AN EVALUATION OF THE TRAFFIC CONFLICTS TECHNIQUE

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The traffic conflicts technique, as developed by General Motors Research Laboratories, was evaluated by the Federal Highway Administration in cooperation with the state highway departments of Washington, Ohio, and Virginia. In addition to a field test of the technique, an attempt was made to find whether there is a statistical relation between traffic accidents and traffic conflicts. Conflicts were counted at 392 intersections before improvements were made and 173 intersections after construction of the improvements. It appears that those characteristics of intersections that contribute to accident causation can be more readily exposed by using conflicts than by using conventional accident analysis techniques. This may be especially true at low-volume rural intersections. Because of this ability to provide more precise information, lower cost remedial actions should result. Correlation coefficients were calculated for bivariate populations of number of conflicts and number of corresponding accidents. The compiled data tend to support a finding that conflicts and accidents are associated.

• THE traffic conflicts technique was developed by the General Motors Research Laboratories in 1968 (1). The advantages of a tool such as this for use in the traffic accident analysis field were obvious; however, because only limited field testing had been done, more extensive testing was needed to determine the correlation between actual traffic accidents and the measurements derived by using this technique. Field testing also was necessary to prove the worth of this technique as a means of gathering data usable in the design process. The Federal Highway Administration in cooperation with three state highway departments set up studies to carry out the necessary field testing.

TRAFFIC CONFLICTS TECHNIQUE

The technique was developed primarily as a tool for measuring traffic accident potential at intersections. A traffic conflict occurs when one driver takes evasive action by braking or weaving 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 effected by the offended driver. The brake-light indication or the lane change, as well as the offending vehicle, must be observed before a conflict can be recorded. Figure 1 shows four common types of conflict situations. In each case, vehicle No. 3 is the observation vehicle, No. 1 is the offending vehicle, and No. 2 is the offended vehicle. Criteria have been defined for over 20 specific conflict situations at intersections, details of which can be found elsewhere (1).

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 counting conflicts, while the other is responsible for recording volume data. Fifteen-minute data samples are taken alternately on each intersection approach leg from the observation vehicle, which is parked on the side of the roadway about 100 to 300 ft back from the intersection. The team is allowed 15 minutes

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after each sample count to record the data and to move to the opposite approach. The team alternately surveys the two approach legs throughout the day.

PROCEDURE

In June 1969, the Federal Highway Administration contracted with the Washington Department of Highways to conduct a traffic conflicts study. Subsequently, contracts were negotiated with the Ohio Department of Highways and the Virginia Department of Highways to conduct similar studies. The contracts provided funds for the counting of conflicts at a minimum of 400 intersection approach legs in each state. The counts were to be made both before and after a "spot improvement" type of change had been made, if possible. Two engineers trained a supervisor and two crews in each state to ensure that the technique was applied in the same manner in all three states.

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. They were to make the counts, compare them to the actual accident data, and determine whether the traffic conflicts technique was advantageous. After each location was analyzed, the conflicts data were to be sent to the Federal Highway Administration, Office of Traffic Operations, for statistical analysis.

The primary objective of the statistical effort was to determine whether there is a significant correlation between conflicts and accidents. The results of this determination are given in Table 1.

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 probably 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 analyses based on accident experience. Because the traffic conflicts technique was developed as a tool for measuring traffic accident potential, it was hoped that the conflicts counts would point up the same safety deficiencies as did the routine accident analyses.

RESULTS

A total of 392 intersections was counted before improvements were made, and 173 intersections were counted after construction of the improvements. In terms of intersection approaches, 886 were counted before and 420 after improvements were made. At least 1 month was allowed after completion of construction before the after counts were taken.

Field Evaluation

Each of the three states reported that the technique provided the kind of information needed as a basis for design of safety improvements. It was reported that, in most cases where there was an adequate history of accident experience, the conflicts counts not only verified the accident analyses but often provided more insight as to the existing hazardous conditions. One example is that of an intersection approach where the cause of a number of ran-off-the-road and rear-end accidents could not be determined. The conflicts counts supported the probability that some drivers chose to leave the roadway rather than become involved in a rear-end accident. Thus, a significant amount of evidence was compiled that indicated that there was the potential for a rear-end accident grouping that was not apparent from the accident collision diagram. The ran-off-the-road accidents were, then, likely results of the same hazardous condition that produced the rear-end accidents.

One of the states found that with slight modification the conflicts technique could be applied to locations other than intersections. The technique is mainly oriented to conflicts between vehicles; therefore, for applications other than intersections, conflicts of single vehicles with highway geometrics have to be defined. For example, the various maneuvers that drivers perform when confronted with a complex gore area may include several types of single-vehicle conflicts not now included in the traffic conflicts technique.

Figure 1. Four common traffic conflict situations.

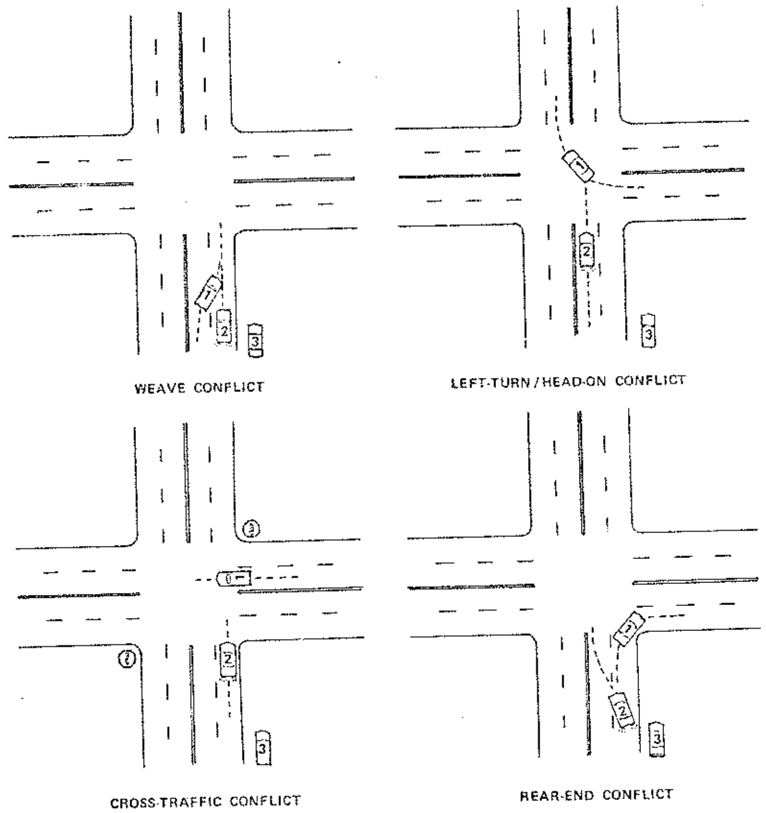


Table 1. Correlation coefficients (r) for T and 4-legged right-angle intersections.

Intersection	Conflict-Accident Situation: Weave	Left-Turn Head-On	Cross-Traffic	Rear-End	All Maneuvers	Critical r	Sample Size
Signalized							
T	-0.207	-0.128	-0.170	0.075	-0.172	±0.532	14
4-legged right-angle	0.360[a]	0.661[a]	0.209[a]	-0.018	0.410[a]	±0.179	122
All[b]	0.402[a]	0.615[a]	0.136	-0.017	0.326[a]	±0.160	157
Nonsignalized							
T	0.294[a]	0.432[a]	0.830[a]	0.410[a]	0.837[a]	±0.205	94
4-legged right-angle	0.159	0.459[a]	0.602[a]	0.213[a]	0.653[a]	±0.192	106
All[b]	0.276[a]	0.453[a]	0.665[a]	0.295[a]	0.671[a]	±0.130	235
All combined[c]	0.356[a]	0.546[a]	0.429[a]	0.154[a]	0.458[a]	±0.100	392

[a]Indicates statistical significance at the 5 percent level.
[b]Includes other intersection types such as skewed and multileg as well as T and 4-legged right-angle.
[c]Composed of all signalized and nonsignalized intersections.

Table 2. Conflict-opportunity and accident-conflict ratios.

Intersection	Conflict-Accident Situation: Weave	Left-Turn Head-On	Cross-Traffic	Rear-End
Conflicts per 1,000 opportunities				
Signalized 4-legged right-angle	51	28	15	29
Nonsignalized 4-legged right-angle	64	28	26	26
All combined[a]	65	28	25	25
Accidents per 100,000 conflicts				
Signalized 4-legged right-angle	7	20	56	3
Nonsignalized 4-legged right-angle	7	9	16	1
All combined[a]	6	15	20	3

[a]Includes other intersection types such as skewed, multileg, and T as well as signalized and nonsignalized 4-legged right-angle.

It was reported that the traffic conflicts technique seems especially applicable to low-volume rural intersections where the accident reporting level is usually low. Collision diagrams prepared for these locations are not very revealing, although a hazardous condition may exist that would be evident through a conflicts count.

Because analysts are often better able to pinpoint hazardous conditions from conflicts data than from collision diagrams, the remedial action taken may be lower in cost than that suggested by collision diagrams. One state told of situations where conflicts counts pointed to low-cost improvements in the $200 to $500 range that were not well received by officials in small incorporated areas. Without the conflicts data, it would have been difficult to show that these low-cost and relatively undramatic improvements would probably be more effective than more costly work such as the installation of traffic signals.

All of the states encouraged their counters to record unusual maneuvers, events, or situations that might affect the safe operation of the intersection. These comments and diagrams proved to be very valuable in some instances. One example given was that of a signalized intersection at which a significant percentage of the volume on one approach was cutting across an abandoned gas station on the red signal, thereby producing conflicts with the through traffic. This situation was not evident from the few available accident reports and was not suspected until actually observed during the conduct of a conflicts count.

Correlation Coefficients

One of the study objectives was to test the hypothesis that traffic conflicts are associated statistically with accident frequency. It was hoped that significant correlation coefficients might be found so that future corrective action might be taken at intersections selected on the basis of conflicts counts. Bivariate populations were described, with the number of conflicts in each category used as one variable and the number of corresponding accidents used as the other variable. [See the Appendix (2) for a description of statistical technique.]

In this analysis, the null hypothesis that there is no correlation between numbers of accidents and numbers of conflicts was tested. Correlation coefficients were calculated for the rear-end situation and for a number of maneuver situations, among which are the weave, left-turn, head-on, and cross-traffic categories given in Table 1. These situations were designated as maneuver situations because each involved one vehicle making a special movement or maneuver. The rear-end situation does not fall into the maneuver classification because it does not involve a vehicle changing its path.

When conflict data are recorded in the field, maneuver conflicts and rear-end conflicts are separated because the exposure for each classification is entirely different. For example, the total number of weaving maneuvers and the total number of weave conflicts that result from the weave maneuvers are recorded. In this case, the total number of weaving maneuvers is considered to be the weave exposure. For rear-end conflicts, the situation is different; the exposure associated with this situation is considered to be the total volume of traffic on the intersection approach that is being counted minus the total maneuver volume.

Coefficients were computed for approaches as well as intersections. In spite of the smaller sample sizes for intersections (each intersection consisted of at least two counted approaches), the general character of the correlations by intersection was very much the same as the correlations by approach; therefore, only the correlations by intersection are given in Table 1. Where the coefficients are significant, the hypothesis of no correlation is rejected and the hypothesis of correlation is accepted.

Overall, there appears to be a stronger case for rejection of the null hypothesis with the nonsignalized intersections than with the signalized intersections. A high percentage of the conflicts at signalized intersections are of the rear-end type. It is one of the most difficult types to observe, especially at signalized intersections where there is much braking that is unrelated to conflicts.

It is characteristic of the coefficients for the rear-end situation throughout the stratifications to be either not significant or somewhat close to the critical value.

Both the signalized and the nonsignalized intersections are further broken down into T and 4-legged right-angle types because these two types were most frequently counted. Data for the other types are not shown because of their small sample sizes.

Based on the data submitted by the three states, Table 2 gives the number of conflicts per 1,000 opportunities and the number of expected accidents per 100,000 conflicts for 4-legged right-angle intersections as well as all intersections combined. As might be expected, these numbers vary by type of situation. It must be remembered that the accident information used in this study represents the reported accidents compiled in the three states and therefore does not represent all the accidents that actually occurred.

It can be seen from Table 2 that the ratio of conflicts to conflict opportunities is higher for weaves than for other types of conflicts. Also, the ratio of accidents to conflicts is relatively low for weave and rear-end situations. These two situations are produced in traffic that is moving in the same direction. Same-direction-type accidents tend to be less severe and are therefore less likely to be reported. It may be reasonable to speculate that, because the same-direction-type conflicts usually result in less severe accidents, drivers may make less effort to avoid them.

Before and After Tests

As previously mentioned, conflicts counts were taken both before and after a spot-improvement type of change for 173 intersections (420 approaches). Although the improvements were not based directly on the conflicts counts, they were influenced by them to some extent as the states gained more confidence in the conflicts technique. Again, the conflicts analyses did generally support the analyses performed using accident experience.

Table 3 gives the improvements that produced a significant reduction in calculated danger indexes for T, 4-legged right-angle, and all intersections combined when t-values were computed from paired sets of before and after data.

The danger index for a particular intersection is found by dividing, for counted approaches only, the total number of types of conflicts by the total volume.

It can be seen from the table that, although danger indexes calculated for rear-end conflicts were not significantly reduced for the new signal improvement type, there were significant reductions in the maneuver indexes. Also, the overall effectiveness of signal upgrading and flashing signal installations appears doubtful from a conflicts standpoint.

By widening intersections (including adding turning lanes) the danger indexes for all cases were significantly reduced; however, widening together with signal improvements did not significantly reduce the danger indexes for the small number of T intersections where this type of improvement was made.

Volume Relationships

Because 4-legged nonsignalized intersections were by far the most predominant type of intersection counted, this type was chosen for the investigation of possible volume-traffic conflicts relationships. Figure 2 shows the number of conflicts per 1,000 opportunities by hourly approach volumes. It can be seen that 1-lane approaches experienced more conflicts per 1,000 opportunities than did the 2-lane or 3-or-more-lane approaches. The 3-or-more-lane approaches had the fewest number of conflicts per 1,000 opportunities possibly because drivers had the option of changing lanes to avoid left- or right-turning vehicles.

CONCLUSIONS

The following conclusions are drawn on the basis of the reported experience of the three states and the results of the statistical analysis:

1. The data compiled in this study tend to support the hypothesis that conflicts and accidents are associated;

Table 3. Before and after danger indexes using t-test.

Intersection	Improvement					
	New Signal	Upgrade Signal	Flashing Signal	Widening	Widening and Signal	Other
Maneuver conflicts danger index						
T	S	NS[a]	NS[a]	S	NS[a]	NS
4-legged right-angle	S	S	NS	S	S	S
All combined[b]	S	S	NS	S	S	NS
Rear-end conflicts danger index						
T	NS	NS	NS	S	NS	NS
4-legged right-angle	NS	NS	NS	S	S	NS
All combined	NS	NS	NS	S	S	NS
All conflicts danger index						
T	S	NS[a]	NS[a]	S	NS[a]	NS
4-legged right-angle	S	NS	NS	S	S	S
All combined	S	NS	NS	S	S	NS

Note: S = significant at 0.05 percent level; NS = not significant at 0.05 percent level.

[a]Sample size 5 or less. [b]Includes other intersection types such as skewed and multileg as well as T and 4-legged right-angle.

Figure 2. Conflicts for 106, 4-legged nonsignalized intersections.

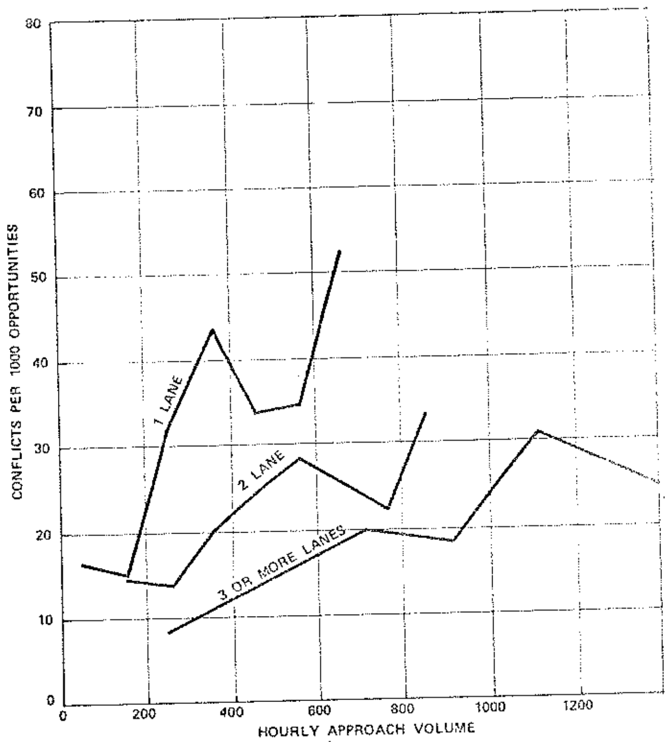
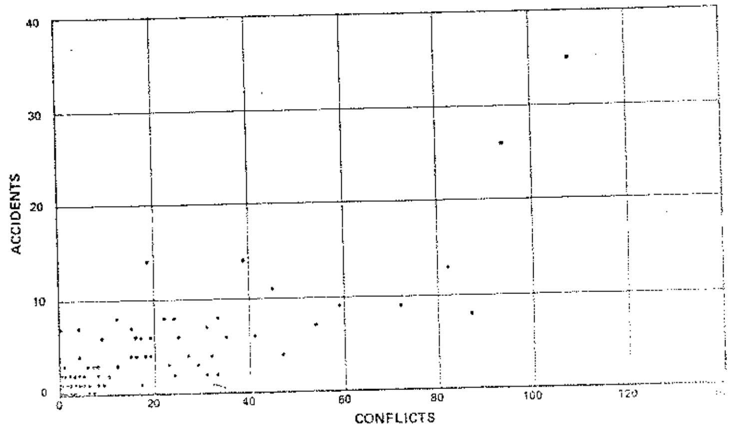


Figure 3. Maneuver conflicts versus maneuver accidents for 94 nonsignalized, 4-legged right-angle intersections.



2. On the basis of the experience of the three states, it appears that safety deficiencies at intersections can be pinpointed more quickly and reliably by using the traffic conflicts technique than by using conventional methods;

3. The traffic conflicts technique may be particularly valuable at low-volume rural intersections where the accident reporting level is low;

4. The traffic conflicts technique, because of its usefulness in pinpointing intersection problems precisely, should lead to lower cost remedial actions;

5. The traffic conflicts technique can be applied with minor modification to locations other than intersections;

6. The effect of intersection improvements may be demonstrated from conflicts counts taken shortly after completion of a spot-improvement type of change; and

7. The general surveillance information obtained during the conduct of conflicts counts may be valuable in improving the overall operations of intersections.

REFERENCES

1. Perkins, S. R. GMR Traffic Conflicts Technique—Procedures Manual. General Motors Research Publication GMR-895, Aug. 11, 1969.
2. Snedecor, G. W. Statistical Methods. The Iowa State College Press, Ames, 19[illegible].

APPENDIX

THE APPLICATION OF PEARSON'S CORRELATION COEFFICIENT

Where bivariate populations are concerned, the mutual relation between measures of each variable may be examined. One may make some evaluation of this relationship without thinking of one variate as dependent on the other. Each data point (X_1, Y_1; and X_2, Y_2) may be plotted to see whether there is a tendency for the points to plot in a band or whether they are scattered randomly in a shotgun pattern. When evaluation of this tendency (or correlation) is required, the correlation coefficient of Pearson, universally symbolized by r, is employed.

An r computed to equal +1 signifies perfect correlation, where the band of points plots in a straight line from lower left to upper right; an r equal to -1 signifies perfect negative or inverse association, where the band plots from upper left to lower right. Each area of investigation has its own range of values for the coefficients, and any judgment concerning a correlation should be made with reference to the size of similar correlations in the same area, with little reference to the theoretical limits of r (± 1). In the case of accidents, conflicts, and other such phenomena, where many variables may affect the results, the coefficients are more apt to be small, that is, nearer in value to zero. Figure 3 shows a plot of accidents and all maneuver conflicts for non-signalized, 4-legged right-angle intersections. It can be seen that there is a tendency for the points to plot in a band. The correlation coefficient for this situation is 0.653. (Table 1).

The formula for the computation of the Pearson r is as follows:

$$r = \frac{N\Sigma XY - (\Sigma X)\cdot(\Sigma Y)}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2]\,[N\Sigma Y^3 - (\Sigma Y)^2]}}$$

An important consideration as to the meaning of a particular value for a correlation coefficient is the size of the sample from which the coefficient was computed because sample r's from a bivariate population are quite variable if the sample is small. For each sample size there is a probabilistically determined cutoff point for the value of the correlation coefficient below which it is not significant, that is, too small to be thought of as other than the result of a random scattering of data points. This critical point corresponds to a percentile (5 percent or 1 percent) of the probability distribution values of the correlation coefficient for a particular sample size. When the value of the correlation coefficient is found to be greater than this critical point, it is referred to as significant at a specific level of significance. Actually a test of significance is being performed when the value of a particular correlation coefficient is thus examined:

A few words might be helpful to explain the implication of the word test. In statistics, one tests a hypothesis. The hypothesis to be tested is proposed on reasonable grounds and defended on statistical grounds. The statement of any hypothesis, H_0, is necessarily tied to a statement of an alternate hypothesis, H_1, which would have to be rejected when the hypothesis H_0 is shown to be acceptable and which is acceptable when the hypothesis H_0 is rejected on the basis of the observed evidence.

Often a null or negative hypothesis is chosen as the appropriate hypothesis to be tested because of convenience, that is, according to the existence or absence of appropriate probability distribution tables. When a null hypothesis is rejected, this becomes the means of focusing attention on the acceptability of the hypothesis stated as its alternate. The correlation hypothesis is tested as a null hypothesis. The null hypothesis indicates that there is no correlation, no tendency for the plotted points of the bivariate population to form a band, and no difference between the plotted points and a random scattering of points. If we can reject this hypothesis at a small risk of being wrong, e.g., a 5 percent risk (5 percent level of significance), the alternate hypothesis is thereby shown to be acceptable. The alternate hypothesis would then indicate there is a correlation. Normally distributed bivariate populations of conflicts and accidents as well as random selection of the sample are assumed.

If the observed data substantiate a rejection of the null hypothesis, we can compute a correlation coefficient by using the preceding formula. If the evidence produces a coefficient larger than the critical value for that sample size, the hypothesis of no correlation is rejected, and the alternate hypothesis of correlation is accepted. The term significant is used to indicate an r-value large enough to reject the hypothesis, and a significant r implies a significant correlation.

When we accept the alternate hypothesis, we mean that we may behave as if it were true. We do not imply that it is actually true, only that, so far as available evidence is concerned, at a given level of significance, we have no reason for concluding that it is not true. This kind of statistical evidence does not constitute proof, and no claim of cause and effect may be had through such a statistical test. An important working hypothesis may have been successfully defended, however, until evidence to the contrary is found.