1. Use of the Traffic Conflicts Technique (TCT)

The TCT is not yet being used in Canada in an operational role. While there is some interest in the potential of this method, there is as yet insufficient information regarding its reliability as a functional tool upon which to base traffic engineering warrants.

There is little purpose in utilizing the TCT solely for the identification or ranking of high accident locations since this can be done in many simpler ways - in most cases through the use of some form of volume index.

The potential use of the TCT has always derived from the tantalizing promise which it holds as the "missing link" between the normal behavior of traffic on the one hand and accidents on the other. That accidents will usually increase with conflicting traffic volumes is a self-evident generality, but it does not allow for the evaluation of changes in vehicular behavior occasioned by other influencing factors, whether random or induced through planned countermeasures. An understanding of the link between traffic behavior and accident occurrence would greatly assist the engineer or planner in designing and implementing effective safety solutions. This connection is currently represented by the concept of traffic conflicts which has been conceived as a readily obtainable surrogate for accidents.

The goal of our research in Canada is to develop a technique which will result in a consistent and reliable indication of hazard associated with certain vehicular maneuvers, traffic control or geometric constraints. In order to perform this function adequately the technique must be based on definitions which are in accordance with the sequence of events leading to accident occurrence or close avoidance.

2. Towards a Conflict Definition

Early work in Canada (1) strongly suggested the inadequacy of the General Motors conflict technique for discriminating among conditions suggested by the above described usage requirements.
While easy to employ, the GM technique does not make sufficient distinction between severe and precautionary conflicts. This hierarchy was defined by the TRRL 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 accident 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 expectation (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, \( t' - t = \Delta t \), 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 B, 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 (d 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 discernable 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 bullnose 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 the 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.
FIGURE 6

Accidents

Evasive Actions

Conflicts

bullnose

fraction of acceleration lane

end of taper.
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
