Development of a Conflicts Analysis Technique for Pedestrian Crossings

Michael J. Cynecki

The purpose of the study described in this paper was to develop a pedestrian conflict technique that will be useful in identifying hazardous locations and specific operational deficiencies at pedestrian crossings. A major concern in the development of this conflict technique was flexibility, ease of use, and the ability to develop countermeasures from the collected data. The technique defines 13 principal pedestrian conflicts that may occur and uses different levels of conflict severity. A conflict data form was constructed to assist in the collection of data. The applicability and feasibility of this conflict technique was tested at five crossing locations in which a total of 25 h of data were collected. Although a significant amount of further testing is required to provide conclusive results on the usefulness of this conflict technique, preliminary investigation has indicated that this procedure can yield information that is valuable for the identification of potential safety hazards at pedestrian crossings. The technique may be used to develop countermeasures to reduce or eliminate pedestrian accidents.

Traffic conflicts are a measure of the potential for traffic accidents. A traffic conflict occurs when a driver takes an evasive action to avoid a collision. In the past several years there has been considerable work in analyzing hazardous locations with conflict-analysis techniques, including some attempts to relate the number of traffic conflicts to the number of accidents at a location. This technique has generated much interest in accidents that involve vehicles with vehicles or vehicles with fixed objects; however, little work has been conducted toward the application of traffic conflict techniques to pedestrian accidents.

The purpose of a conflict study is to identify hazardous locations and accident potentials so that these deficiencies may be eliminated before an accident occurs. This is especially important in accidents that involve pedestrians, which often result in an injury or fatality. Although less than 1 percent of all motor vehicle accidents involve pedestrians, approximately 18 percent of all fatality accidents in the United States are pedestrian accidents (1). This indicates that pedestrian accidents are more severe than the average accident. Because of this severity, a conflict technique needs to be developed that will identify hazardous locations and safety deficiencies and assist in the development of countermeasures to reduce or eliminate pedestrian accidents.

The purpose of this study was to develop a conflicts technique for measuring pedestrian accident potentials and to identify operational deficiencies on roadways that pertain to pedestrian safety. The pedestrian conflict technique presented in this paper includes a description of conflict classifications, a data collection procedure, and a form for data collection.

CHARACTERISTICS OF A CONFLICT STUDY

A conflict procedure should contain certain characteristics to be a useful tool to traffic engineers. These characteristics or attributes include the following (2):

1. Safety-relatedness—Conflicts must be defined in such a way that they are related to a safety problem or an operational hazard. Some driver actions of braking or changing lanes may be unrelated to a collision with a pedestrian. These actions may be a response to a traffic control device or to avoid a pothole. The conflict definitions must also not be too broad. If many types of conflicts are combined into one category, it will be difficult to identify a specific problem at a location from the collected data.
2. Site-relatedness—The conflict definitions that are used must be applicable to the location under investigation. For example, some types of conflicts may occur only at intersections or at locations that have on-street parking. This may call for defining many types of conflicts even though only a few conflict types may occur at a given location.
3. Reliability—A pedestrian conflict procedure should be valid and have a high statistical correlation with pedestrian accidents.
4. Repeatability—The procedure developed must provide consistent results from day to day and from location to location (given similar conditions) or it will be of little use. Another major concern is observer reliability or the consistency of results between observers. This is difficult because of differences in personal concepts of a conflict. Therefore, special training may be required to achieve observer reliability.
5. Practicality—The technique must be easy to use and provide adequate results with a minimum of personpower. One pitfall to avoid is the definition of too many conflicts and assignment of too many sophisticated tasks which may place unrealistic and unachievable demands on human observers.

FACTORS INVOLVED IN CONFLICT STUDIES

Vehicle-pedestrian conflicts differ from vehicle-vehicle conflicts in several ways. Pedestrian conflicts involve various factors, some of which have little bearing in vehicle conflicts. These differences need to be discussed and analyzed to develop a better understanding of the relationships that are involved and to assist in defining conflict types. Some of these fundamental differences follow:

1. Vehicle-pedestrian accidents are not as numerous as vehicle-vehicle (or vehicle-fixed object) accidents.
2. Accidents are considerably more severe when they involve pedestrians. There is little chance of a property-damage-only (PDO) accident when a pedestrian is struck by a vehicle, and there is a very good chance of a severe injury or fatality, particularly at high-speed locations.
3. Many of the pedestrians involved in accidents are school age, preschool, or elderly. Pedestrians in these age groups may not have adequate knowledge of highway safety, lack responsibility and maturity, or have reduced eyesight and reflexes, which are factors in many pedestrian accidents. On the other hand, motorists must be at least 16 years of age and have good eyesight and health. Although this is not always the case (i.e., drunk drivers), on the average, drivers should have better eyesight and reflexes than children and elderly pedestrians.
4. The operation of a motor vehicle is considerably

more complex and involves many more distractions than does the action of a pedestrian crossing a roadway.

5. Pedestrians are more maneuverable than automobiles in the actions of stopping and changing directions.

6. The speed differential between automobiles and pedestrians is considerable. Automobiles usually travel in speeds that range from 24 to 100 km/h (15 to 60 mph); pedestrian speeds average at about 5 km/h (3 mph).

7. Most pedestrian conflicts occur at right angles when pedestrians are in the action of crossing a roadway. This is not the case with vehicle conflicts.

8. Pedestrians may access a roadway at almost any point. Automobiles normally access a roadway at specified points (i.e., other roadways, driveways, or curbside parking spaces). Therefore, a motorist must be cognizant of pedestrians at every point along a roadway.

9. Sight restrictions may be more prevalent in pedestrian conflicts than in vehicle conflicts. A pedestrian is smaller than a vehicle and can access a roadway from between parked cars and may be shielded from a motorist until he or she is in the roadway (without giving the motorist advance warning).

10. For nighttime conditions, vehicles have headlights, taillights, and running lights that make them more visible to other motorists. Pedestrians are often dressed in dark clothing and are more difficult to detect at night.

11. Pedestrian conflicts and conflict severity can be measured from the movements and reactions of vehicles and pedestrians. When only vehicles are involved, conflicts and conflict severity can usually be measured by watching the movements and reactions of only one vehicle. The example of this is a slow-for-right-turn rear-end conflict. The first vehicle slows for a right turn while the second vehicle brakes or weaves to avoid a collision. The conflict can only be viewed and measured by watching the second vehicle. When pedestrian conflicts occur, a conflict can be viewed from the vehicle's actions (braking or weaving) to avoid a collision or from the pedestrian's actions (stopping, changing directions, or running).

Such items indicate that there is a significant difference between vehicle conflicts and pedestrian conflicts.

The factors that play a part in the number and severity of pedestrian conflicts were investigated. Many of these factors should be noted in the data collection procedure at the site to assist in the identification of hazardous roadway features that should be eliminated. The following list was developed to represent some of these pedestrian conflict factors:

1. Traffic volumes,
2. Percentage of vehicles turning,
3. Right-turn-on-red regulations,
4. Traffic speeds,
5. Vehicle mix (percentage of trucks and buses),
6. Pedestrian volumes,
7. The relationship between pedestrian and vehicle volumes,
8. Time of day and day of week,
9. Season,
10. Weather conditions,
11. Visibility conditions,
12. Sight restriction,
13. On-street parking,
14. Road width and number of lanes,
15. Shoulder widths,
16. Pavement markings,
17. Presence of a left-turn center lane,
18. Medians and pedestrian islands,
19. Roadway surface conditions (i.e., potholes or drainage),
20. Geometrics (grade and horizontal and vertical curvature),
21. The number of vehicle access points,
22. Roadway lighting,
23. One-way versus two-way operation,
24. Location of sidewalks,
25. Crosswalks,
26. Pedestrian warning signs or flashers,
27. Crossing guards,
28. Pedestrian age,
29. Enforcement of vehicle and pedestrian traffic regulations,
30. Pedestrian barriers,
31. Grade separations,
32. Crossing location (intersection or midblock),
33. Number of legs at intersection and angle of intersection,
34. Traffic control devices,
35. Pedestrian phasing at signalized intersections (i.e., WALK-DON'T WALK signs), and
36. School site selection.

Various sources have identified the above factors as contributing factors in increasing or reducing the chance of a pedestrian conflict (3-7). For example, at a signalized intersection where there is a high percentage of vehicles turning, pedestrian crossing is impeded and conflicts involving turning vehicles with crossing pedestrians will result. If right turns on red are allowed at that intersection, the number of conflicts and potential pedestrian hazards will be increased. Wider streets cause longer crossing times for pedestrians, which may increase the chance for a conflict. Other factors (such as roadway geometrics or on-street parking) may cause sight restrictions for motorists or pedestrians; features such as warning signs and pavement markings may forewarn motorists of a crossing location and may assist in reducing conflicts.

The types of conflicts used in this technique are defined in the following section. The conflict definitions are based on the manner in which the pedestrian accesses the roadway (i.e., walking or running into the roadway, walking along the side of the roadway, or walking in a center left-hand turn lane), vehicle turning movements, and vehicle and pedestrian violations of traffic signals.

Conflict Definitions

Slow or Weave for Walking Pedestrian

This is a conflict that occurs when a pedestrian accesses a roadway at a normal walking pace (at a right angle to vehicle traffic) and a vehicle weaves or brakes to avoid a collision. This conflict does not include vehicles turning into the path of a pedestrian at intersection locations or violations of a traffic signal by a motorist or pedestrian.

The occurrence of this conflict may, for example, indicate a sight restriction for the motorist or pedestrian. If this is the case, conflicts may be reduced by removing sight obstructions or by improving warnings to motorists of pedestrian access points or crosswalks. However, slow for walking pedestrian is a very general conflict type that may indicate many diverse safety hazards. Walking pedestrian (PW) conflicts may also be caused by inadequate gaps in vehicle traffic, excessive street width, excessive vehicle speeds, or too many pedestrian

crossing locations. Thus, recording the type of conflict alone may not indicate a specific operational deficiency. Other data, such as condition diagrams, vehicle and pedestrian volume counts, and gap studies may also be needed to determine the actual locational deficiencies.

When data are being recorded, one conflict should be counted for each pedestrian who conflicts with each vehicle. That is, if two pedestrians are walking across the street and a vehicle brakes to avoid a collision with both pedestrians, then two conflicts are recorded. If a pedestrian causes a conflict with two passing vehicles, then two conflicts are recorded. If, however, a pedestrian causes a vehicle to slow down and this action causes a vehicle-vehicle conflict that does not involve the pedestrian, then only one of these conflict types is counted. The remaining types of pedestrian conflicts are counted in the same manner.

Slow or Weave for Running Pedestrian

This conflict occurs when a pedestrian accesses a roadway while running (at right angles to vehicle traffic). This conflict is similar to the PW conflict in other respects. A running pedestrian (PR) conflict may indicate the existence of a similar type of problem situation that a PW conflict indicates, except the degree of severity is increased. This type of conflict is also very general in description and the specific locational deficiency should be further identified by collecting additional site-related data.

Because younger children are more apt to run into a roadway without due caution, PR conflict may occur more often at a school crossing or near playgrounds. These conflicts may be reduced by using crossing guards for elementary-school-age children and by fencing off play areas and, if possible, locating schools and play areas away from major roadways. The conflict may also occur at crossings of very wide roadways or may indicate the lack of gaps in traffic large enough to allow crossing. Countermeasures may include the implementation of pedestrian-actuated signals or pedestrian islands.

Pedestrian Walking or Running in the Roadway with the Flow of Traffic

A conflict of this sort is a result of a vehicle weaving or braking because of a pedestrian walking or running in the roadway or on the shoulder in the direction of vehicle traffic. Such conflicts may indicate the need for sidewalks or wider shoulders to safely accommodate pedestrian traffic.

A with-the-flow-of-traffic (WF) conflict may also occur in areas of on-street parking due to pedestrians accessing parked vehicles. Countermeasures for this problem may include the reduction or the elimination of on-street parking and the widening of parking lanes and shoulders to safely accommodate pedestrians accessing parked vehicles.

Pedestrian Walking or Running in the Road Against the Flow of Traffic

A pedestrian walking or running in the road against the flow of traffic (AF) is similar to the WF conflict with the exception that the pedestrian is walking or running in the road opposing the direction of traffic.

Diagonal Pedestrian Crossing

A diagonal pedestrian crossing (PD) conflict occurs when a pedestrian crosses a road at an angle other than 90° to the flow of traffic. This type of crossing can occur at midblock or an intersection. A PD crossing is a hazardous situation because the pedestrian will be in the roadway for a longer time interval and, if the road is a two-way street, the pedestrian will have his or her back to traffic during a portion of the crossing.

This conflict may occur due to the offset of sidewalks accessing a roadway or due to the location of pedestrian traffic generators that are not directly across the street from each other. This problem may be corrected by using better alignment of sidewalks or by implementing pedestrian barriers.

Pedestrian in Center Lane

This conflict designates the presence of a pedestrian in the center left-hand turn lane or a roadway during the commission of a conflict with a vehicle. This conflict can involve a vehicle in the center lane or the lane adjacent to it. Center lane (CL) conflicts will only be recorded at wide roadways, usually consisting of five lanes or more. This type of conflict will indicate the necessity of additional protection for pedestrians from through and turning traffic. Countermeasures for this problem may include the restriction of vehicle turning movements or pedestrian crossings at the specified location.

Outside Crosswalk

At locations where crosswalks are marked out, it may be desirable to indicate the number of conflicts that occur outside of the crosswalk. Studying outside crosswalk (OC) conflicts may be useful in investigating the effectiveness of crosswalks in reducing the number of pedestrian access points to a roadway and in identifying the effectiveness of the crosswalk as a safety countermeasure for pedestrians. If a considerable number of OC conflicts are observed, it may be desirable to implement countermeasures to channel the pedestrians to the crosswalk. This may be achieved by using pedestrian barriers, repainting the crosswalk, or relocating the crosswalk. If, however, a sizable number of conflicts occur within the crosswalk, it may indicate that the crosswalk is not providing adequate safety to the pedestrians, and additional protective measures may be required. These measures may include additional warning to motorists, lower speeds, additional police enforcement, pedestrian signals, grade separations, and others.

Right-Turning Conflicts

Right-turning (VR) conflicts are the result of a vehicle turning right at an intersection or making a right turn into or out of a driveway. For a more involved analysis, this conflict can be subcategorized into two different types: (a) vehicles turning right from the roadway being observed and (b) vehicles turning right onto the roadway of interest. Countermeasures to reduce this conflict may include the restriction of turning movements, special signal phasing to protect pedestrians crossing, or the location of pedestrian crossing points at alternative locations.

Left-Turning Conflicts

Left-turning (VL) conflicts occur from a vehicle turning left at an intersection or from a vehicle turning left out of or into a driveway. As in VR conflicts, this conflict can also be subcategorized into two separate types: (a) vehicles turning left from the road being observed or (b)

vehicles turning left onto the road being observed. Countermeasures for this conflict may include, but not be limited to, prohibition of left turns, special phasing to protect crossing pedestrian, and grade crossing separations.

Right-Turn-on-Red Conflicts

This conflict occurs when a vehicle initiates a right turn during a red signal phase that conflicts with a crossing pedestrian. The recording of right-turn-on-red (RR) conflicts at signalized intersections is optional, but may yield useful information regarding the safety implications when right-turn-on-red movements are allowed. There may be two types of RR conflicts: (a) right-turn-on-red off of the road under investigation or (b) right-turn-on-red onto the road.

Signal Change

A signal change (SC) conflict occurs only at signalized pedestrian crossings or at signalized intersections. A conflict of this type occurs when a pedestrian crosses a street with the signal and, before the pedestrian completes the crossing, the signal changes to red and a vehicle brakes, weaves, or hesitates to avoid a collision. This type of conflict may be caused by improper signal timing and may be corrected by using pedestrian islands, improved signal timing, or by the installation of WALK-DON'T WALK signals.

Pedestrian Violation

A pedestrian violation (PV) designates a conflict that occurs as a result of pedestrian violation of a traffic signal. A pedestrian violation can be either a pedestrian walking against a traffic signal or a pedestrian starting to cross when the pedestrian signal is flashing a DON'T WALK sign. Recording this type of conflict is optional and may be used to indicate pedestrian compliance with traffic signals.

Vehicle Violation

A vehicle violation (VV) designates a conflict that occurs as a result of a vehicle violation of a traffic control device. The VV can be a failure to stop, failure to yield, running a red light at a traffic signal, or an illegal right turn on red (i.e., where signing prohibits a right turn on red). Recording this type of conflict is optional and may be more appropriate at intersections or signalized locations. It may also be desirable to subclassify these conflicts to identify specific hazardous vehicle actions. Depending on the site and the type of VV observed, these conflicts may be reduced by added enforcement, improving visibility of traffic signs and signals, upgrading traffic control devices, and adding a delayed-red signal phase.

Summary

Thirteen basic pedestrian conflicts were defined in this section. This does not mean that other types of conflicts do not exist. In some situations, additional conflict definitions may be required to describe specific hazardous movements. It may also be desirable to subclassify a conflict type into two or more specific conflicts to properly understand the problems at a given location.

Since there is a major difference between the activities at intersection and nonintersection locations, some of the defined conflicts will not be applicable to all situations. For example, PW, PR, WF, and AF conflicts may be recorded only at midblock locations; conflict types such as VL, VR, SC, RR, and PV can only occur at intersections.

Conflict Severity

An important task in this study was to define conflict severity and to determine methods of measuring conflict severity. As previously mentioned, conflict severity can be measured by observing the actions of the pedestrian or vehicle during the occurrence of a conflict. The following is a list of pedestrian actions that can be used to measure conflict severity. These actions are listed by increasing severity, and the subscript p corresponds to the pedestrian action.

1. Hesitation (H_p)—Pedestrian hesitates momentarily in travel across a street in response to vehicular traffic,
2. Backup movement (B_p)—Pedestrian momentarily reverses direction of travel while in the roadway in response to vehicular traffic,
3. Running movement (R_p)—Pedestrian increases speed to avoid a collision with through traffic while in the roadway (similar to an erratic maneuver),
4. Near-miss accident (N_p)—A collision is imminent, but is avoided just before impact,
5. PDO accident (P),
6. Injury accident (I), and
7. Fatality (F).

Conflict severity can also be evaluated by observing the action of the vehicle involved in the conflict. Six vehicle actions given below are measures of conflict severity, listed in increasing order of severity. The subscript v indicates a vehicle action.

1. Routine conflict (C_v)—When a vehicle brakes or weaves routinely to avoid a collision with a pedestrian,
2. Complete stop or erratic maneuvers (E_v)—When a vehicle comes to a complete stop or swerves erratically to avoid a collision,
3. Near-miss accidents (N_v)—A collision is imminent but is avoided just prior to impact,
4. PDO accident (P)—Property damage only to the vehicle and the pedestrian does not sustain an injury,
5. Injury accident (I), and
6. Fatality accident (F).

The severity of a conflict was determined by observing the actions of the vehicle in this study. This decision was made because it was felt that severity defined by vehicle actions would provide more consistent results and would be easier for the observer to view.

Furthermore, an additional measure of conflict severity was defined, a moving-vehicle action (M). This action occurs when a pedestrian moves across the path of a through or turning vehicle and is approximately 7 m (25 ft) downstream of that moving vehicle but the vehicle takes no evasive action to avoid a collision. The pedestrian is in the moving lanes of traffic when this action occurs. Although the vehicle does not brake or weave in this action, this is still considered a hazardous situation and should be recorded. The hazard is usually indicated by a pedestrian hesitating, backing up, or running to avoid a collision.

Three levels of conflict severity were selected in this conflict procedure to simplify data collection (see Figure 1). The least severe type of conflict (minor conflict) is defined as moving-vehicle conflicts (M) where a hazardous situation exists but no actual weaving or braking takes place. Moderate conflicts are defined as routine

Figure 1. Conflict data form.

1. Observer: _____ Date: _____
2. Location: City - _____
   Street name - _____
   Name of nearest intersecting street - _____
   Distance to nearest intersection - _____
3. Weather conditions: (a) Clear/cloudy (b) Rain (c) Snow/sleet (d) Fog/Mist (e) Other - _____
4. Lighting Conditions: (a) Day light (b) Dawn/Dusk (c)Dark
5. Roadway Condition: (a) Dry (b) Wet (c) Snow/Ice/Mud (d) Other - _____
6. Type of Roadway: (a) One-way (b) Two-way (c) Divided (d) Other - _____
7. Posted speed: _____
8. Environment: (a) Residential area (b) Commercial area (c) Industrial area (d) Rural/Undeveloped area (e) School - Elementary - Secondary - Universities/Colleges (f) Other _____
9. Draw a condition diagram of the study area and indicate the following items on the sketch:
   - Number of lanes and width of roadway
   - Distance to nearest intersection
   - Medians
   - Driveways or other access points
   - Locations of on-street parking zones and shoulder parking
   - Other sight obstructions
   - Indicate Northerly direction
   - Established crosswalks
   - Predominate pedestrian crossing points
   - Locations and types of traffic control devices (signs, signals)
   - Other necessary details (i.e. Sidewalk locations, etc.)

Starting Time	Severity	PW	PR	WF	AF	PD	CL	VR	VL	RR	SC	PV	VV	OC	__	__
	Minor															
	Moderate															
	Severe															
	Minor															
	Moderate															
	Severe															
	Minor															
	Moderate															
	Severe															
	Minor															
	Moderate															
	Severe															

VEHICLE AND PEDESTRIAN VOLUMES

	Direction of Travel	Counting Periods			
Vehicle Traffic					
Pedestrian Traffic					

conflicts (C_v) and complete-stop or erratic-maneuver (E_v) conflicts. Therefore, a moderate conflict is when a braking or weaving action is taken by a vehicle to avoid a collision with a pedestrian. The third level of conflict severity is a severe conflict, which is defined as a near-miss accident (N_v). If an observer witnesses a collision (PDO, injury, or fatality accident), it will be recorded and described separately on the data form.

DATA COLLECTION PROCEDURE

Conflict studies can be conducted at intersections or at midblock locations, such as school crossings and midblock crossings in the central business district (CBD) or shopping areas and other sites where a hazardous pedestrian problem may exist. The selection of the survey mechanism and sampling procedure for this conflict technique is described below.

The Survey Team

The survey team consists of two individuals in a single vehicle or on foot along the roadway, at a spot that is inconspicuous, offers clear observation of all pedestrian and vehicle movements, does not disrupt vehicular flow, and does not endanger the safety of the observers. The two must observe the same section of roadway or intersection approach leg at the same time. One individual will be responsible for recording conflicts data while the other is responsible for recording pedestrian and vehicular volumes. The survey team should observe at a distance of 45-90 m (150-300 ft) from the intersection, crosswalk, or point of interest. The observation position should be recorded on the layout sketch and included with the data. Efforts should be made to use the same observation positions in before and after studies.

Survey Day and Times

Pedestrian conflicts should be counted on a Tuesday, Wednesday, or Thursday for locations where pedestrian and vehicle volumes are constant from day to day. However, at locations where pedestrian volumes vary greatly from one day to the next (i.e., near stadiums and churches), the conflict study should be performed when the problems are most prevalent. Data should be collected for an interval of 2-4 h. The survey may be extended to a longer period of time if the conditions warrant it, such as where insufficient data are available. Where sufficient accident data are available, the survey should be performed when the accident data indicate high hazard time interval. At other locations, the study may be performed when the engineer perceives a problem will exist or when traffic and pedestrian volumes are highest. However, to achieve a full understanding of the potential safety problems at a location, data should be collected during both the peak and off-peak periods.

Sampling Procedure

The sampling procedure of the General Motors Research (GMR) Traffic Conflicts Technique (7) is recommended. This is the procedure whereby 15-min samples are taken by the survey team for each intersection leg of the roadway under investigation (for intersection locations) or upstream and downstream of the crosswalk or predominant pedestrian crossing point (for midblock locations). At intersection locations, only two intersection approach legs are assigned to a survey team. For example, if the north-south leg of an intersection is the survey assignment, the data on the northbound leg would be counted for exactly 15 min. The survey team would then move to the southbound approach, where an additional 15 min of

data would be collected. This would continue throughout the survey period.

Conflicts Data Form

A data form has been prepared to collect pedestrian conflicts, as shown in Figure 1. This form is designed to assist the observer in recording all of the important operational features of the roadway and the vehicle and pedestrian movements. The data form is divided into four major sections. The first section is designed to identify the conditions that exist at the location under investigation. This information is recorded prior to the study and includes the following: (a) names of the observers, (b) date and location of survey, (c) weather and visibility conditions, (d) classification of roadway, and (e) type of area where the survey is taking place.

In the second section of the data sheet, the observer is provided a space to draw a sketch of the study location, including locations of pedestrian movements, crosswalks, traffic control devices, on-street parking, sight obstructions, and location of the observer. A list of information that may be desirable to record is noted on the data sheet. This information is used with the data from the first section to assist in identifying hazardous roadway features and developing appropriate countermeasures.

The third section of the data form, located on the second page, is where the conflict data are recorded. The starting time of the survey period will be indicated in the first column. Space is provided to record data for four survey periods or one hour. If the survey period is longer than one hour, additional data forms are to be completed and attached to the first form. Conflicts are to be recorded by type and severity. Thirteen types of conflicts are listed at the top of this section and space is provided for two additional types of conflicts. The types of conflicts to be recorded are up to the discretion of the observer. Conflicts are to be recorded by one member of the survey team during the survey period.

The fourth section of the data form is to record pedestrian and vehicle volumes. This section is located on the bottom of the second page of the data form. Pedestrian and traffic volumes are recorded by the second member of the survey team on a counting board (or a separate piece of paper) and are tabulated on the data sheet after each counting period (15 min). The vehicle and traffic volumes are to be recorded by direction when practical. Volume data may be used to indicate conflict rates and will assist in fully describing the operational features of the study location.

Training should be provided to the survey team regarding the proper methods of filling in the data form and recording of conflict data. The observers will also need instruction on distinguishing conflict types and identifying conflict severity. A goal to achieve in the training process is observer reliability or the consistency of results between different observers.

Data Collection and Analysis

To investigate the feasibility, applicability, and effectiveness of this conflict technique, conflict studies were performed at five pedestrian crossing locations in which a total of 25 h of data were collected. Three of the survey locations were on the campus of Wayne State University, one was in the cultural center of Detroit, Michigan, and the fifth location was in the Detroit CBD.

Pedestrian Crosswalk at Anthony Wayne Drive

The pedestrian crosswalk investigated at Anthony Wayne Drive is a major crossing point between the parking structure for Wayne State University and the main campus (Figure 2). The crosswalk is located midblock and is designated by pavement markings, overhead flashing warning lights, and advance warning signs. Anthony Wayne Drive is a divided roadway that has four lanes in each direction and a 13-m (20-ft) median. The posted speed is 40 km/h (25 mph), but a sizable portion of motorists exceed the posted speed.

Five hours of data, which included both peak and off-peak periods, was collected at this location. The average pedestrian crossings during the survey period was 300 persons/h and the vehicle traffic was 1150 vehicles/h. An average of 306 conflicts/h were recorded, 77 percent of which were minor (not involving braking or weaving by the vehicle); 23 percent were moderate conflicts; and one near-miss accident occurred. The near-miss accident involved a pedestrian who, while in the middle of the street, stopped to talk to another person at the curb and was almost struck by a speeding vehicle. Although the average pedestrian conflict rate was higher than the average number of crossing pedestrians per hour, this does not mean that every pedestrian was involved in a conflict. On many occasions a single pedestrian was involved in more than one conflict with passing motorists. Conflicts were classified to indicate whether or not they occurred within the crosswalk. The results showed that 59 percent of the conflicts occurred to pedestrians while in the crosswalk and 31 percent occurred outside the crosswalk. Furthermore, 24 percent of the conflicts that occurred within the crosswalk were moderate, but only 20 percent of the conflicts occurring outside of the crosswalk were moderate.

The data collected show that the crosswalk may give the pedestrian a false sense of security, and further precautions should be implemented to reduce vehicle speeds to the posted limit. A reduction in the volume of vehicle traffic on Anthony Wayne Drive is also suggested to improve pedestrian safety. An extensive amount of data is needed from hundreds of other locations to reach a firm conclusion on the level of safety. Therefore, a firm conclusion cannot be made regarding the location until additional data are collected.

Antoinette Avenue at Cass Avenue

The second crossing investigated was at Antoinette Avenue at the intersection of Cass Avenue in Detroit. Antoinette runs east and west and separates the administration building and computer service center of Wayne State University from the main compus and parking structures (Figure 3). There is a small parking lot on the southeast corner of the intersection opposite the administration building, which is a popular crossing location. The intersection is signalized but does not include special phasing for pedestrians (i.e., WALK-DON'T WALK signs).

Five hours of data were collected to investigate the hazards to pedestrians crossing Antoinette. During this period, crossing pedestrian traffic averaged 200 persons/h. Traffic data also indicated that a high percentage of vehicles turn at this location. An average of 77 conflicts/h were recorded, of which 35 percent were moderate and 65 percent were minor. No severe conflicts were recorded. Approximately 34 percent of the conflicts involved turning vehicles, 10 percent were caused by signal changes during crossings, and 17 percent of

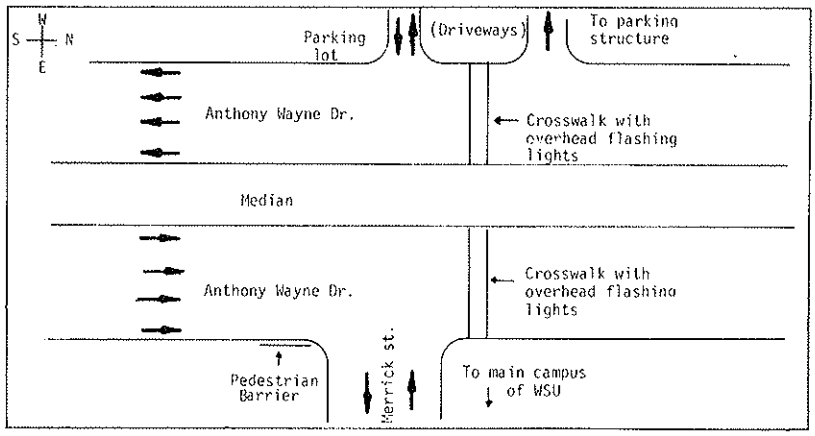


Figure 2. Pedestrian crosswalk at Anthony Wayne Drive.

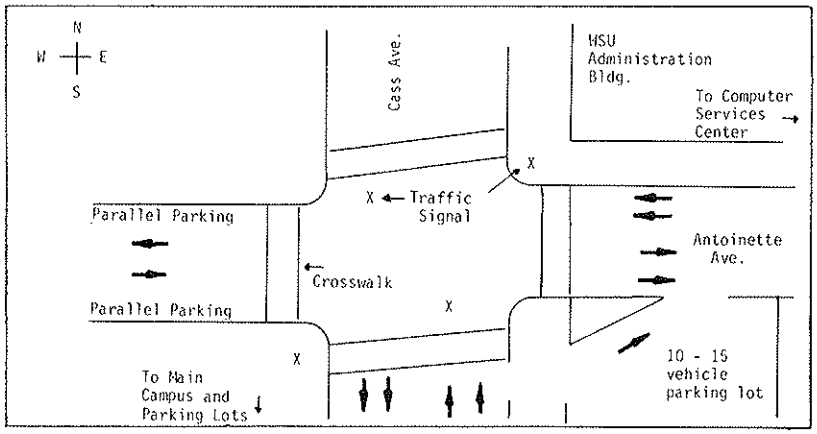


Figure 3. Antoinette Avenue at Cass Avenue.

the conflicts occurred when pedestrians crossed against the signal. An additional 39 percent of the conflicts occurred east of the intersection from pedestrians crossing from the small parking lot to the administration building.

Since many of the conflicts occurred during vehicle turning movements, a countermeasure to reduce some of the turning movements may lead to increased safety. One possible measure will be making Antoinette Avenue a one-way street (westbound) from Woodward Avenue to Cass Avenue. Other studies, such as an analysis of traffic flow patterns in the area, will be needed to analyze the feasibility of restricting turning movements. Another problem was caused by the traffic signal changing during pedestrian crossings. This problem may be corrected by installing WALK-DON'T WALK pedestrian signals at the intersection. An additional improvement at the location may be to prohibit pedestrians from crossing east of the intersection (from the small parking lot) and channel all the crossing pedestrian traffic to the intersection. This may be accomplished by installing a pedestrian barrier. If a countermeasure is employed, a careful investigation must be conducted to study what new problems, if any, will occur. This may be accomplished by comparing before-and-after conflict data to investigate the countermeasure's impact on the number and severity of conflicts.

Cass Avenue at Antoinette Avenue

To complete the investigation at the intersection of Cass and Antoinette, conflict data were collected for pedestrians crossing Cass Avenue (Figure 3). Approximately 85 pedestrians/h made this crossing, usually on the way to the administration building.

An average of 72 conflicts/h were recorded, of which 53 percent were minor and the remaining 41 percent were moderate in severity. Analysis of the data showed that 74 percent of the conflicts involved turning vehicles, 14 percent occurred during signal changes, and 11 percent of the conflicts were the result of traffic signal violations by pedestrians.

The major problem at this location is the high number of turning vehicles conflicting with crossing pedestrians. Therefore, a restriction to reduce turning movements may be required. The installation of pedestrian signals to reduce signal-change conflicts is also recommended.

Woodward Avenue at Putnam Avenue and Farnsworth Avenue

The fourth pedestrian crossing investigated was located on Woodward Avenue in the cultural center of Detroit (Figure 4). This site is at a signalized intersection that has pedestrian phasing. The Detroit Public Library and the School Center Building are located on the west side of Woodward Avenue, and the Detroit Institute of Arts, Engineering Society of Detroit, and the Detroit Science Center are located on the east side of Woodward Avenue. Woodward Avenue has three through lanes in each direction, one center lane for left turns, and a lane for parallel parking on each side of the street.

Five hours of data were collected during which an average of 210 pedestrian crossings/h occurred. An average of 66 conflicts/h were recorded, of which 57 percent were minor and the remaining 43 percent were moderate. Vehicle turning movements accounted for 88 percent of the conflicts and pedestrians crossing against

Figure 4. Woodward Avenue at Putnam and Farnsworth Avenues.

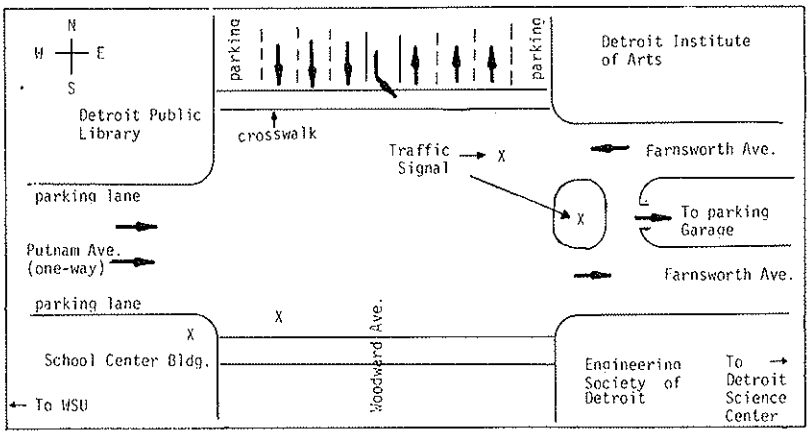
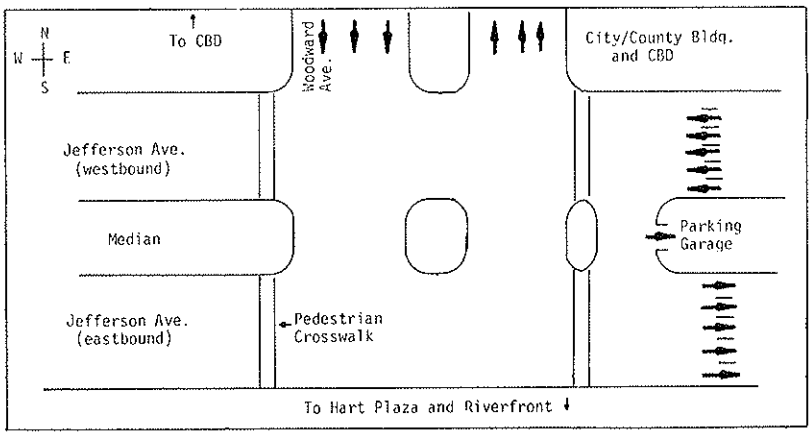


Figure 5. Jefferson at Woodward Avenue.



the signal were responsible for an additional 10 percent of the conflicts. Although Woodward Avenue is approximately 33 m (110 ft) wide, there were only five conflicts caused by signal changes during crossings.

Analysis of the data indicated that the major problem encountered at this location involved vehicle turning movements, especially left turns onto Woodward Avenue conflicting with crossing pedestrians. However, because of the nature of the traffic patterns in the area, turning restrictions are not recommended. A possible safety improvement may include providing protected left-turning phases so that left-turning vehicles will not have to be concerned with through traffic, thus allowing more attention to be given to crossing pedestrians.

Jefferson Avenue at Woodward Avenue

The fifth pedestrian crossing studied was on Jefferson Avenue in Detroit (Figure 5). Jefferson Avenue is divided by a 10-m (30-ft) median and has five eastbound lanes and six westbound lanes. The CBD of Detroit is located north of Jefferson Avenue, and the Hart Plaza, a riverfront park, is located south of Jefferson.

The study at this location was performed on a Wednesday, during the morning and noon hours. The average vehicle traffic on Jefferson was 1760 vehicles/h and 1437 persons/h crossed Jefferson Avenue during the study. An average of 375 conflicts/h were recorded—60 percent were minor conflicts, 40 percent were moderate, and two near-miss accidents occurred. Both near-miss accidents involved pedestrians who crossed against the light and weaved through the heavy traffic on Jefferson. Vehicle turning movements from Woodward Avenue onto Jefferson Avenue accounted for 56 percent of the conflicts and left-turning movements accounted for an additional 10 percent of the conflicts. Pedestrians caught crossing when the signal changed accounted for 14 percent of the recorded conflicts.

Because of the high vehicle and pedestrian volumes at the intersection and the width of Jefferson Avenue, a grade separation between vehicles and pedestrians may be desirable. This countermeasure may be undesirable, however, because of the cost involved. Since 56 percent of the conflicts involved right-turning movements from Woodward Avenue onto Jefferson Avenue, another countermeasure would be to prohibit crossings on Jefferson Avenue west of the intersection, thus eliminating many of the conflicts that occurred.

CONCLUSIONS AND RECOMMENDATIONS

Conflict values can be used to rank priority locations based on hazard. Conflict information, along with other data from the site, can be used to identify which countermeasure should be selected. Most importantly, safety deficiencies can be identified when accident data are not available.

The result of the five study locations shows that the conflicts technique presented in this paper can be helpful in indicating safety deficiencies at the pedestrian crossings. This technique was not difficult to use and was applicable to each location investigated. However, further testing is required at additional and more diverse types of pedestrian crossings to determine the full effectiveness of this conflict technique.

This conflict technique may be useful in indicating

the relative hazardousness of a pedestrian crossing by a measure such as conflict rate. If this is desired, then a comparison of data from many other locations is required to produce a measure of hazardousness to pedestrians. Once this is accomplished, a few hours of data collection at a site may produce important information on the relative hazardousness of a crossing, as well as safety deficiencies.

Further investigation is needed to determine the amount of data collection required at a site to provide reliable results. Studies are also recommended to investigate the repeatability of results from one day to the next, and comparisons of results from similar locations are desired to further investigate reliability of this technique.

During this study, it was assumed that pedestrian conflicts are a measure of vehicle-pedestrian accident potential. It was not within the scope of this study to determine the exact relationship that exists between conflicts and accidents. However, this relationship should be investigated; this can be accomplished by comparing pedestrian accident histories with conflict data collected at various locations. Investigations can also be conducted to determine which types of pedestrian conflicts are more hazardous. The results of these studies will assist in providing more concise information from this conflict technique regarding hazards to pedestrians at roadway crossings.

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Causal Factors of Non-Motor-Vehicle-Related Bicycle Accidents

Patricia L. Wheatley and Kenneth D. Cross

The Santa Barbara County Bicycle Safety Project was created in September 1977 and funded through September 1979. The primary area of development in this project involved research into the causal factors of non-motor-vehicle-related bicycle accidents. Many types of accidents fall into this category—bicycles hitting other bicycles, pedestrians, or fixed objects. In addition, bicyclists lose control of their bicycles and fall for many reasons. Although considerable emphasis has been given to bicycle-motor vehicle accidents in the last few years, relatively little attention has been given to the non-motor-vehicle-related bicycle accident. The purpose of the project research has been to provide comprehensive material on the nature and cause of non-motor-vehicle-related bicycle accidents in Santa Barbara County. In addition, the project performed a study on the nature and cause of bicycle-related accidents on separated off-road bicycle facilities in the county. To provide proper perspective on this information, a survey was first taken of the general population of bicyclists in the county.

The Santa Barbara County Bicycle Safety Project was created in September 1977, funded by the California Office of Traffic Safety to the University of California at Santa Barbara. The funding for this project continued through September 1979.

A major emphasis of the Santa Barbara County Bicycle Safety Project, and the topic of this report, was research into the causal factors of non-motor-vehicle-related bicycle accidents. Many accidents fall into this category. For the purposes of this report, all bicycle-related accidents that do not involve a motor vehicle will be referred to as non-motor-vehicle (NMV) accidents.

Bicycle-motor vehicle accident research has received considerable attention over the last few years. On the average, accidents that involve a motor vehicle result in more severe injuries than do NMV accidents. In addition, the study on NMV accidents is difficult because such accidents are rarely reported to any record-keeping agency. In spite of this scarcity of information, it is generally recognized that NMV accidents occur with far greater frequency than do bicycle-motor vehicle accidents. For this reason, the study of NMV