Spicer, 1972; Spicer, 1973]. Four observers were used, one at each leg of an intersection, the site was filmed from a tower, and counts were made from Monday to Thursday between 8.00 a.m. and 4.00 p.m. All conflicts were graded according to a five level scale of severity ranging from precautionary braking or lane changing through to emergency actions followed by a collision. Amundsen [1974] used similar techniques to Spicer [1971], recording conflicts for seven hours each day, but he classified conflicts in only four categories of severity; moderate, dangerous and critical conflict, and traffic accident.

Special severity scales were developed in several other studies. Malaterre and Muhlrad [1977] divided conflicts into five classes: slight, moderate, serious conflict resulting in a minor collision and conflict resulting in a serious accident. Two or three observers counted conflicts for one day from 7.00 a.m. to 12.00 midnight. Amundsen and Larsen [1977] separated conflicts into the three categories: moderate conflict, dangerous conflict and critical conflict. A special scale showing the distance between opposing vehicles involved in such conflicts was given. One or more observers collected data during 7 hours periods. Zimmerman et al.[1977] separated conflicts into four categories, controlled braking or change of lane to avoid collision, vehement braking and/or abrupt change of lane, emergency stopping and/or avoidance in the "last second" and collision. The method of collection of data was not reported. Merilinna [1977] simplified the definition of conflict into two categories, evasive action and traffic violation, to suit conditions in Finland. Two observers collected data for eight hours on two or three days.

All the previous studies relied on subjective assessments of traffic conflicts made by trained observers in the field. An alternative method is to make objective assessments of conflicts based, in essence, on the shortest distance between interacting vehicles. Hayward [1972] postulated that the time-to-collision, the hypothetical time required for two vehicles to collide if they had continued at their existing speeds and on the same path, was a reliable method of counting conflicts. Data was collected from 4.30 a.m. till 1.00 p.m. and from 2.00 p.m. to 4.00 p.m. on two consecutive days. A similar method was suggested by Hyden [1975] who measured the time which elapsed from the moment one road user began evasive action to the hypothetical moment when the road users would have collided if they had continued on their initial paths at the same speed. The author recommended 7 hour conflict counts per day.

Guttinger [1977] developed a special method of recording conflicts between pedestrians and vehicles in residential yards. He defined a serious conflict as a sudden motor reaction by one or both parties involved in a traffic event with a separation of 1 m or less between them. Data was recorded by observers who followed children unobtrusively or who watched the entrances of infant schools. Jorgensen [1977] defined conflicts at a heavily trafficked, high speed rural intersection in Denmark as the simultaneous occurrence of gap acceptance less than 4 s from the secondary road, speed above 80 km per hour on the main road and braking by the main road vehicles. Data collection techniques were not described.

The variety of these definitions makes it difficult to decide precisely what constitutes a traffic conflict, and illustrates the problems associated with comparing results.

Two recent studies have indicated that conceptual deficiencies exist in the early definitions. Cooper [1977] applied the time-to-collision concept to a study of merging vehicles at freeway entrances but found that many of the collisions recorded on video-tape were not preceded by a discernible evasive action. This is an important result because it is assumed that traffic conflicts are the same as traffic accidents except that in the case of a conflict, a collision has been avoided as a result of some evasive action. If accidents are not preceded by evasive actions then there are grounds for concluding that a traffic conflict, defined on the basis of evasive actions, is not equivalent to an accident minus the final collision.

The same author was associated with a later study which sought to overcome this
conceptual problem. Allen et al. [1978] questioned the power of techniques which relied on observations of brake application by a driver to signify the occurrence of a conflict. They reasoned that braking habits vary from driver to driver, some braking is strictly precautionary, some conflicts are avoided by acceleration rather than braking and brake lights may be defective. They suggested and tested six objective methods of estimating time to collision based on the separation in time of vehicles whose paths cross. The measures did not require the occurrence of an evasive action or brake application from either vehicle. Of the measures RD (remaining distance to the potential point of collision), PSD (proportion of stopping distance available), GT (gap time), ET (encroachment time) PET (post encroachment time) and IPET (initially attempted post encroachment time), PET was the most satisfactory. It is defined as the time from the end of encroachment of one vehicle on the potential collision point to the time that a through vehicle actually arrives at that point. These measures have not been tested thoroughly but they appear to overcome the main deficiencies in previous definitions of a traffic conflict.

DEFINITIONS OF ACCIDENTS
The “accidents” referred to in the reviewed studies are also defined loosely and appear to vary at random from property damage to fatal accidents even though the level of severity of an accident is of considerable importance. Several authors used the total of all accidents reported at the sites under study; that is property damage, injury and fatal accidents [Campbell and King 1970, data for one year; Blunden and Munro 1976, data for two years; Zimmerman et al. 1977, data for three years; Cooper, 1973 data for four years; Zegeer and Decn, 1978, data for two years].

Pugh and Halpin [1974] used total accidents in three years but weighted property damage accidents by 1, injury accidents by 2 and fatal accidents by 3 prior to analysis. Spicer [1971] used the more severe category of personal injury accidents and data from the previous five years. Amundsen [1974], Hyden [1975] and Mulaterre and Mulbrad [1977] used this category of accidents and used data from the previous three, five to eight and two years respectively. Allen et al. [1978] used data on collisions recorded at their study sites during the previous four years.

Many of the authors did not accurately specify accidents used in their data base. Perkins and Harris [1969] used reported accidents in 1966, Baker [1972] used reported accidents (period not stated), Paddock [1974] used accidents per two years, Al-Ashari [1976] used accidents (period not stated), Amundsen and Larsen [1977] used recorded accidents in the previous three years and Jorgensen [1977] used accidents (period not stated). Presumably the authors were referring to all accidents in the study period but this is not explicitly stated.

The absence of standard techniques for defining accidents and conflicts has produced a series of research results which are difficult to compare. The authors have attempted to relate a different pair of variables each time their version of conflicts and accidents has varied from that originally proposed by Perkins and Harris [1969]. This problem may be overcome by adopting standard definitions for conflicts and accidents but certain fundamental differences exist in the characteristics of road accidents and traffic conflicts which appear to limit the possibility of predicting one from the other.

VARIATION IN ACCIDENTS AND CONFLICTS OF DIFFERENT SEVERITY
Recent research indicates that three distinct types of accident, property damage, personal injury and fatal, vary greatly in their most fundamental characteristics of manoeuvre prior to collision, location on the roadway and time of day. Similarly, traffic conflicts of different severity (minor and serious) and of different methods of recording (objective and subjective) appear to differ greatly.

Variations in the properties of accidents of different severities was indicated by Troy and Butlin [1971] who examined police reports of each individual accident which occurred in the Australian Capital Territory between 1 May 1965 and 30 April 1966. They studied a full representation of minor and major property damage accidents, personal injury and fatal accidents. By cross checking with records of motor car repair workshops they found that very few accidents, especially property damage accidents had been omitted from the police data. They reported that accidents of different severity involved quite different types of collision (i.e.
right angle, acute angle, rear end, head on and run-off road). Jarvis [1977] analysed this data and found that the differences were highly significant (Table 1).

Jarvis [1977] then proceeded to analyse data collected for accidents in South Australia in 1976. Special effort was made to collect property damage accident data in this case also. He found that property damage, personal injury and fatal accidents varied by type of accident, location on the roadway (curve, straight road, uncontrolled intersection, etc.) and time of day (Tables 2–4).

The differences were highly significant. Not unreasonably, Jarvis [1977] concluded that property damage accidents do not make good predictors of more severe accidents and it is clear that personal injury accidents in turn do not make good predictors of fatal accidents.

Cooper [1977] described a study of merging vehicles at freeway entrances in which conflicts were initially recorded by observers according to the subjective evasive action definition [Perkins and Harris, 1969]. Later, conflicts were categorised from a video record according to the objective least-time-to-collision method [Hayward, 1972]. He found that evasive action

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Table 1. Collisions by accident type—A.C.T. 1965–66 (excluding pedestrian accidents)

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Damage only</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Angle</td>
<td>777</td>
<td>185</td>
</tr>
<tr>
<td>Acute Angle</td>
<td>510</td>
<td>26</td>
</tr>
<tr>
<td>Rear End</td>
<td>1093</td>
<td>44</td>
</tr>
<tr>
<td>Head On</td>
<td>129</td>
<td>30</td>
</tr>
<tr>
<td>Run Off Road</td>
<td>273</td>
<td>88</td>
</tr>
<tr>
<td>Stationary Object</td>
<td>566</td>
<td>96</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 215 \text{ FOR 5 D.F.} \]

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Table 2. Collisions by manoeuvre type—South Australia, 1975 (excluding pedestrian accidents)

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Damage only</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head On</td>
<td>525</td>
<td>382</td>
</tr>
<tr>
<td>Rear End</td>
<td>12942</td>
<td>1617</td>
</tr>
<tr>
<td>Side Swipe: Same</td>
<td>5837</td>
<td>685</td>
</tr>
<tr>
<td>Opposite</td>
<td>1373</td>
<td>185</td>
</tr>
<tr>
<td>Right Angle</td>
<td>11734</td>
<td>7484</td>
</tr>
<tr>
<td>Fixed Object</td>
<td>2736</td>
<td>1209</td>
</tr>
<tr>
<td>Overturned</td>
<td>1915</td>
<td>920</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 1803 \text{ FOR 6 D.F.} \]

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Table 3. Accidents according to road location—South Australia, 1975 (excluding pedestrian accidents)

<table>
<thead>
<tr>
<th>Road Location</th>
<th>Damage only</th>
<th>Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at Intersection</td>
<td>23449</td>
<td>2645</td>
</tr>
<tr>
<td>Road Straight</td>
<td>1327</td>
<td>585</td>
</tr>
<tr>
<td>Slight Curve</td>
<td>731</td>
<td>543</td>
</tr>
<tr>
<td>Sharp Curve</td>
<td>264</td>
<td>96</td>
</tr>
<tr>
<td>Other</td>
<td>4133</td>
<td>741</td>
</tr>
<tr>
<td>At Intersection</td>
<td>1172</td>
<td>779</td>
</tr>
<tr>
<td>Traffic Signals</td>
<td>670</td>
<td>159</td>
</tr>
<tr>
<td>Give Way</td>
<td>180</td>
<td>76</td>
</tr>
<tr>
<td>Other</td>
<td>12960</td>
<td>2394</td>
</tr>
<tr>
<td>Rail Crossing</td>
<td>141</td>
<td>47</td>
</tr>
<tr>
<td>Other</td>
<td>2244</td>
<td>131</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 690 \text{ FOR 10 D.F.} \]
Validity of the traffic conflicts technique

Table 4. Accidents by time of day—South Australia, 1975 (including pedestrian accidents)

<table>
<thead>
<tr>
<th>TIME OF OCCURRENCE</th>
<th>DAMAGE ONLY</th>
<th>INJURY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000-0200 hrs.</td>
<td>1235</td>
<td>554</td>
</tr>
<tr>
<td>0200-0400</td>
<td>353</td>
<td>163</td>
</tr>
<tr>
<td>0400-0600</td>
<td>165</td>
<td>32</td>
</tr>
<tr>
<td>0600-0800</td>
<td>3802</td>
<td>571</td>
</tr>
<tr>
<td>0800-1000</td>
<td>5668</td>
<td>685</td>
</tr>
<tr>
<td>1000-1200</td>
<td>5978</td>
<td>672</td>
</tr>
<tr>
<td>1200-1400</td>
<td>3788</td>
<td>792</td>
</tr>
<tr>
<td>1400-1600</td>
<td>4640</td>
<td>1039</td>
</tr>
<tr>
<td>1600-1800</td>
<td>8060</td>
<td>1759</td>
</tr>
<tr>
<td>1800-2000</td>
<td>4272</td>
<td>1177</td>
</tr>
<tr>
<td>2000-2200</td>
<td>2176</td>
<td>666</td>
</tr>
<tr>
<td>2200-2400</td>
<td>1896</td>
<td>673</td>
</tr>
</tbody>
</table>

\[ x^2 = 395 \text{ for } 11 \text{ d.f.} \]

based conflicts and least-time-to-collision conflicts occurred at completely different sections of the merge area between the bull-nose and taper (Fig. 1).

Cooper [1977] concluded that subjectively determined conflicts were not related to objectively measured conflicts and that neither were related to accidents at the sites. Indications that conflicts of different severity vary greatly was presented by Spicer [1971] in his study at a rural (dual carriageway) intersection. While serious conflicts, characterised by rapid deceleration, violent swerving and stopping, were reported to correlate with personal injury accidents in
terms of location and time, less severe conflicts which involved minor evasive action did not correlate with accidents. Zimmerman et al. [1977] reported that in a study of six signal controlled junctions, slight conflicts correlated better with total accidents than either medium or serious conflicts. This result is in direct contrast with Spicer's finding but both suggest that minor conflicts differ from severe conflicts.

**Prediction of Accidents from Conflicts**

The universal practice in traffic conflict studies has been to compare conflicts to accidents in some form but the type of conflict which should be used to predict a given type of accident has not been established. The substantial variations in the different types of conflict and accident suggest that they have unique properties and may not be comparable at all.

This question can be resolved somewhat by referring to a model presented by Shimada [1974] which represents the hazard or danger inherent in a section of the road (Table 5).

Hazard is defined as the inherent risk or danger of a road section or site. It can be described mathematically by an occurrence function whose inputs are Driver, Environment, Vehicle and Random Variables. These variables act as aggravating factors, that is they increase risk, when a road section with a given level of danger is encountered. The outcome is a traffic event with a particular level of manifest severity, that is a Borderline Manoeuvre, Hazardous Manoeuvre or Accident. It is assumed that each traffic event in the range of manifest severity can be defined by a unique occurrence subfunction.

The model must include more than three output dependent variables. There are three forms of accident whose properties are known to differ significantly (property damage, personal injury and fatal accident) and another form exists, unreported minor collisions, whose characteristics probably differ again. In addition, there are several forms of non-collision traffic event which appear to differ (slight and severe conflict, subjective and objective conflict) and a model of hazard at a road site logically should encompass events whose outcome involves no disturbance to the traffic stream. Presumably these can be represented by traffic volume at the particular site.

The model can be adjusted to account for these additional output variables (Table 6).

Shimada [1974] claimed, and the layout of the model appears to confirm, that conventional methods of determining correlations between accidents and a given non-accident traffic event would be more successful if the severity of the two categories was similar. That is, it would be logical for “serious conflicts” to correlate well with unreported minor collisions or property damage accidents. Empirical results appear to contradict this suggestion because traffic events of a given severity make poor predictors of the same events. Accidents, for example, make poor predictors of future accidents and traffic conflicts make poor predictors of future conflicts.

**Prediction of accidents from accident data**

It is well known that historical accident data is of limited use in predicting future accidents. Pugh and Halpin [1974] compared the number of accidents at 240 intersections for each of the years 1970, 1971 and 1972. Correlation between accidents in successive years ranged from 0.62 and 0.69. Guttinger [1977] analysed accident data for a group of intersections in the Netherlands which indicated that low correlations (0.64) existed between accidents in successive 2.5 year time periods. Zegeer and Deen [1978] analysed accident data from 60 intersections in Kentucky. The correlation between accidents in successive years was 0.64. The 95 per cent confident limit for this relationship was ±10.9 accidents per year and the average number of accidents per year at the intersections was 11.1. This indicated that an error of 100 per cent in either direction was...
possible in predicting accidents from one year to the next. This poor correlation probably results largely from unreliability in the collection of accident data, a matter which is discussed later.

**Prediction of conflicts from conflict data**

Similar problems arise with traffic conflicts. Available data indicates that traffic conflicts do not occur in consistent numbers at a single site from one time period to another. Hauer [1978] collected conflict data on 19 consecutive days at an intersection in Toronto. The daily conflict counts were subject to wide random fluctuations (Table 7).

A comparison has been made between these daily counts which indicates that the differences between the observed and expected value are highly significant ($\chi^2 = 52.1 \ p < 0.0005$, 18 d.f.). This result is consistent with the hypothesis that the 19 daily conflict counts are randomly distributed.

Zegeer and Deen [1978] counted traffic conflicts at a single intersection on two separate days, 13 days apart. Although there is less data to use in this case and the results are likely to be less reliable, the total daily conflict counts have been analysed on the same basis as the data presented by Hauer [1978]. These also have proven to be significantly different ($\chi^2 = 8.82$, $p < 0.005$, 1 d.f.). In both cases the method of counting conflicts proposed by Perkins and Harris [1969] was used.

These analyses suggest that it may not be possible to predict conflicts using historical data. In addition they indicate that conflicts counted using this technique may not provide a consistent and repeatable measure of traffic characteristics at a particular site. The implications of this result are discussed later.

**VARIATIONS IN THE CAUSE OF TRAFFIC ACCIDENTS**

A study of causative factors in accidents provides further evidence of the difficulties associated with predicting accidents from traffic conflicts. Traffic conflicts appear to be caused by a different set of factors to accidents. As a consequence the influence that countermeasures produced from a study of traffic conflicts can have on road accidents may be limited.

Extensive research indicates that road accidents result from combinations of a great variety of interacting factors (referred to as Driver, Road Environment and Vehicle Factors) rather than from single identifiable causes [Haddon et al. 1964; Svenson, 1978; Kihlberg and Tharp, 1978].

**Table 7. Daily traffic conflict counts (from Hauer, 1978)**

<table>
<thead>
<tr>
<th>DAY</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>44</td>
<td>41</td>
<td>47</td>
<td>22</td>
<td>11</td>
<td>29</td>
<td>35</td>
<td>25</td>
<td>35</td>
<td>30</td>
<td>26</td>
<td>33</td>
<td>35</td>
<td>43</td>
<td>28</td>
<td>25</td>
<td>48</td>
<td>23</td>
<td>40</td>
</tr>
</tbody>
</table>
If accidents result from a combination of Driver, Environment and Vehicle factors then as a direct corollary, traffic conflicts must result from a combination of these factors. For the two to be directly comparable the combinations should be similar but this does not appear to be the case.

It has been established that accidents of different severity occur in quite different circumstances of time of day, day of week, manoeuvre before impact and location in the road system. These variations reflect different contributions of Driver, Environment and Vehicle Factors in the different forms of accidents. Fatal and injury accidents are over-represented in the early hours of Saturday and Sunday morning in low volume traffic [Jarvis, 1977; Kennedy et al. 1979; Malo and Mika, 1960; Bailey, 1979]. In these conditions excessive alcohol use, risk taking and speed appear to be principal contributory factors [Mayer, 1969; Kontaratos, 1974; Finch and Smith, 1970, Bailey, 1979]. Property damage accidents are concentrated in weekday peak hour traffic [Jarvis, 1977; Mayer, 1969] when traffic volumes and congestion are high. Different driver factors (for example, impatience and frustration) are likely to be paramount at these times.

Traffic conflicts, a considerably less severe form of traffic event, are likely to differ again in the relative involvement of Driver, Environment and Vehicle Factors. Evidence to establish this difference is sparse both because no attempts have been made to investigate the cause of conflicts and conflict counts are made principally during working hours rather than in the early hours of the morning when their nature is likely to be different.

If conflicts result from different combinations of Driver, Environment and Vehicle Factors to accidents then data obtained from a study of conflicts may not be of much use in reducing accident numbers. The traffic conflicts technique is applied in practice with a main aim of finding traffic engineering countermeasures to alleviate the problems identified in the conflicts study. On face value, these countermeasures would appear to be most suitable for overcoming problems related to the Road Environment rather than the Driver or Vehicle factors. If so they would affect only the comparatively small proportion (about one third) of road accidents caused principally by deficiencies in the road environment [Eckhardt and Flanagan, 1956; Kontaratos, 1974; Sabey and Staughton, 1975]. Of course, the same countermeasures or others which originate from conflicts or other traffic engineering studies may modify or compensate for driver failings or vehicle problems as some studies suggest [Taylor et al. 1972; Anderson and Pedersen, 1963; Taylor, 1967] but this potential has never been investigated specifically.

This possible limitation on the usefulness of the traffic conflicts technique may be circumvented by altering the criterion for evaluating traffic countermeasures. The potential for this method of application is discussed later.

RELIABILITY OF ACCIDENT DATA

A further problem with the traffic conflict technique is related to one of the primary reasons for its development. The method was set up originally to provide reliable information about traffic problems at intersections which would replace the distorted, sparse and incomplete data recorded from road accidents [Perkins and Harris, 1969; Campbell and King, 1970; Baker, 1972]. The inadequacy of road accident data and the form of its deficiencies has been documented widely [Matson et al. 1955; Allen and Shin, 1978; Roosmark and Fraki, 1969; Paddock, 1974; Pfundt, 1969] and has been acknowledged by most users of the traffic conflicts technique. What has been overlooked, however, is that this same unreliable accident data has been used in all recorded attempts to link traffic conflicts with accidents. It is illogical for a new research tool to be proven using data gained from the unreliable research tool it is to replace.

An alternative is to validate conflicts using the most reliable accident data possible. This is obtained from in-depth studies in which multidisciplinary teams of researchers attend accidents and record relevant data on the spot [McKay 1966; Nagel et al. 1972; Staughton and Storie, 1977].

FUTURE USE OF THE TRAFFIC CONFLICT TECHNIQUE

The traffic conflicts technique has gained widespread acceptance in spite of its considerable and largely unrecognised conceptual weaknesses. If the future use of the technique is to be justified then either these deficiencies must be overcome or the limitations they produce must be accounted for in applications of the technique.
It is essential to establish whether traffic conflicts represent a meaningful measure of hazard in the road system. This could be achieved by determining whether stable relationships exist between traffic conflicts and accidents in circumstances such that the influence of confounding variables can be minimised. Initially this would involve restricting investigations to a single site so that between-site variations in the driver-vehicle-environment system (e.g. flow characteristics, vehicle mix, intersection layout and weather conditions) can be avoided. Conflicts of different types can then be related to representative samples of equivalent forms of collision and accident obtained from a multidisciplinary in-depth study. Similar techniques could be used to determine whether the relationships are generalisable or represent a site-specific measure in studies at a variety of locations in widely different conditions.

The most accurate method of collecting conflict data available should be used in these investigations. At present this appears to be the objective method developed by Allen et al. [1978] which overcomes the principal deficiencies of existing methods because it does not rely on the presence of evasive actions for indicating the occurrence of a conflict. This method does have the drawback that it involves the laborious process of analysing video film of traffic events but it appears to be more sound conceptually than the simpler method of counting directly observed conflicts.

It may be valid to apply this objective method of counting conflicts to traffic engineering problems despite the fact that no clear relationship has emerged between traffic conflicts and accidents. For the method to be applicable however, the criterion for justifying the use of traffic engineering countermeasures must be changed from one of reducing future accidents to one of eliminating chosen inappropriate driving behaviour, operational deficiencies or some other pre-determined criteria at a given location.

Allen et al. [1978] define their objective methods of counting conflicts on the basis of post encroachment time (PET). PET may be a direct function of danger at a site, it may be related to future accidents or it may represent an objective measure of nothing more than operational deficiencies. Its exact nature, which may be determined eventually, is unimportant if it is a consistent and repeatable measure of traffic events at a given site. If so, it can be used to monitor the effectiveness of countermeasures within the terms of the criteria chosen to suit a particular site. It must be emphasised that this new conflicts method must be thoroughly tested for repeatability and consistency, properties which present methods do not appear to possess.

The potential of the technique can be illustrated using a simple example. The objective method of counting conflicts can be applied at a site where problems are known to exist. The nature and relative frequency of conflicts can be measured and, using engineering judgement, suitable criteria can be developed to decide which of the conflicts should be eliminated. After having applied appropriate countermeasures the site can be studied once again to see whether the chosen group of conflicts has been eliminated. If so, and if no other undesirable conflicts have been introduced, the usefulness of the countermeasures in performing specific chosen tasks will have been demonstrated. The actual effect of the countermeasures on the incidence of accidents at the site must be determined using a conventional before-after study because it has not yet been established that a reduction in conflicts will produce a reduction in accidents.

This method of applying the traffic conflicts technique may be useful for pinpointing and solving problems at individual intersections but it cannot give a direct indication that the application of particular countermeasures will guarantee a reduction in future accidents nor can it prove, given existing knowledge, that the application of the countermeasures at another site will have a similar effect.

CONCLUSIONS

Studies devoted to the evaluation of the traffic conflicts technique have failed to establish that conflicts are related to road accidents and have not demonstrated how or whether traffic conflicts reflect hazard in the road system. This remains the primary requirement in future traffic conflicts research.

The inconsistency in research findings has resulted from a lack of standard operational definitions for either traffic conflicts or road accidents and from conceptually unsound definitions of conflicts which appear to bear little relationship to accident circumstances. A newly developed objective method of recording conflicts which is still in the experimental stage
appears to overcome this problem but it involves sophisticated instrumentation and data reduction techniques unlike the present methods which simply require observations of braking and evasive actions.

Certain fundamental differences in conflicts and accidents appear to limit the likelihood of predicting one from the other but this matter requires further study. Several forms of traffic conflict and accident appear to exist, each with different properties. They are minor and severe conflicts, objective and subjective conflicts, minor unreported collisions and property damage, personal injury and fatal accidents. Evidence exists which indicates that accident and traffic conflict data make poor predictors of future accidents and future traffic conflicts respectively.

A study of known causative factors in accidents suggests that the countermeasures developed from traffic conflict studies are likely to influence directly about one-third of accidents. However, if the criterion for evaluating traffic engineering countermeasures is changed from one of accident reduction to one of checking whether pre-determined changes in driving behaviour or traffic operations have been produced then an objective form of the traffic conflicts technique offers some promise as an evaluative tool. The effect of the countermeasures on the incidence of accidents can be evaluated then as a separate issue.

REFERENCES
Validity of the traffic conflicts technique


