CRITERIA FOR TRAFFIC CONFLICT CHARACTERISTICS
SIGNALIZED INTERSECTIONS

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ABSTRACT

The objective of the Traffic Conflict Characteristics Project is to study and understand the basic causes of accidents. The initial effort has been directed at driver conflict characteristics at intersections. This report serves to document the criteria of traffic conflicts which appear to be related to the various types of intersection accidents.
INTRODUCTION

Drivers, vehicles, and roads are complicated co-contributors in traffic accidents. All three can vary significantly in character from one area to another, from one year to the next. It thus appeared that gross accident statistics alone would not reveal the details of the complex interactions. Instead, it was felt that it should be possible to objectively measure the accident potential of a given area—to evaluate an intersection dynamically, not waiting for an accident history to evolve.

SUMMARY

A driver-conflict study technique for measuring the type and frequency of accident circumstances at intersections was developed. This report describes the criteria for the various types of accidents, and the procedures employed in measuring an intersection using the driver-conflict criteria as working hypotheses.

Five of the basic types of accidents at signalized intersections may be termed as left-turn, weave, thru-on-red, left-turn-on-red, and rear-end incidents. Specific, objective criteria for traffic conflicts associated with each of these types of accidents have been defined.

It is intended to follow this report with a series of reports on intersections, which are being evaluated by the conflict criteria described herein.

This report supersedes "Criteria for Traffic Conflict Characteristics," General Motors Research Publication GMR-610, dated November 14, 1966. Conflict criteria for rear-end incidents had not been defined at the time the first report was published.

TRAFFIC CONFLICT CRITERIA

Left-Turn

There are two traffic circumstances which are defined as left-turn traffic conflicts. The first circumstance is one in which a left-turn vehicle (1) crosses directly in front of an opposing through vehicle (2), causing the through vehicle (2) to apply his brakes. The criterion of the conflict is determined by the indication of the brake signal on the through vehicle.
A second circumstance of a left-turn conflict is one in which the left-turn vehicle (1) stops before completing his turn, blocking the lane of an opposing through vehicle (2) and causing (2) to change traffic lanes to avoid the left-turn vehicle, with no brake light indication necessary to be counted.

A weave conflict is defined as a traffic circumstance in which a vehicle (1) changes lanes within some 200 feet of an intersection causing a following vehicle (2) to brake. The criterion of the conflict is a brake light indication on the following vehicle (2).
A thru-on-red conflict is defined as a situation in which a vehicle runs a red light, either after the light has turned red or before the light changes to green. The criterion of a thru-on-red conflict is determined by a vehicle entering the intersection on a red signal. The fact of the violation is defined as the conflict; no other vehicle need be present when the violation is committed.
A left-turn-on-red conflict is defined as a situation in which a left-turn vehicle (1) runs a red light either after the traffic signal has turned red, or before the signal has turned green. The criterion of a left-turn-on-red conflict is determined by a left-turn vehicle entering the intersection on a red signal. The left-turn-on-red violation is defined as the traffic conflict; no other vehicle need be in close proximity.

Rear End

A rear-end conflict, in general, can be defined as a vehicle stopping unexpectedly, causing a following vehicle to stop or weave. Three specific categories of rear-end conflicts are defined here; a vehicle that prematurely stops for a traffic signal while being followed by another vehicle, a vehicle that slows or stops because it is involved in another conflict while followed by another vehicle, and a vehicle that slows or stops with no other conflict present, but followed by another vehicle. The criterion for each of these rear-end conflicts is the braking or weaving of the following vehicle. The conflict criteria presented here for rear-end collisions were only recently devised and are currently being tested.

![REAR-END CONFLICT - PREMATURE STOPPING](image)

The first type of rear-end conflict is defined as a circumstance in which a vehicle (1) prematurely stops for a traffic signal causing a following vehicle (2) to brake or weave; vehicle (2) could have legally entered the intersection at his approach speed. If, for example, vehicle (2) is traveling at 45 mph approaching an intersection having a 4-second amber light and the traffic signal changes from green to amber when vehicle (2) is less than 264 feet from the intersection, vehicle (2) could enter the intersection legally. A vehicle at 45 mph can travel 264 feet in 4 seconds. If, however, vehicle (1), traveling in front of vehicle (2), stops for the traffic signal, vehicle (2) would be caused to stop or weave, the criterion of the conflict.
The second type of rear-end conflict is defined as a situation in which a vehicle slows or stops when involved in a traffic conflict and causes a following vehicle to take evasive action to avoid a rear-end collision. For example, if vehicle (1) slowed or stopped because it was involved in a left-turn conflict with vehicle (3), the incident would also be counted as a rear-end conflict if vehicle (2) was caused to brake or weave to avoid vehicle (1).

The third type of rear-end conflict is defined as a circumstance in which a vehicle stops at an intersection with no other conflict present, causing a following vehicle to brake or weave. Vehicles approaching an apparently clear intersection on a green signal have been observed coming to a complete stop before proceeding thru the intersection. If such a vehicle (1) were being followed by another vehicle (2) which was caused to take evasive action, the situation would be termed as rear-end conflict. A multiple car situation is considered as a single incident.
**Miscellaneous Incidents**

A number of intersections have special circumstances which lead to additional traffic conflicts. Some intersections have a high pedestrian volume. Some intersections have individually different lane designs and signalization, which lend themselves to certain traffic conflicts peculiar to the individual intersection. Under these circumstances, an appraisal of special types of conflicts must be made before measuring the intersection.

An example of such an intersection is one which has a red flashing arrow permitting right turns after stopping at a red traffic signal.

A red arrow-right turn traffic conflict is defined as a situation in which a right-turn vehicle (1) turns on a red arrow signal directly in front of a through vehicle (2) having a green signal, causing the through vehicle (2) to brake. The criterion of the red arrow-right turn conflict is a brake light indication on the through vehicle (2).

In addition to counting the conflicts that were previously mentioned, other counts are taken that are felt to be indicative of the intersection. They include counts of the proportion of thru vehicles that are stopped by the traffic signal. This indicates the ability of the intersection to service the vehicles that approach the intersection. Another count is made of the traffic movements of the intersection, the lanes of the intersection, and how they are used. This indicates how the drivers are using the intersection.
The accumulation of data for measuring an intersection requires three twelve-hour observation periods for each intersection. During the first two observation periods, one for each of the intersecting roads, the traffic should be observed (from behind) as it approaches the intersection to view the conflicts defined by vehicle brake light criteria. During the third twelve-hour observation period, the traffic should be observed as it enters the intersection to view conflicts defined by traffic movement criteria.

During all three observation periods, data are taken for alternating fifteen-minute increments for each direction of traffic flow.
TABLE I - SAMPLE OBSERVATION SCHEDULE

Twelve-Hour Observation Periods (7 a.m. to 7 p.m.)

First Day -- North-South Road
Alternate 15-Minute Observations
North-Bound Brake-Light Criteria
South-Bound Brake-Light Criteria

Second Day -- East-West Road
Alternate 15-Minute Observations
East-Bound Brake-Light Criteria
West-Bound Brake-Light Criteria

Third Day -- Traffic Movement Criteria
Alternate 15-Minute Observations
East-Bound and North-Bound Vehicles
West-Bound and South-Bound Vehicles

Brake Light Criteria Observations

Conflicts that are determined by brake-light criteria should be observed from a position approximately 300 feet behind the intersection. From this position the traffic can be viewed as it approaches the intersection. At a distance of 300 feet all of the vehicles which are stopped by the traffic signal and can pass through the intersection on a single green-light cycle, can generally be observed.

During the brake light observations, the left-turn conflicts are counted along with the total number of opposing left turners, the number of vehicles that change lanes within 200 feet of the intersection with the number which have weave conflicts, and the three types of rear-end conflicts. In addition, all of the vehicles in the thru lane are counted: those completely stopped, slowed, and undisturbed. Since brake lights play an important role in these studies, vehicles are observed as they are stopping to detect those which have operating brake lights and those which have no perceptible brake-light indication. It will be necessary to be aware of an intersection having a disproportionate number of vehicles not having operable brake lights.

A sample data sheet and the explanation for its use for brake-light criteria observations is given in Appendix A.
BRAKE LIGHT CRITERIA

FIGURE 9 - BRAKE-LIGHT CRITERIA OBSERVATIONS

TRAFFIC MOVEMENT CRITERIA OBSERVATION

FIGURE 10 - TRAFFIC MOVEMENT CRITERIA OBSERVATION
One twelve-hour observation period for each intersection should be used to measure the traffic movement criteria, namely, through red light violations, left turn-red light violations, improper turns, and lane usage. These observations should be made from a position facing the traffic as it enters the intersection. A sample data sheet for recording traffic movement criteria observations is given in Appendix B.

**DISCUSSION**

**Twelve-Hour Observation Periods**

After numerous appraisals of many intersections to view the variations in traffic patterns throughout the day, it appeared necessary to institute twelve-hour observation periods, namely 7 a.m. to 7 p.m. Traffic characteristics at certain times of the day, not only during rush hours, are inclined to produce traffic conflicts. For example, at some intersections, noon-hour traffic patterns result in a significantly high number of traffic conflicts. At some intersections, there are very few left-turn conflicts during rush hours. Opposing through traffic is so heavy that left turns can be executed only during the amber portion of the traffic signal, after the opposing through traffic has stopped. The same intersection during medium traffic periods, however, may produce a high number of left-turn conflicts.

**Fifteen-Minute Sample Periods**

During the twelve-hour observation periods, data is recorded for each direction of traffic flow in alternating fifteen-minute sample periods. For example, if a north-south road were being observed, data for southbound traffic would be recorded for a fifteen-minute period, and the north-bound traffic would be recorded for the subsequent fifteen-minute period. Although traffic patterns and conflict situations do vary throughout the day at a given intersection, the fluctuations are not extremely rapid. Fifteen-minute sample periods appear to be quite representative of the situation.

**Brake-Light Indications of Traffic Conflicts**

Considerable effort was expended in attempting to appraise traffic situations which could lead to accidents and to define these conflict situations so that intersections could be measured and compared. It was desired to formulate definitions of traffic conflicts which were clear, simple, and objective. It was found that it was most difficult to measure the distances between conflicting vehicles or the relative speeds of conflicting vehicles. Further observation of vehicles in conflict led to the brake-light indication criteria. This type of vehicle conflict formulation could be simply and clearly defined and did not require any observer's opinion.
One near-miss definition for traffic conflicts was attempted early in the project. A near-miss was defined as a situation in which a driver violently stopped or swerved to avoid another vehicle. Besides the obvious definition difficulty, it was soon concluded that the amount of data would not be numerically significant.

Stopped Vehicles

Stopped vehicles are defined as those which come to a complete stop. The stopped vehicles are counted in two categories; those which have working brake lights, and those which have no brake lights. Since brake-light indications are used to determine traffic conflicts, it is necessary to know whether any given intersection has a disproportionate number of vehicles without brake lights. In determining the number of vehicles stopped by the traffic signal at an intersection, only the through vehicles are considered. Turning vehicles normally slow or stop. Through vehicles, however, intend to travel through the intersection without slowing or stopping.

Red Light Violations

A red light violator is defined as a vehicle that enters the intersection on a red traffic signal. This is the accepted police definition.

Camera Techniques

Various techniques of utilizing a movie camera for recording conflict data were tried. It proved impossible to view an entire intersection from a single camera position. It was found that it would be necessary to film each direction of traffic individually. Under these conditions, it was felt that camera techniques would be too time consuming and in addition would cause unnecessary delay in data reduction. Camera techniques as an aid in understanding the basic causes of accidents will continue to be explored.

It is intended, however, to produce demonstration and driver training films on the traffic situations encountered on this project.

Versatility of Conflict Criteria

Some 20 intersections have been viewed with respect to the applicability of the defined traffic conflict criteria. These intersections represented a wide range of variations in design, layout, signalization, traffic patterns, and environment. It was found that the conflict criteria were applicable as defined to every intersection. Some intersections had, in addition, individual peculiarities requiring additional categories, but the criteria for the traffic conflicts which lead to accidents appeared valid.
APPENDIX A

BRAKE LIGHT CRITERIA OBSERVATIONS

Table A1 shows a sample data sheet for conflict data observations. One sheet is used for each direction of traffic.

Line 2 of the data sheet is used to identify the intersection and the design of the particular road being observed.

Column 1
Data sheet identification:  A = Conflict Data Sheet
                          B = Traffic Flow Data Sheet

Column 2
Direction of road:  N, S, W, or W

Columns 9-40
Name of intersection

Columns 41-46
Date

Column 47
Day of week

Columns 48-50
Traffic signal cycle, total time, seconds

Columns 51-53
Green signal time

Columns 54-56
Amber signal time

Columns 57-59
Red signal time

Columns 60-62
Left-turn green arrow time

Columns 63-65
Left-turn amber time

Columns 66-68
Right-turn red arrow time

Column 69
Left-turn,  0 = Prohibited
           1 = Allowed
Column 70
  Right-turn only, number of lanes
Column 71
  Right-turn and thru lanes
Column 72
  Right center lanes, thru only
Column 73
  Left center lanes, thru only
Column 74
  Left-turn and thru lanes
Column 75
  Left-turn only lanes

Lines 5-28 of the Conflict Data Sheet are utilized to record the data observed during each 15-minute period.

Column 1-3
  Stopped vehicles, no brake lights, number of vehicles
Column 4-6
  Stopped vehicles, brake lights operating
Column 7-9
  Stopped vehicles, brake lights not observed
Columns 10-12
  Slowed vehicles, brake-light indication
Columns 13-15
  Thru vehicles, no brake-light indication

Note: Turning vehicles tend to slow or stop. Thus only the vehicles in the thru lanes approaching the intersection are counted for columns 1-15.

Columns 16-17
  Stopped vehicles that turned right
Columns 18-20
  Vehicles stopping on amber signal
Columns 21-22
  Rear-end conflicts, premature stopping
Columns 23-25
  Weave vehicles
Columns 26-27
  Weave conflicts
Columns 28-29
  Rear-end conflict following weave conflict
Columns 30-32
  Right-turn vehicles stopping or slowing in thru lane, green signal
Columns 33-34
  Rear-end conflict, stopping right-turn vehicle followed by thru vehicle
Columns 35-36
  Thru vehicles stopping on green signal
Columns 37-38
  Rear-end conflict following thru vehicle stopping on green signal
Columns 39-41
  Left-turn lane premature stopping, number of vehicles
Columns 42-43
  Rear-end conflicts following left-turn premature stop
Columns 44-46
  Number of opposing left-turn vehicles
Columns 47-48
  Left-turn conflicts
Columns 49-50
  Rear-end conflict following left-turn conflict
Columns 51-52
  Left-turn vehicles crossing directly in front of signaling right-turn vehicle
Columns 53-54
  Rear-end conflicts following left-turn right-turn incident
Columns 55-56
  Vehicles slowing in center of intersection
Columns 57-58
  Rear-end conflict following vehicle slowing in center of intersection
Columns 59-61
Perpendicular right-turn vehicles on red arrow

Columns 62-63
Right turn on red arrow conflicts

Columns 64-65
Rear-end conflict following right turn on red arrow conflict

Columns 66-73
Time of count

Columns 74-75
Weather condition
<table>
<thead>
<tr>
<th>Direction</th>
<th>Intersection</th>
<th>DATE</th>
<th>TRAFFIC SIGNAL CYCLE</th>
<th>NO. Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT: Stop A Weave</td>
<td>STOP</td>
<td>Opposing Left Turn</td>
<td>LRT</td>
<td></td>
</tr>
<tr>
<td>NOHL B L 26</td>
<td>LOW TIBU &amp;</td>
<td></td>
<td>Time of Count</td>
<td></td>
</tr>
<tr>
<td>SI: #</td>
<td>RE #</td>
<td>CNR #</td>
<td>RE #</td>
<td>PE #</td>
</tr>
</tbody>
</table>

0 = LT Prohibited
1 = LT Allowed
APPENDIX B

TRAFFIC MOVEMENT CRITERIA

Table B1 shows a sample data sheet from traffic flow data observations. One sheet is used for each direction of traffic.

Line 2 of the data sheet is used to identify the intersection and the design of the particular road being observed. Utilization is identical to that of Conflict Data Sheet.

Lines 5-24 of the Traffic Flow Data Sheet are used to record the data observed during each 15-minute period.

Columns 1-3
  Right turn on green and amber

Columns 4-6
  Right turn on red signal

Columns 7-9
  Right turn on arrow

Columns 10-12
  Thru vehicles, right lane, on green and amber

Columns 13-15
  Thru vehicles, right-center lane, on green and amber

Columns 16-18
  Thru vehicles, left-center lane, on green and amber

Columns 19-21
  Thru vehicles, left lane, on green and amber

Columns 22-24
  Thru on red signal

Columns 25-27
  Left turn on green and amber

Columns 28-30
  Left turn on red signal

Columns 31-33
  Left turn on arrow

Columns 34-36
  Escape Route 1

Columns 35-37
  Escape Route 2
Columns 66-73
Time of count
Columns 74-75
Weather condition