Rural Intersection Investigation for the Purpose of Evaluating the General Motors Traffic-Conflicts Technique

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A traffic conflict is any potential accident situation. The traffic-conflicts technique developed by General Motors Research Laboratories is a means for analyzing the accident potential of roadway intersections through observation and tabulation of 5 conflict categories: left-turn, weave, cross-traffic, rear-end, and violation. These conflicts occur when evasive action, such as braking or weaving, is necessary to avoid an accident. To date, this technique has been applied mainly to urban intersections. The purpose of this study was to investigate the application of the traffic-conflicts technique to rural roadway intersections.

The technique was found to be flexible enough to be applied to both rural and urban intersections, and it is the authors' opinion that the traffic-conflicts technique does detect accident potential and that it appears to be a good systematic method for studying and evaluating the accident potential of an intersection prior to development of an accident history. However, more research and experience with the technique will be necessary to establish this as a fact.

•DURING 1966, 44,200 motor vehicle accidents took approximately 53,000 lives in the United States and incurred an estimated financial loss of $10 billion (2). The loss of lives and money took place partly because potential accident locations were not identified before a number of accidents had occurred. In the past, identification of these locations has been based on cumulative accident statistics. However, accident statistics alone cannot adequately assess the problem for a particular site. Each location must be analyzed with regard to the interaction of the roadway, vehicle, and driver. An accident can be the result of a driver error, a defective vehicle, a poorly designed or maintained road, or any combination of these.

Accident statistics may identify the problem, but they are not satisfactory in finding its solution because they do not account for all the elements that contribute to the accident situation; they can only identify the potential accident site after loss of property or life. In addition, accident records may be distorted, incorrect, incomplete, or not readily available. Thus, some other method should be developed for identifying potential accident sites.

Because the roadway intersection has been recognized as an area of vehicular conflict and potential accidents and because approximately 27 percent of all rural accidents in 1966 took place at intersections (2), this research was limited to 2 rural intersections in the area of Morgantown, West Virginia. The traffic-conflicts technique was used to measure the accident potential of the intersections. With this technique the interaction of the driver, vehicle, and roadway can be analyzed and the problem areas identified in a relatively short period of time (15). The intersections are both Y-type intersections and are known to have either sight or accident problems or both. This

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investigation identified, recorded, tabulated, and analyzed the traffic conflicts that occurred at the 2 intersections during the study period.

THE TRAFFIC-CONFLICTS TECHNIQUE

The traffic-conflicts technique is a systematic method for observing traffic flows at an intersection in order to determine any existing potential for traffic accidents. This tool is of particular value because an intersection can be studied and evaluated before an accident history is developed (15). Information collected during before-and-after studies can be used to evaluate changes in traffic-conflict characteristics brought about by some physical change at the intersection.

For the purposes of this report, a traffic conflict is defined as any potential accident situation and is identified by observing (a) evasive actions of drivers to avoid a collision and (b) violations of traffic regulations. Evasive actions are denoted by brake lights or lane changes, and traffic violations are defined in the uniform vehicle code. A traffic violation is viewed as a conflict, even though only one vehicle is involved. The intersection area is defined as the area that can be observed by the data collection team. It includes the area of all approaches within 300 ft of the center of the intersection.

A condensed description follows of the traffic-conflicts method (15). The traffic-conflicts technique requires 3 days for data collection, the first 2 days for collecting traffic-conflicts data, and the third for collecting traffic-movement data. Counting is done on Tuesday, Wednesday, and Thursday, the days generally considered as average weekdays with regard to traffic. Data are collected from 7:00 a.m. to 7:00 p.m. in 15-min increments. For example, a position is selected 100 to 300 ft from the intersection on one approach, the actual distance being determined by the amount of intersection area visible to the observer, space available for parking the observation vehicle, the length of waiting queues, and other peculiarities of the intersection area. Traffic approaching the intersection from one direction is observed for a 15-min period, and conflicts are recorded on hand tally counters. When the 15 min have passed, the hand tally data are transferred to a data sheet, and the observation team moves to the opposite approach of the intersection and records conflict data. After a 15-min period, the observation team moves back to the first approach. Data are collected in this manner for the 12-hour period from 7:00 a.m. to 7:00 p.m. On the second day the conflict data collection process is repeated for the remaining 2 approaches.

Traffic movement counts are made during the third day as follows: A position is selected at one corner of the intersection, and traffic on the 2 approaches nearest this corner is observed as it enters the intersection. After 15 min of counting, the observation team moves to the diagonally opposite corner of the intersection and records movements of the traffic on the remaining 2 approaches. Hand counters are used to record individual vehicles, and 15-min totals are recorded on the data sheets.

One of the purposes of collecting the traffic-movement data is to have a standard against which conflict data can be compared. For example, the number of left-turn conflicts can then be compared to the number of opposing left-turn vehicles (15). Therefore, intersections, which may vary greatly in volumes, can be compared on a basis of conflicts per vehicle rather than conflicts per intersection.

Figure 1 shows the 5 categories of traffic conflicts: left-turn, weave, cross-traffic, rear-end, and violations. In the left-turn conflict in Figure 1, vehicle A crosses in front of vehicle B causing vehicle B to brake or weave. The weave conflict is created when a vehicle changes lanes and, in so doing, moves into the path of another vehicle causing it to brake or weave. A cross-traffic conflict is caused by a vehicle crossing or turning into the path of a through vehicle that has the right-of-way. The indication of the conflict is the braking or weaving of the vehicle having the right-of-way. A vehicle entering an intersection on a red signal is a violation whether or not another vehicle is present. Any traffic violation is recorded as a conflict. A rear-end conflict occurs when a vehicle slows or stops causing a following vehicle to slow, weave, or stop. It is identified by the braking or weaving of the following vehicle.

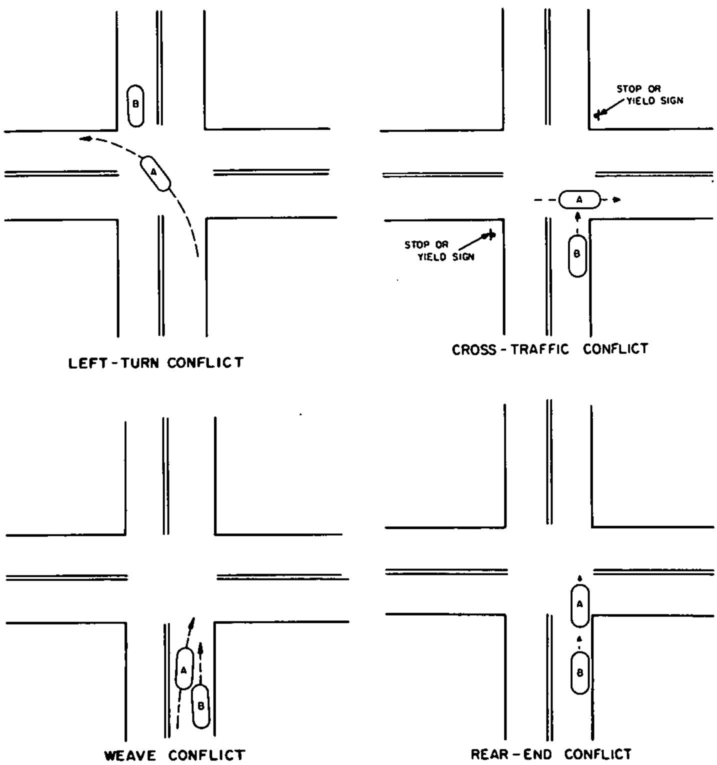

Figure 1. Examples of traffic conflicts, which also include all violations.

The categories of traffic movements are right-turn, left-turn, and through. Other movements such as opposing left-turn, weave, turn-into-wrong-lane, turn-from-wrong-lane, and cross-traffic movements are more easily identified and recorded during the traffic-conflict data collection phase. If a traffic signal is present, violations are recorded during the traffic-movement data collection phase. Either poor signal timing or congestion or both may encourage violations.

If there is more than one through lane or special right-turn or left-turn lanes, movements for these lanes are recorded individually in order to indicate how each lane and, consequently, the total intersection is being used. It may be useful to know that a large number of through vehicles are using the right-turn or left-turn lanes, which could indicate poor signing and lead to driver confusion and vehicular conflict.

Brake lights play an important role in the traffic-conflicts technique, and for this reason through vehicles are observed to determine whether their brake lights are operating. This is easy to record if a vehicle has to stop or slow for an intersection, but difficult if a large number of through vehicles do not slow or stop. A study conducted in an area where there is a high percentage of vehicles with inoperable brake lights could possibly produce misleading results (15).

Study Sites

Study site 1, shown in Figure 2, is a high-accident location and is presently under consideration for improvement by the West Virginia State Road Commission. The general area has a number of billboards and signs, and there are some buildings located very close to the edge of the pavement. The intersection is not lighted at night, but one large billboard between the two northernmost approaches contributes some

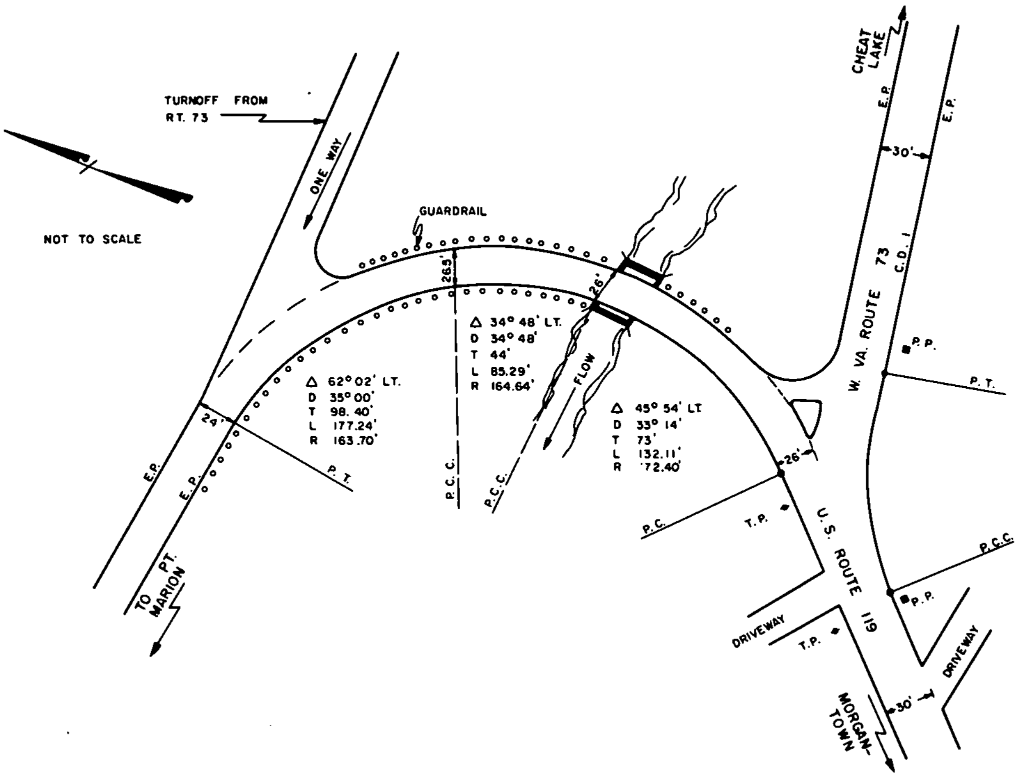

Figure 2. Location of study site 1.

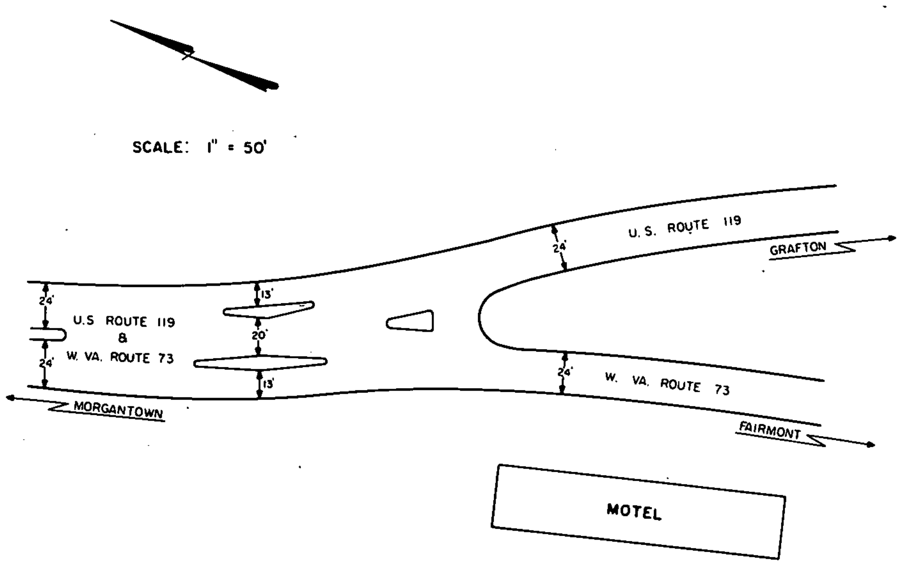

Figure 3. Location of study site 2.

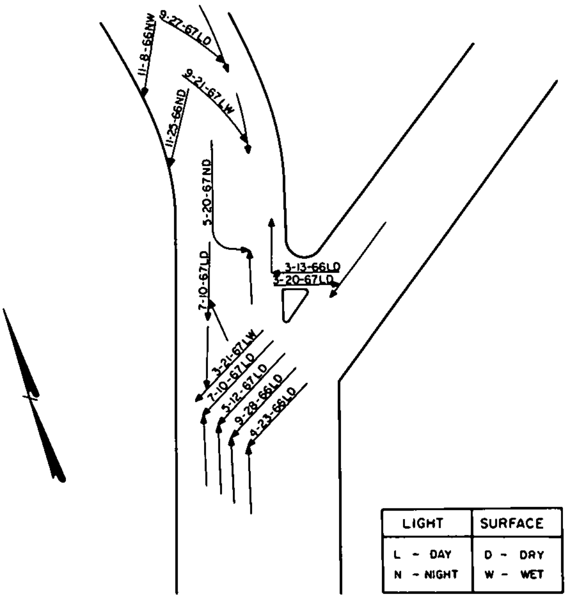

Figure 4. Accidents at site 1 at the intersection of US-119 and WVA-73 north of Morgantown.

illumination until it goes off at 11:55 p.m. In general the area appears to be adequately marked but in some respects has too many signs.

Approximately 20 percent of the vehicles using US-119 are single-unit trucks or larger, but passenger vehicles account for almost 100 percent of the traffic on WVA-73. Traffic flow is approximately 7,000 vehicles per day (vpd) for the southern approach of US-119 and WVA-73, 4,600 vpd for the east approach of WVA-73, and 3,700 vpd for the north approach of US-119.

Study site 2 is shown in Figure 3. The major problem at this intersection seems to be the limitation of sight distance created by a vertical curve in the northwest approach as one proceeds to the intersection from Morgantown. The area appears to be well signed, and illumination is provided at night by light from a nearby motel. However, pavement markings could be improved. Single-unit trucks or larger account for approximately 14 percent of the vehicles on the south approach, 10 percent on the southeast approach, and 16 percent on the northwest approach. Traffic flow is approximately 7,500 vpd on the northwest approach of US-119 and WVA-73, 4,400 vpd on the south approach of WVA-73, and 3,350 vpd on the southeast approach of US-119.

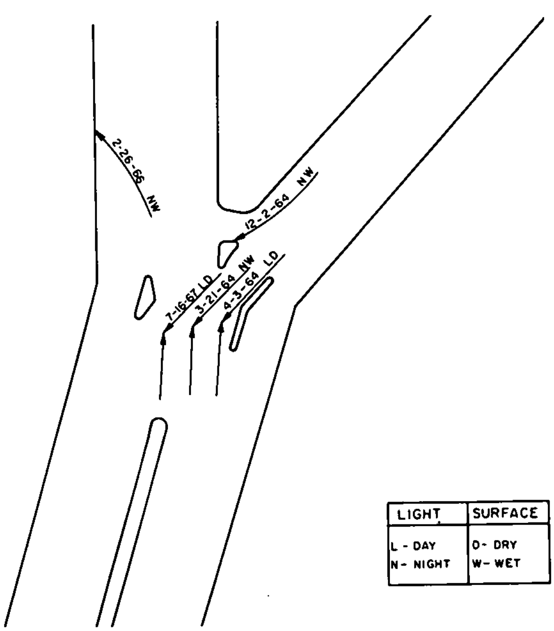

Figure 5. Accidents at site 2 at the intersection of US-119 and WVA-73 south of Morgantown.

Accident History

Figure 4 shows the accidents that occurred at site 1 from January 1966 through December 1967. Thirteen accidents were recorded during this period, none fatal, and total property damage from January 1966 through September 1967 was estimated to be $3,400, an average of $377 per accident (6). Figure 5 shows the 5 accidents that occurred at site 2 from January 1964 to January 1967. None of the accidents was fatal (7).

Data Recording

Traffic-conflict data were recorded by a 2-man team utilizing hand counters and previously prepared data forms. The counts were made from a vehicle parked approximately 300 ft from the intersection in such a position that it was as inconspicuous as possible. One member of the team counted traffic conflicts while the other counted traffic movements. This slight departure from the original General Motors method allowed conflicts and movements to be recorded simultaneously, eliminating the third day of counting. One approach was counted on the first day and two on the following day.

The data for site 1 were collected from 7:00 a.m. to 6:00 p.m. on Wednesday and Thursday, May 8 and 9, 1968. A night study was also conducted at this intersection from 8:00 p.m. to 1:00 a.m. on Wednesday and Thursday, May 22 and 23, 1968. Data for site 2 were collected on Tuesday and Wednesday, May 14 and 15, 1968, between 7:00 a.m. and 6:00 p.m.

Modification of Method

Previous studies made by General Motors Research Laboratories were conducted using a before-and-after approach on 4-way intersections. It appears that all reported intersections were signalized during either the before or the after study.

The intersections selected for this study are Y-type with a stop sign facing one approach. In addition, there are appreciable grades and sight restrictions that made observation of some conflicts impossible. For example, at site 1, the left-turn and cross-traffic conflict for the south approach could not be seen because of limited sight distance. Site 2 also had the same problem for the northwest approach where sight distance is limited by a vertical curve.

The elimination of the fourth leg of the intersection meant a decrease in the number of conflicts that would be recorded. For example, there could be no opposing left-turn into the approach that was missing and, therefore, no corresponding left-turn conflict.

RESULTS AND STATISTICAL ANALYSIS

Site 1 Conflicts

The most frequent conflicts observed at site 1 during the daylight study were rear-end and cross-traffic conflicts. The highest number of rear-end conflicts occurred on the east approach prior to the intersection and were primarily caused by vehicles slowing and halting for the stop sign. A small number of rear-end conflicts were also caused by right-turning vehicles. Rear-end conflicts on the north approach were caused by vehicles turning left at the intersection and other vehicles backing up behind this conflict, and also by through vehicles slowing on the curve causing brakes to be applied in the following vehicles. Rear-end conflicts were frequent on the south approach and were attributed to through vehicles slowing for the intersection and for right turns. Rear-end conflicts were also frequent for consecutive right-turning vehicles. Rear-end conflicts can result in rear-end collision, but no accidents of this type were recorded at site 1 during the past year. If they did occur, they probably went unreported because only minor damage resulted as most rear-end conflicts occur at low speeds.

Cross-traffic conflicts were high on the east and south approaches. On the east approach they were most frequent during the evening peak hours, and were caused by vehicles turning left from the north approach and crossing the through flow of traffic on the east approach. Cross-traffic conflicts for the south approach were attributed to vehicles from the east approach crossing the through flow of northbound traffic in order to complete a left turn. These cross-traffic conflicts would most likely result in an almost right-angle collision for the east approach, and would vary from a right-angle to an almost head-on angular collision for the south approach. The accident data showed that such an accident occurred on the east approach, and 4 occurred on the south approach. The high number of stop-sign violations (Table 1) could also contribute to the cross-traffic conflicts and accidents on the south approach.

No weave conflicts were observed for the intersection nor were there any weave accidents recorded during the past year. The opposing left-turn conflict was recorded for the south approach but was small in number compared to those previously discussed. Only one associated accident, a right-angle collision, occurred during the past year.

Site 2 Conflicts

The most prevalent conflicts at site 2 were rear-end and cross-traffic. Rear-end conflicts on the southeast approach occurred in the through lane because vehicles slowed prior to the intersection (for no apparent reason) or vehicles slowed or stopped behind left-turns or previous conflicts. The northwest approach had rear-end conflicts occurring mainly in the through lane immediately after the intersection, which were caused by slowly moving vehicles ascending the relatively steep grade in that area. Rear-end conflicts on the south approach were caused by vehicles slowing or stopping for the stop sign or for a previous right-turning vehicle, or by traffic backing up from the stop sign. Accidents occurring as a result of these conflicts would be rear-end collisions, but no accidents of this type were recorded from January 1964 to January 1967. Through and cross-traffic conflicts occurred predominantly in the northwest approach and were caused by traffic from the south approach crossing the through flow from the north approach. Conflicts of this type would be associated with an angular collision, and three such accidents were recorded between January 1964 and January 1967. A high number of stop-sign violations were also observed here. Few left-turn conflicts were noted for the north approach, and no associated accidents have been recorded. Weave conflicts were neither observed during the study period nor associated with any accidents recorded between January 1964 and January 1967.

Brake-Light Functioning

Brake-light data at sites 1 and 2, where sufficient data could be collected, indicated that only 3 percent of all the observed vehicles had malfunctioning brake lights. This falls within limits noted by previous studies (15). At site 1 these data were easily collected for the east approach as nearly all through vehicles had to brake in the vicinity of the intersection. However, on the south approach, vehicles were usually accelerating out of the curve into the steep ascending grade of the south approach, and there was little need to apply brakes.

Site 2 presented more of a problem because the northwest approach was on an ascending grade that extended through the intersection, and many drivers did not find it necessary to apply their brakes. The southeast approach, located on a descending grade, also had few brake-light indications. Because of the stop sign on the south approach, however, an adequate determination of functioning brake lights for the vehicles using this approach was possible.

Comparison of Day and Night Conflicts

At site 1, both a day and night study were conducted and statistically compared. Conflicts per vehicle were used in this comparison because conflicts per hour would vary with traffic volume, and the daylight volume at this intersection was greater than the night volume. Conflicts per vehicle were calculated for each type of conflict and are given in Table 1.

The Mann-Whitney U-test was used to test for significant differences in conflicts per vehicle for the day and night studies. The test was applied to each individual approach and to the combined data for each intersection. From the tests it was concluded that conflicts per vehicle were not significantly different during the night and day.

Comparison of Conflicts at Sites 1 and 2

The Mann-Whitney U-test was also used to determine if there was a significant difference between conflicts per vehicle at sites 1 and 2. The higher rate of accidents at site 1 suggested that conflicts per vehicle would also be higher there. The results of the test, however, showed that there is no significant difference between the two sites. Conflicts per vehicle at both sites are given in Table 1.

TABLE 1

CONFLICTS PER VEHICLE AT SITES 1 AND 2

Approach	Conflict	Site 1		Site 2
		Day Study	Night Study	
East	Rear-end	0.184	0.147	0.170
	Through and cross-traffic	0.191	0.017	0
	Left-turn and cross-traffic	0	0	0.002
North	Rear-end	0.185	0.016	0.052
	Left-turn and cross-traffic	0.009	0	0
	Through and cross-traffic	0	0	0.040
	Left-turn	0	0	0.143
	Weave	0	0	0
South	Rear-end	0.126	0.112	0.116
	Weave	0	0.250	0
	Left-turn	0.065	0	0
	Through and cross-traffic	0.067	0.013	0.200
	Right-turn and cross-traffic	0.060	0	0
	Stop-sign violations	0.403	–	0.112
	Percent stop-sign violations	40.3	12.0	–

Note: Only the east approach at site 1 and only the south approach at site 2 were faced by stop signs.

Comparison of Conflicts and Accidents

Data for site 1, the high-accident location, were used to determine if there was any association between conflicts and accidents. Conflicts and accidents per vehicle were used. These values were determined from accident records for 1966 and 1967 and by estimating the yearly number of vehicles making the movement involved in the conflict. It would have been desirable to have a larger sample of conflict data as well as accident data—at least data for a three-year period.

The Spearman rank correlation coefficient was used to measure the degree of association between the two variables. The results are given in Table 2. Based on the available data, there appears to be no significant association between conflicts per vehicle and accidents per vehicle at the 0.05 level.

Because this is in contrast to the basic assumption that there is an association between conflicts and accidents a second comparison was made in which rear-end conflicts were eliminated. There was some doubt about the rear-end conflicts data because a large number of rear-end conflicts were observed during data collection, and it appeared that some of these were not conflicts but just the drivers' braking for personal comfort or for caution. In these cases there were 2 or more vehicles, often separated by as much as 150 ft, and there appeared to be no reason to judge them to be

TABLE 2

RELATIONSHIP BETWEEN CONFLICTS AND ACCIDENTS PER VEHICLE AT SITE 1

Approach	Conflict	Conflicts per Vehicle	Accidents per Vehicle
East	Rear-end	$\frac{190}{1,032} = 0.184$	$\frac{1}{365 \times 2,377} = 0.000001153$
	Through and cross-traffic	$\frac{52}{271} = 0.191$	$\frac{1}{365 \times 512} = 0.000005351$
North	Rear-end	$\frac{71}{382} = 0.185$	0
	Left-turn and cross-traffic	$\frac{4}{465} = 0.009$	$\frac{1}{365 \times 2,203} = 0.000001244$
South	Rear-end	$\frac{118}{937} = 0.126$	0
	Weave	0	0
	Left-turn	$\frac{9}{139} = 0.065$	$\frac{1}{365 \times 512} = 0.000005351$
	Through and cross-traffic	$\frac{34}{506} = 0.067$	$\frac{5}{365 \times 2,203} = 0.000006218$
	Right-turn and cross-traffic	$\frac{4}{67} = 0.060$	0

conflicts. Moreover, if any rear-end accidents had occurred on the slower approaches, they might have gone unreported because of insignificant damage. The rear-end conflicts and accidents were, therefore, eliminated and the Spearman's rank correlation coefficient again calculated. The results again showed no association between conflicts per vehicle and accidents per vehicle at the 0.05 level. However, these data showed a much higher degree of association, and more data might possibly indicate an even higher degree of association.

Because it can be argued that the results of the test would probably change if there was a change of one accident at a number of points, a 3- to 5-year accident record should be used to obtain more reliable results.

CONCLUSIONS

During this investigation of the traffic-conflicts technique the following observations and conclusions were made. Data collection of traffic movements and conflicts can be understood in a single day, but competence in the identification of conflicts of all types may require practice during several days. The conflicts recorded for the same location by 2 individuals may vary over short periods of time, but this variation will be minor if the conflict definitions are adhered to. Conflicts were noted to vary in degree of severity (which could not be recorded), and conflicts that could have resulted in accidents were more numerous in the through- and cross-traffic category at both sites. This, plus the statistical analysis, seems to indicate an association between conflicts and accidents.

The statistical comparison made between the day and night studies combined with the authors' observations led to the conclusion that conflicts per vehicle is a farily stable measure that could be verified through time, provided no physical changes or major changes in traffic volumes occur. The technique is flexible and can be applied to both urban and rural intersections.

The most important conclusion is that the traffic-conflicts technique can and does seem to detect accident potential because it identifies potential accident situations. The technique does not always show what changes are necessary to reduce the accident potential, but it does define the area or areas to be investigated.

The results of the investigation show that even though only one rear-end accident is recorded in the accident histories, there is a comparatively high number of rear-end conflicts at both intersections. These conflicts occurred mainly at low speeds, and it is likely that if other accidents occurred they caused little damage and went unreported. The through- and cross-traffic conflict was most directly related to accident history at the 2 locations. The traffic-conflicts technique identified this as a major conflict and also detected the stop-sign violations that contribute to it.

The traffic-conflicts technique, as used in this study, is a systematic method for studying and evaluating the accident potential of an intersection. If applied conscientiously it can aid in determining changes and modifications needed in present design. It can then be used to evaluate the effectiveness of the changes. The true test of the method, however, must come with time. It must be tried by state highway departments and by other groups with varying personnel and interpretations. Then perhaps it can make a contribution to improving highway design and reducing highway accidents.

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