U.S. Department of Transportation

Federal Highway Administration

TRAFFIC CONFLICT TECHNIQUES FOR SAFETY AND OPERATIONS

Engineer's Guide

Report No. FHWA-IP-88-026

June 1988

FOREWORD

This Engineer's Guide provides traffic and safety engineers with the basic background information and standard procedures needed to incorporate traffic conflict studies into daily routine practice. The guide contains step-by-step instructions for using traffic conflicts to analyze safety and operational problems at intersections. Included are guidelines for training observers, conducting the survey, analyzing conflict data, and interpreting the results to make decisions and recommendations. Each procedure is supplemented with illustrative examples.

The traffic conflict techniques described in this guide were primarily developed for signalized and unsignalized intersections. Traffic conflict studies can be used to identify abnormal conflict situations, diagnose specific unsafe conditions, select corrective treatments, and evaluate the effectiveness of countermeasures without having to wait a long time for additional accidents to occur. Also, a traffic conflict study will often reveal problems that otherwise may go undetected in a conventional accident-based and/or operational analysis.

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Office of Implementation

NOTICE

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16. Abstract

This guide provides basic background information and standard procedures for using traffic conflicts to analyze safety and operational problems at signalized and unsignalized intersections. The guide was prepared for engineers and supervisors who have the responsibility for analyzing conflict data and using the results to make decisions and recommendations for improvements.

Based on previous research and experiences, the procedures described in this guide provide a standard, cost-effective method for using traffic conflicts to diagnose safety and operational problems at intersections. The guide contains definitions with illustrations and examples of conflict types, step-by-step procedures for conducting a conflict study, methods for analyzing and interpreting the data, and guidelines for using conflict data to select countermeasures.

Because the reliability of conflict data is dependent upon the ability of the observers to record conflicts accurately, a section of the guide is devoted to training data collectors. Also available, as a training aid and reference source, is an observer's manual (FHWA-IP-88-027).

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
	AREA			
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha
	MASS (weight)			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	VOLUME			
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

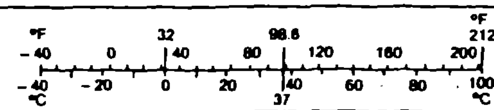
NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
	AREA			
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac
	MASS (weight)			
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
	VOLUME			
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

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ENGINEER'S GUIDE

CHAPTER 1 - INTRODUCTION

A traffic conflict is a traffic event involving the interaction of two or more road users, usually motor vehicles, where one or both drivers take evasive action such as braking or weaving to avoid a collision. Traffic conflicts are potential accident situations. Definitions for specific conflict types have been developed based on their corresponding accident types for intersections. For example, a left-turn traffic conflict situation is shown in figure 1. In this case, vehicle 1 has made a left turn placing vehicle 2 in danger of a head-on or broadside collision. The driver in vehicle 2 has reacted by braking to avoid a collision, which is a traffic conflict. If the driver had failed to take evasive action, took the wrong action, or acted too late, the resulting collision would have been a left-turn related accident. In a similar manner, other conflict situations have been defined for other accident patterns; i.e., rear-end, angle, sideswipe.

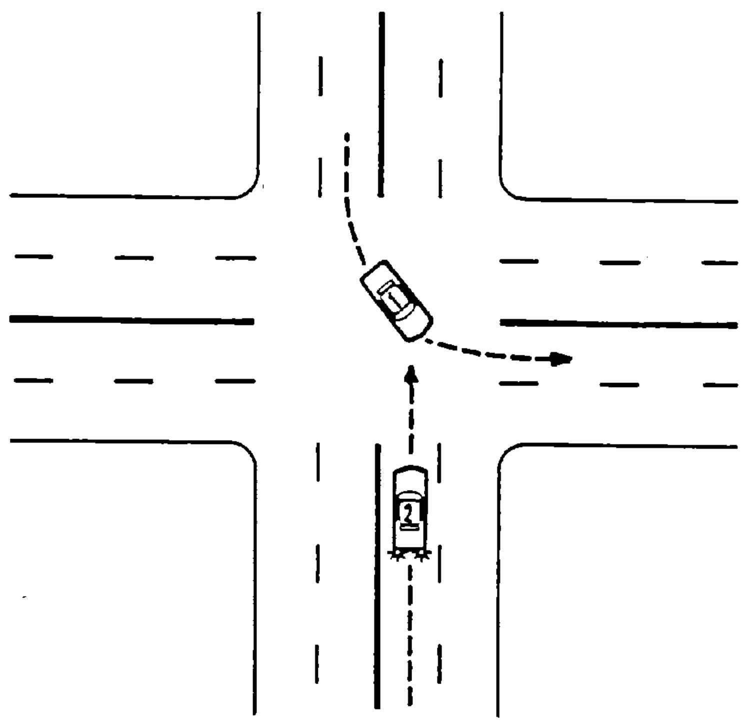


Figure 1. Opposing left-turn traffic conflict.

After years of extensive research, reliable, cost-effective procedures have been developed for conducting traffic conflict studies at intersections. Relationships between some traffic conflict types and their corresponding accident types have been established and validated. Also, abnormally high conflict values have been developed so traffic engineers can determine if conflicts observed at a study location are indicative of a safety problem that warrants corrective action. The major research efforts have now been completed and the results have been synthesized in this guide for widespread implementation by highway agencies.

This guide provides traffic engineers with the basic background information and procedures needed to incorporate traffic conflict studies into daily routine practice. The guide contains step-by-step instructions for performing an analysis of safety and operational problems using traffic conflicts. Included are guidelines for training observers, conducting the survey, analyzing conflict data, and interpreting the results to make decisions and recommendations. Each procedure is supplemented with illustrative examples. In addition to this guide an observer's manual is available for persons who have the responsibility of collecting the field data.[1]

The traffic conflict techniques described in this guide were primarily developed for signalized and unsignalized intersections. As the need for other applications are identified by engineers, it is anticipated that standardized procedures will be developed for other roadway situations such as freeway entrance and exit points, weaving areas, and constructions zones.

Background

An analysis of reported accidents has conventionally been the primary method of measuring highway safety. There are numerous problems and limitations with using accident reports for safety analysis as outlined below.

- Accident files contain records of reported accidents only, which are only a fraction of the accidents that actually occur.

- Due to manpower and budget limitations in recent years, there is a growing trend nationwide by police agencies not to report property damage only accidents. For example, in 1982 in Maryland reduced accident reporting resulted in a loss of 40 percent of the total number of accidents previously reported.[2]

- Accident records often contain incomplete, inaccurate, or biased information. Errors in locating accidents, changes in report forms, and the subjective information provided by crash victims or judgments made by police officers pose formidable problems.

- At most locations accidents occur infrequently and sporadically, so a long time period is needed (usually 3 years or more) to collect enough accident data to conduct a useful diagnostic analysis.

- Because they are based on the history of system failures, accident records often fail to identify specific safety problems and probable causal factors.

- Effectiveness evaluations, based on accident data, require a long time (6 years or more) to determine if a treatment was effective.

- Often the effect of many minor treatments (such as changes in signal timing, signing, etc.) cannot be determined by an accident analysis as the accident information reported does not reflect a causal factor related to the treatment.

For these reasons, other traffic indicators or measures are desirable.

Evolution of the Traffic Conflict Technique

For many years traffic engineers have made observations of traffic movements at hazardous locations in an effort to identify what operational and roadway characteristics were contributing to the safety problem. Traffic events such as near misses, drivers hitting their brakes, and swerving to avoid a rear-end collision were often noted and sometimes documented. In a sense, anyone who has made these observations has conducted a traffic conflict study.

The problem, however, with simple observation without the use of objective criteria or predefined measures is that the human mind cannot always sort, categorize, measure and count what is seen with the eye. The solution is to predefine observations which have been tested for repeatability (variation in the counts at the same site under identical conditions), and reliability (variation between different observers recording the same event).

In 1967, two researchers with the General Motors Research Laboratories developed a set of formal definitions and procedures for observing traffic conflicts at intersections.[3] The researchers identified traffic conflict patterns for over 20 corresponding accident patterns. The procedure became known as the Traffic Conflict Technique. Because each traffic conflict was based on a related accident type, the technique was considered to be a measure of accident potential.

Conflicts were defined as the occurrence of evasive vehicular actions and were recognized by braking and/or weaving maneuvers. Conflicts were only recorded if both the offending and offended vehicle could be seen to be on a collision course, thus, normal braking for traffic control devices or other roadway conditions are not counted as conflicts.

Publication of the General Motors paper produced considerable interest in the technique and a flurry of research activities in the United States and abroad. Much of the work was focused on developing accident and conflict correlations and refining the procedure to identify potential hazards and operational deficiencies. Most of the efforts produced little success due to a number of factors including inadequate training of observers, improper research technique, and small sample sizes.

In 1979 additional extensive field testing was conducted to develop standard definitions and refine the data collection procedure to ensure that trained observers could provide accurate results.[4] The definitions and procedures presented in this guide were taken from that research study.

Another major study, completed in 1985, provided proof that relationships exist between some conflict types and their corresponding accident types at intersections.[5] The researchers found that traffic conflicts are good surrogates for accidents (for the conflict accident types that were validated) in that they produce estimates of average accident rates just as precise as those produced from historical accident records. This finding means that traffic conflicts can be used as a substitute for accident data.

The research also produced average and abnormally high daily conflict values by type of traffic conflict for intersections. The daily conflict counts, as well as the procedures for using them to identify problems at any given study site, are included in this guide.

With the developmental work complete, no new research on traffic conflicts is being conducted or is needed. Accident/conflict ratios and abnormal conflict values have not been established for every possible intersection and traffic volume configuration. The procedure for establishing abnormal values for other situations is simple and is included in this guide. As more highway agencies conduct conflict studies using the standard procedures described herein, conflict and accident data can be pooled so that larger validation and more widely applicable accident prediction values can be obtained. While these future enhancements are desirable, they do not inhibit an agency from immediately implementing the conflict techniques to obtain numerous benefits that are not possible with conventional-based analysis.

Benefits of Using Traffic Conflicts For Safety and Operational Analyses

As outlined below, there are numerous advantages and benefits to conducting traffic conflict studies.

- Unlike accident data which take a long time to accumulate in sufficient numbers for analysis, traffic conflicts are readily observable events which occur frequently and can be accurately and reliably obtained in a short time by trained observers.

- Conflict definitions are based on accident types and research has shown that conflicts are good surrogates for accidents.

- Safety studies, using traffic conflicts, can be made with or without the use of accident data.

- When safety problems are reported, such as a severe accident or rash of accidents, the engineer can respond immediately with a traffic conflict study to determine if a problem exists and to identify the problem without having to wait for other accidents to occur.

- Conflict studies are extremely useful in diagnosing specific safety and operational problems at any intersection and assist in identifying alternative treatments. Often a traffic conflict study will reveal problems that otherwise would go undetected in a conventional accident and/or operational analysis.

- The effectiveness of minor and major roadway treatments can be evaluated with a traffic conflict study immediately after the change is made, and additional corrective action taken if the treatment is unsuccessful.

As clearly demonstrated by the research, conflict studies do require a modest (1- to 2-week) training program which can be conducted by the engineer. Training procedures are incorporated in this guide. As an additional training aid and reference source, a separate publication has been developed for observers.[1]

CHAPTER 2 – TRAFFIC CONFLICT STUDY

Purpose

The Traffic Conflict Technique is an excellent tool for studying locations that have been singled out for review because of their accident histories. Also, it is applicable for locations where safety and operational problems have been reported through complaints; i.e., citizen, police, and politician, but accident data are not available or are insufficient for analysis. Traffic conflict studies are conducted at problem locations for the following reasons:

- Scope of the Problem - What is the magnitude of the safety and operational problem compared to other similar locations?

- Problem Diagnosis - What roadway and/or operational characteristics contribute to or are probable causes of the problem? Also, what alternative treatments should be considered to correct the problem?

- Effectiveness Evaluation - Was the treatment effective in eliminating or reducing the problem?

Method

A traffic conflict study is usually conducted under the direction of a traffic engineer who determines that the study is needed, schedules the field survey, supervises data collection, and performs or supervises the analysis. The engineer also interprets the findings and makes decisions and recommendations concerning intersection improvements. Field observations of conflicts are normally the function of traffic and/or planning personnel.

The field survey usually takes from several hours to several days of careful observation of traffic interactions at an intersection. Specific procedures are used to assure uniform data collection so that valid comparisons and judgments can be made. A survey requires one or more observers, who follow a set schedule and perform a number of separate but related tasks. These tasks include recording dimensions and other details about the intersection such as the type of traffic control devices in place. The observer is also required to make judgments about the traffic flow problems and their causes, and most importantly, to observe and record traffic events.

Typically, during the survey, the observer obtains samples of conflicts for specified time periods by alternating his position between opposite approaches as shown in figure 2.

No sophisticated equipment is needed to make a conflict survey. In the past some agencies have used motion picture or video equipment to record conflict data, however, to improve accuracy and reduce data collection costs, manual observations of conflicts in the field are recommended.

Getting Started

For agencies that have not conducted traffic conflict studies, there are two essential requirements for initiating a program. The first requirement is for the engineers to become familiar with the procedures presented in this guide. The second requirement is to train observers. After completing these two steps, conflict studies become a routine safety and operational tool.

This guide was written to assist the engineer in understanding the basic steps needed to conduct, analyze, and interpret conflict data and to outline the program needed to properly train observers.

To get started, chapter 3 provides detailed definitions of the types of traffic conflicts that are observed and recorded in a conflict survey. Also, suggestions are given for observing other potential accident events under certain conditions.

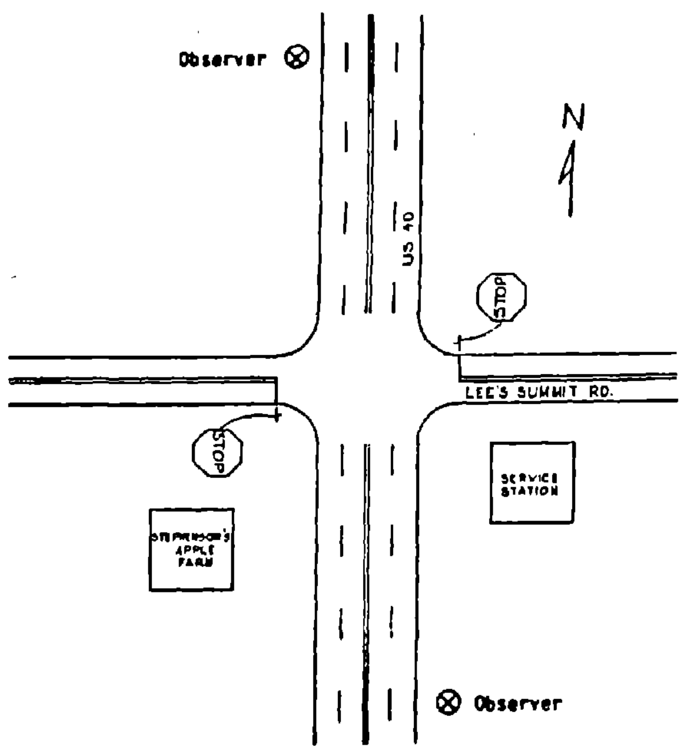


Figure 2. Typical intersection diagram showing observer positions.

Once the basic concept of a traffic conflict is understood, it is time to begin training observers. Chapter 4 is devoted to training, including examples that will assist observers in clearly differentiating between conflicts and other traffic events.

Following observer training and subsequent practice sessions, it is time to conduct a conflict study. Chapter 5 provides the engineer with guidelines to determine when to conduct a conflict study, and where, what, and how much data should be collected.

In chapter 6, the process for summarizing and analyzing the raw data is presented. Chapter 7 of the guide provides methods for determining the magnitude of the problem and how to use conflict counts to pinpoint probable causal factors, and how to select alternative treatments. Also, the process for conducting effectiveness evaluations using traffic conflicts is outlined.

In chapter 8, the method for using conflicts to predict certain types of accidents is illustrated. Guidelines for establishing project priorities using nonaccident-based analyses are included in chapter 9.

The appendix material contains data forms and other information useful in conducting traffic conflict studies.

CHAPTER 3 - TRAFFIC CONFLICT DEFINITIONS

In this section the general concept of a traffic conflict is discussed followed by the definitions of specific types of conflicts for intersections.

General Definition

> A traffic conflict is an event involving two or more road users, in which the action of one user causes the other user to make an evasive maneuver to avoid a collision.

Generally, the road users are motorists, but the definition also includes pedestrians and cyclists. The action of the first user includes a variety of maneuvers such as turning left across the path of a through vehicle just as the through vehicle is entering the intersection area; turning from the cross street into the path of a through vehicle; and slowing to turn at the cross street placing a following vehicle in danger of a rear-end collision. The general definition, however, does rule out actions that nearly all drivers take under the same conditions such as normal stopping for a STOP sign or red traffic signal.

Conflicts are vehicle interactions which can lead to accidents. For a conflict to occur, the road users must be on a collision course; i.e., the users must be attempting to occupy the same space at the same time. The primary requirement of a traffic conflict is that the action of the first user places the other user on a collision path unless evasive action is taken by the other user to avoid the accident. Sometimes the other user is either unaware of the collision potential or has poor judgment in estimating time intervals and clearances and does not make an evasive maneuver. Collisions and near miss situations that occur without evasive maneuvers, or when the evasive action is inadequate or inappropriate for conditions, are also recorded as conflicts under the general definition.

An intersection traffic conflict is described as an event involving the following stages.

Stage 1. The first vehicle makes a maneuver; e.g., pulling out from the cross street.

Stage 2. A second vehicle is placed in danger of a collision.

Stage 3. The driver of the second vehicle reacts by braking or swerving.

Stage 4. The second vehicle then continues to proceed through the intersection area.

The last stage is necessary to convince the observer that the second vehicle was actually responding to the maneuver of the first vehicle and not, for example, to a traffic control device or nearby driveway or median opening.

The evasive maneuver taken by the second vehicle is evidenced by obvious braking or swerving. Braking is usually observed as brake-light indications, however, some vehicles are driven with inoperative brake lights. A noticeable diving of the vehicle or squealing of tires in the absence of brake lights is acceptable evidence of an evasive maneuver.

Operational Definitions

Within this general framework, a basic set of conflict definitions were developed for intersections, corresponding to the different types of maneuvers and related accident patterns. Similar to the manner in which accidents are grouped by type of collision, traffic conflicts are categorized by type of maneuver. The primary types of intersection conflicts are:

- Same direction.
- Opposing left turn.
- Cross traffic.
- Right-turn-on-red.
- Pedestrian.
- Secondary.

Overall, 14 basic intersection conflict situations are useful in pinpointing safety and operational problems, and several other events may be important in special situations. The conflict definitions are presented in the following paragraphs along with figures illustrating the event.

To view conflicts, an observer is stationed on one intersection approach for a specified time period. All conflicts observed from that vantage point are recorded. Conflicts that occur on the other approaches are recorded by other persons or during different time periods when one observer is used. The conflict definitions were developed to give the observer a clear view of the evasive action; i.e., braking or swerving, taken by the second road user. While the observer can see the action taken by the first road user, the primary focus is on the reaction of the driver in the second vehicle. To aid in learning the various conflict patterns, the position of the observer is marked on each of the following conflict diagrams.

Same-Direction Conflicts

A same-direction conflict occurs when the first vehicle slows and/or changes direction and places the following vehicle in danger of a rear-end collision. The second vehicle brakes or swerves to avoid the collision, then continues to proceed through the intersection area. The four basic types of same-direction conflicts are described below. It should be noted, however, that all secondary conflicts (described later in a separate category) are also same-direction conflicts.

Left-turn, Same-Direction Conflict

A left-turn, same-direction conflict occurs when the first vehicle slows to make a left turn, thus placing a second, following vehicle in danger of a rear-end collision (see figure 3).

Right-Turn, Same-Direction Conflict

A right-turn, same-direction conflict occurs when the first vehicle slows to make a right turn, thus placing a second, following vehicle in danger of a rear-end collision (see figure 4).

Slow-Vehicle, Same-Direction Conflict

A slow-vehicle, same-direction conflict occurs when the first vehicle slows while approaching or passing through the intersection, placing a second, following vehicle in danger of a rear-end collision (see figure 5).

The reason the driver of the first vehicle slows down may not be evident, but it could simply be a precautionary action, or a result of congestion or some other cause beyond the intersection. When the cause of the slow-vehicle conflict is seen by the observer, it should be noted on the conflict form.

Lane-Change Conflict

As shown in figure 6, a lane-change conflict occurs when the first vehicle changes from one lane to another, thus placing a second, following

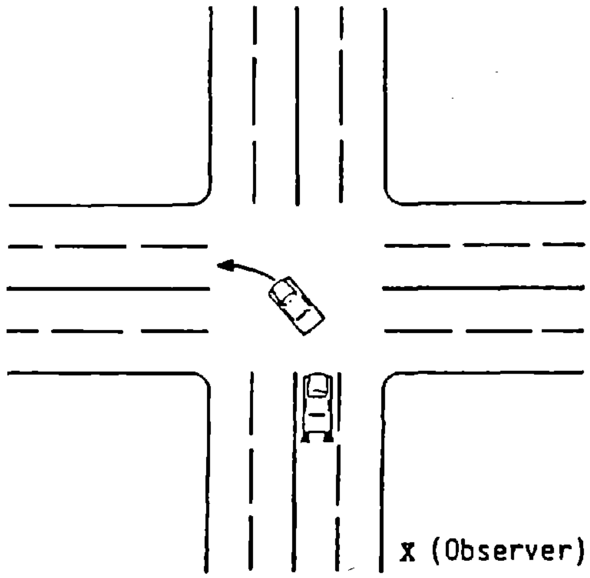


Figure 3. Left-turn, same-direction conflict.

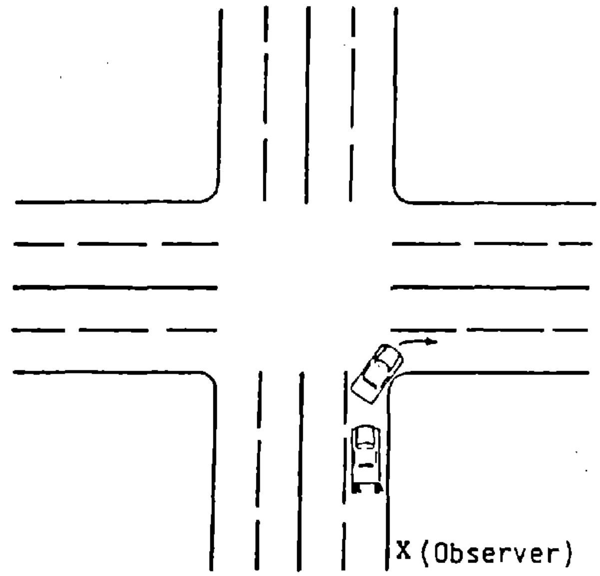


Figure 4. Right-turn, same-direction conflict.

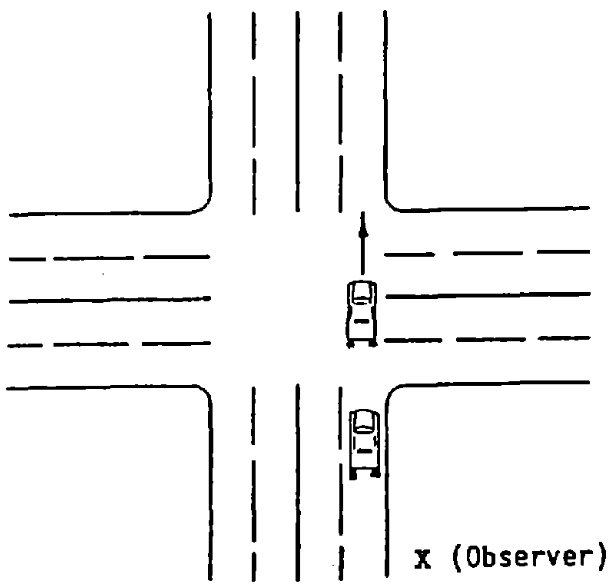


Figure 5. Slow-vehicle, same-direction conflict.

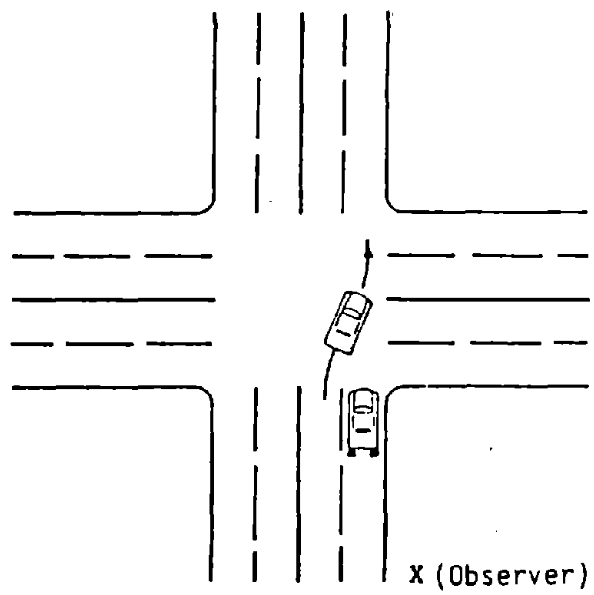


Figure 6. Lane-change conflict.

vehicle in the new lane in danger of a rear-end or sideswipe collision. However, if the lane change is made by a vehicle because it is in danger, itself, of a rear-end collision with another vehicle, the following vehicle in the next lane is said to be faced not with a lane-change conflict situation, but with a secondary conflict situation. (Secondary conflicts are described in a subsequent category.)

Opposing Left-Turn Conflict

An opposing left-turn conflict occurs when an oncoming vehicle makes a left turn, thus placing a second vehicle, going in the other direction, in danger of a head-on or broadside collision (see figure 7).

In this and the following conflict situations, the second vehicle is presumed to have the right-of-way, and this right-of-way is threatened by the first road user. Situations such as a second vehicle placed in danger of a collision because the driver of the second vehicle is running a red light, for example, are not treated as traffic conflicts. These situations are described in the section on other types of traffic events.

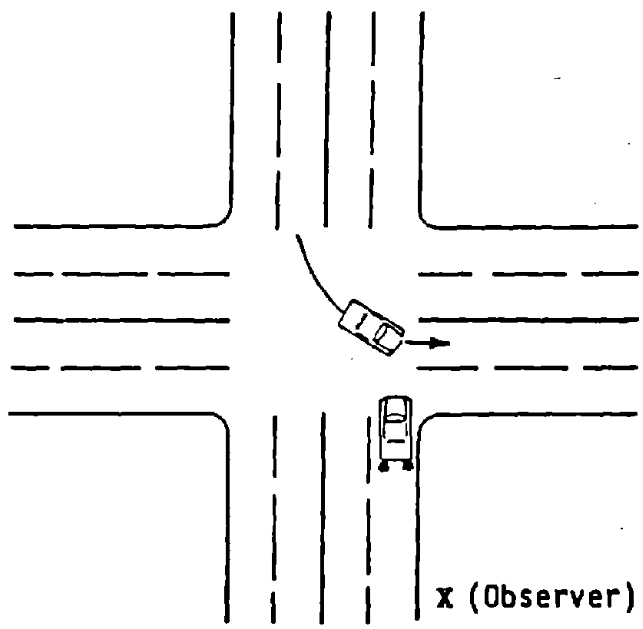


Figure 7. Opposing left-turn conflict.

Cross-Traffic Conflicts

A cross-traffic conflict occurs when a vehicle on the cross street turns or crosses into the path of a second vehicle on the main street who has the right-of-way and places the second vehicle in danger of a rear-end, sideswipe, or broadside collision. The second vehicle brakes or swerves to avoid the collision, then proceeds through the intersection area.

Cross-traffic conflicts can occur from vehicle maneuvers on the right-hand and/or left-hand cross street approach.

Cross-Traffic Conflicts From the Right Cross Street Approach

Right-Turn, Cross-Traffic-From-Right Conflict

A right-turn, cross-traffic-from-right conflict occurs when a vehicle on the right-hand cross street makes a right turn, thus placing a second vehicle on the main street in jeopardy of a broadside or rear-end collision. See figure 8 for the directions of the two vehicles.

At signalized intersections where right turns on red are permitted, it is sometimes desirable to further subdivide the right turn category to identify conflicts related to right-turn-on-red (RTOR) maneuvers.

Left-Turn, Cross-Traffic-From-Right Conflict

A left-turn, cross-traffic-from-right conflict occurs when a vehicle on the right-hand cross street makes a left turn, thus placing a second vehicle on the main street in danger of a broadside collision (see figure 9).

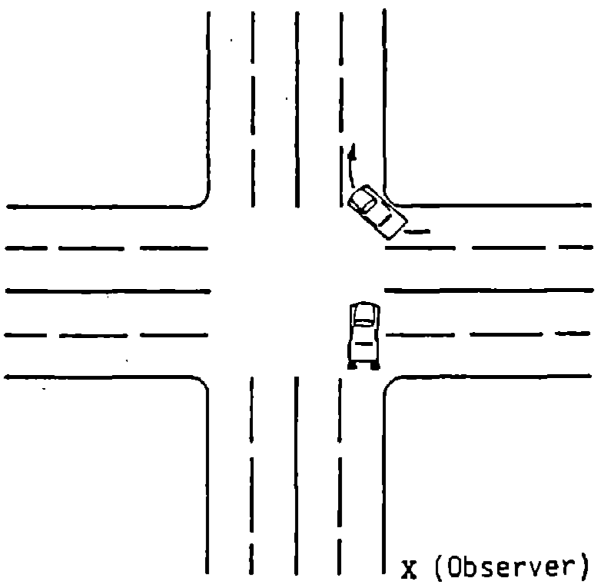


Figure 8. Right-turn, cross-traffic-from-right conflict.

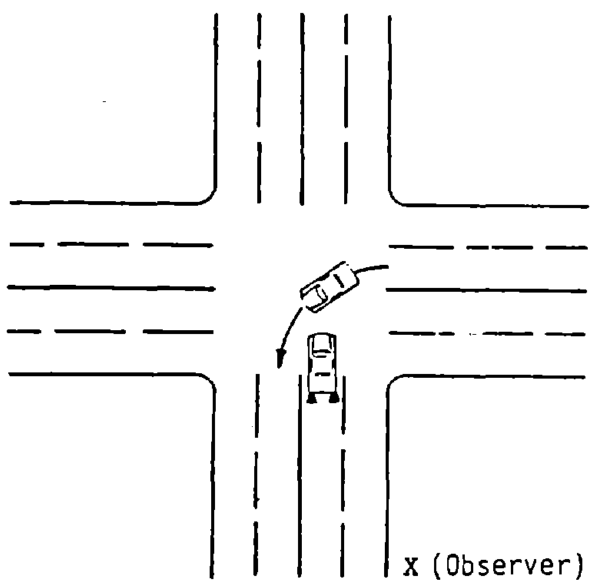


Figure 9. Left-turn, cross-traffic-from-right conflict.

Through, Cross-Traffic-From-Right Conflict

A through, cross-traffic-from-right conflict occurs when a vehicle on the right-hand cross street crosses in front of a second vehicle on the main street, placing it in danger of a broadside collision (see figure 10).

Cross-Traffic Conflicts From the Left Cross Street Approach

Right-Turn, Cross-Traffic-From-Left Conflict

A right-turn, cross-traffic-from-left conflict occurs when a vehicle on the left-hand cross street makes a right turn across the center of the main street roadway and into an opposing lane, thus placing a vehicle in that lane in danger of a head-on collision (see figure 11). This conflict is sometimes observed when the cross street is narrow, or when large trucks or buses make wide right turns. Note that the first vehicle must cross the center line for there to be a conflict.

Left-Turn, Cross-Traffic-From-Left Conflict

A left-turn, cross-traffic-from-left conflict occurs when a vehicle on the left-hand cross street makes a left turn, thus placing a second vehicle on the main street in danger of a broadside or rear-end collision (see figure 12).

Through, Cross-Traffic-From-Left Conflict

A through, cross-traffic-from-left conflict occurs when a vehicle on the left-hand cross street crosses in front of a second vehicle on the main street placing it in danger of a broadside collision (see figure 13).

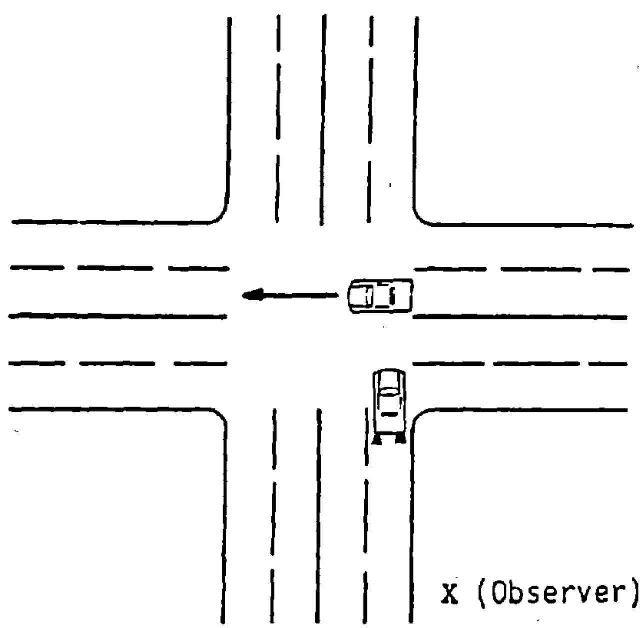


Figure 10. Through, cross-traffic-from-right conflict.

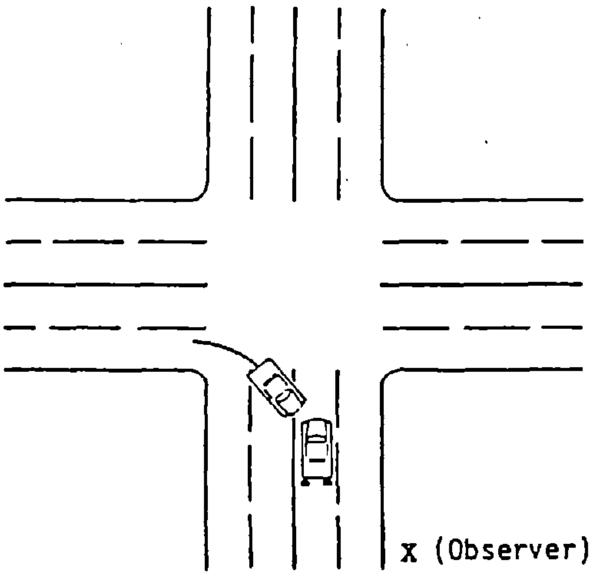


Figure 11. Right-turn, cross-traffic-from-left conflict.

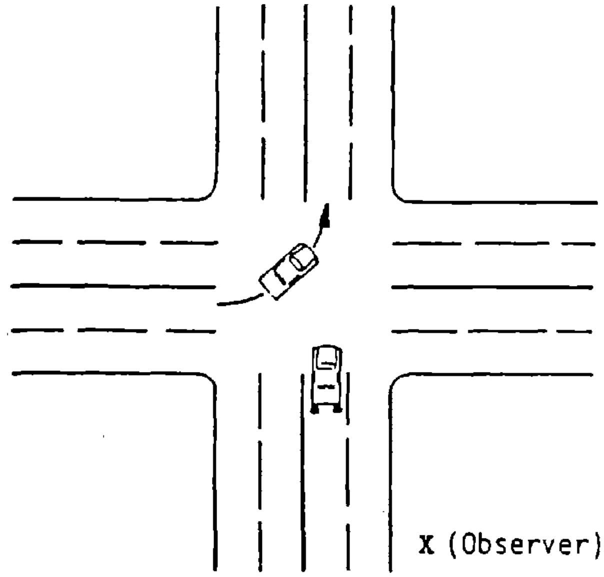


Figure 12. Left-turn, cross-traffic-from-left conflict.

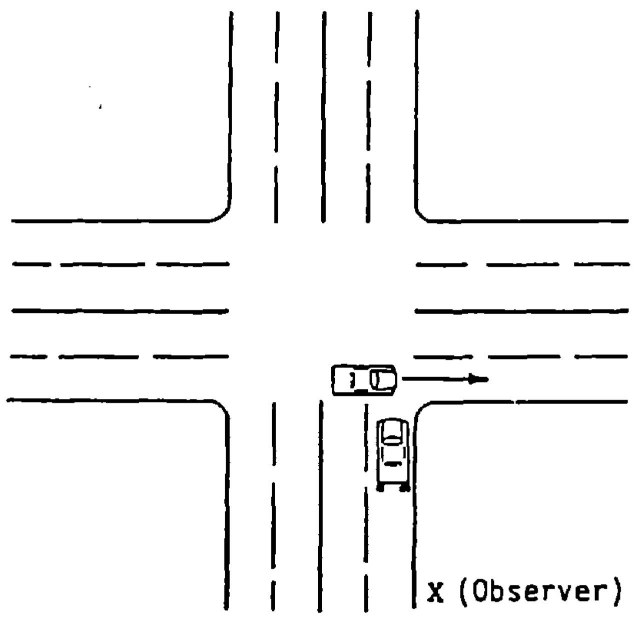


Figure 13. Through, cross-traffic-from-left conflict.

Right-Turn-On-Red Conflicts

Right-turn-on-red conflicts occur when a RTOR vehicle makes a turn and crosses into the lane of a second vehicle which has the right-of-way. The driver of the second vehicle brakes or swerves to avoid a broadside, sideswipe, or rear-end collision, then proceeds through the intersection area.

Opposing Right-Turn-On-Red Conflict

An opposing right-turn-on-red conflict can only occur at a signalized intersection with a protected left-turn phase. It happens when an oncoming vehicle makes a right-turn-on-red during the protected left-turn phase, thus placing a left turning, second vehicle (which has the right-of-way) in danger of a broadside or rear-end collision (see figure 14).

Right-Turn-On-Red-From-Right Conflict

A right-turn-on-red-from-right conflict is a special category of the right-turn, cross-traffic-from-right conflict (see figure 8). The right-turn-on-red conflict occurs only at signalized intersections when a RTOR vehicle on the right-hand cross street makes a RTOR maneuver and places a second vehicle on the main street in danger of a sideswipe, broadside, or rear-end collision.

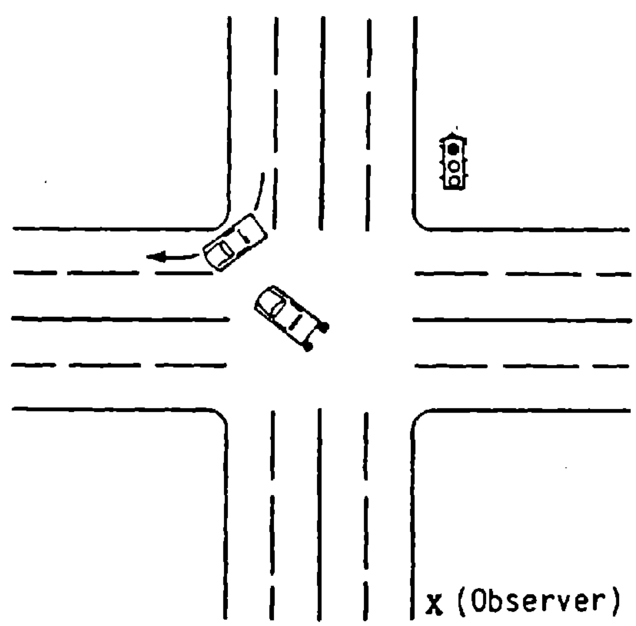


Figure 14. Opposing right-turn-on-red conflict.

Pedestrian Conflicts

There can also be pedestrian conflicts. They occur when a pedestrian (the road user causing the conflict) crosses in front of a vehicle that has the right-of-way, thus creating a possible collision situation. The vehicle brakes or swerves, then continues through the intersection area. Any such crossing on the near side or far side of the intersection (see figures 15 and 16) is liable to be a conflict situation. However, the pedestrian movements on the right and left sides of the intersection are generally not considered to create conflict situations if the movements have the right-of-way, such as during a WALK phase.

In some cases, the observer may be asked to count bicycle conflicts. These conflicts are similar to the pedestrian conflicts described above except the road user causing the conflict is a bicyclist.

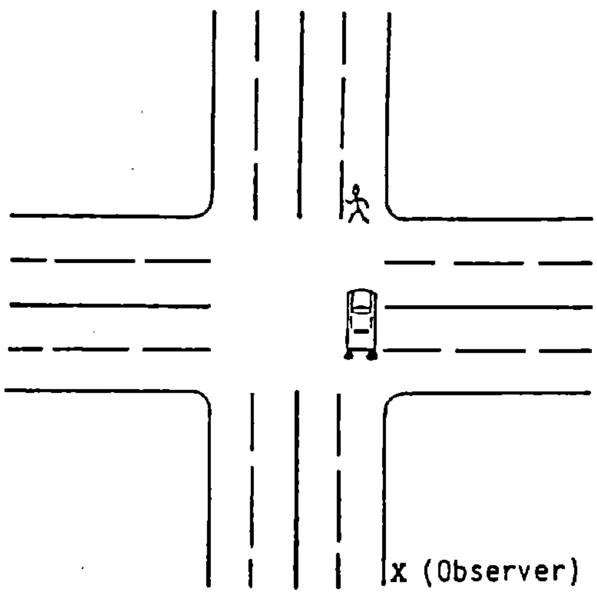


Figure 15. Pedestrian, far-side conflict.

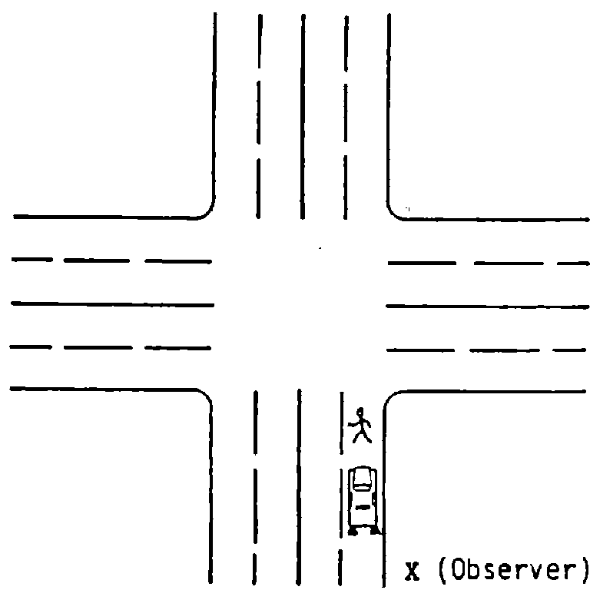


Figure 16. Pedestrian, near-side conflict.

Secondary Conflicts

In all of the foregoing conflict situations, when the second vehicle makes an evasive maneuver, it may place another road user (a third vehicle) in danger of a collision. This type of event is called a secondary conflict. Nearly always, the secondary conflict will look much like a slow-vehicle, same-direction conflict or a lane-change conflict. The difference is that, in a secondary conflict, the third vehicle is responding to a second vehicle that, itself, is in a conflict situation. Some examples are shown in figures 17 and 18.

By definition, only one secondary conflict for any initial conflict should be counted. Even if a whole line of cars stops because the first vehicle turns left, the event would be recorded as one left-turn, same-direction conflict and one secondary conflict.

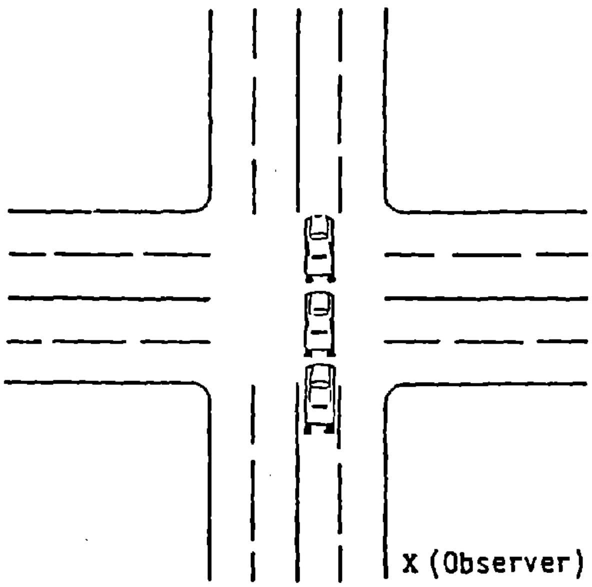


Figure 17. **Slow-vehicle, same-direction secondary conflict.**

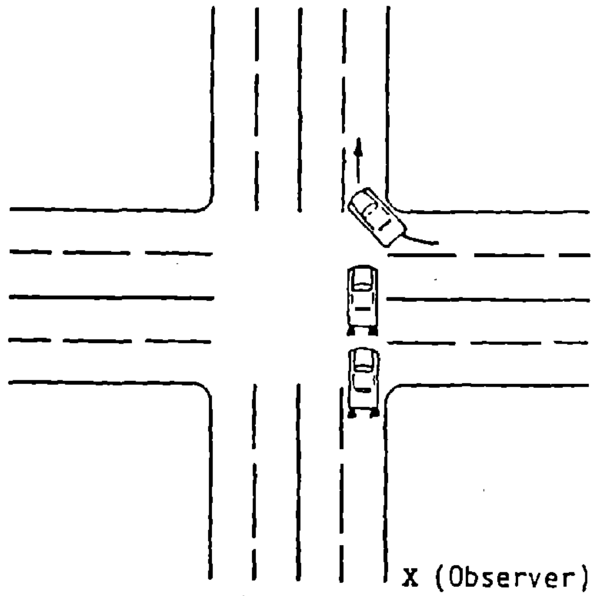


Figure 18. **Right-turn, cross-traffic-from-right secondary conflict.**

Other Types of Traffic Events

For some studies, the engineer may request the observer to count other types of traffic events, which are not defined in this manual. For example, to examine the effectiveness of a new traffic signal display, the observer may be asked to collect the number of red-light violations (a driver who crosses the stop line after the light has turned red), and the number of red-light violations that resulted in a conflict with other road users. Note that neither a red-light violation nor the resulting violation conflict is a traffic conflict under the conditions outlined in the general definition. In any case, the two events may be appropriate measures for some studies. In these special situations, the engineer will define the events to be counted and provide observer training prior to data collection.

Observers should always record any unusual or unexpected events during a conflict survey. Even if the event is rare or not described in this manual or during training, it may have important implications concerning safety and operations at the intersection. These events should be recorded in the comments section on the conflict data form.

Some special studies may require modifications of the conflict definitions. For example, in addition to pedestrian conflicts with through vehicles, as previously defined, a pedestrian conflict situation can also occur with a turning vehicle. A right-turn, vehicle-pedestrian conflict occurs when a vehicle begins a right-turn maneuver on a green signal phase and must brake or weave to avoid striking a pedestrian crossing the right leg of the intersection during the WALK interval (see figure 19). A left-turn, vehicle-pedestrian conflict occurs when a vehicle makes a left turn on a green light and must brake or weave to avoid a pedestrian on the left leg of the intersection (see figure 20). Another special case is a right-turn-on-red, vehicle-pedestrian conflict, where a right-turn vehicle fails to yield the right-of-way and must brake or weave to avoid a pedestrian in the near or far crosswalk (see figure 21).

At certain intersections, many types of special conflicts or other traffic events may occur which may be indicative of a safety and/or operational problem. For example, motorist and pedestrian signal violations (although not conflicts), may be useful measures for data collection at some intersections since they often lead to accidents.

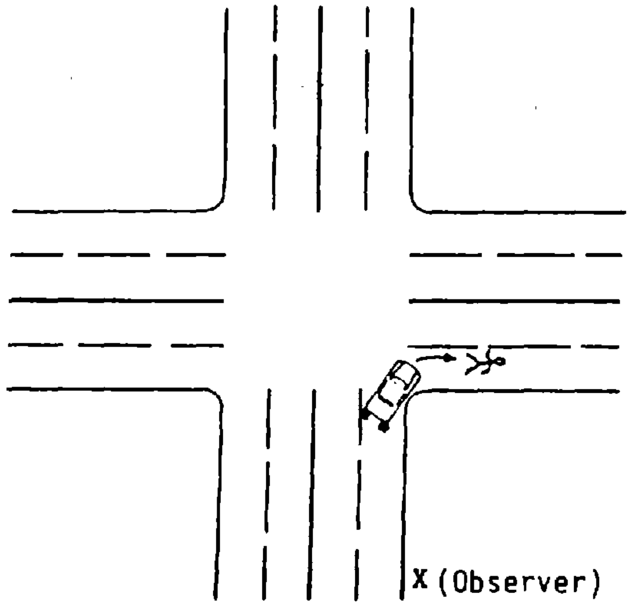


Figure 19. Right-turn, vehicle-pedestrian conflict.

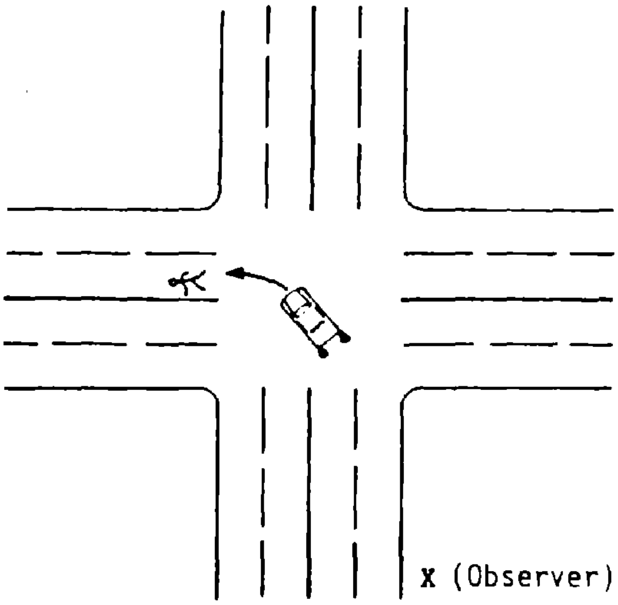


Figure 20. Left-turn, vehicle-pedestrian conflict.

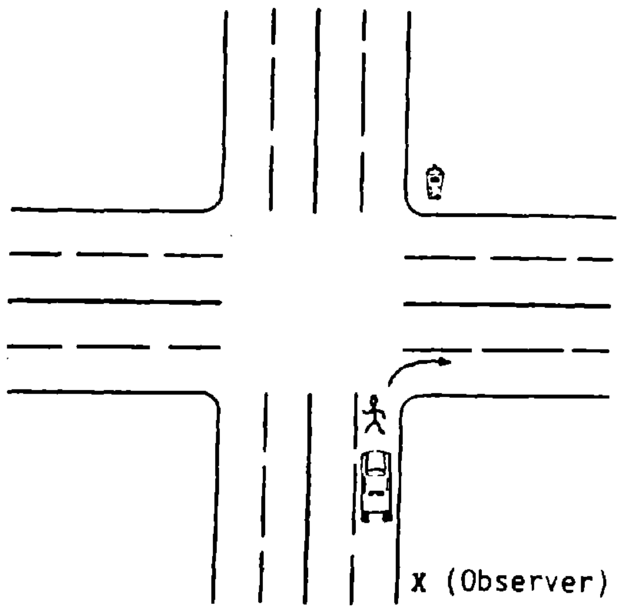


Figure 21. Right-turn-on-red, vehicle-pedestrian conflict.

Conflicts at driveways are also a common problem at many intersections. Driveway-related conflicts occur in several ways, as illustrated in figure 22, from vehicles turning into or out of driveways causing through vehicles to brake or swerve to avoid a collision.

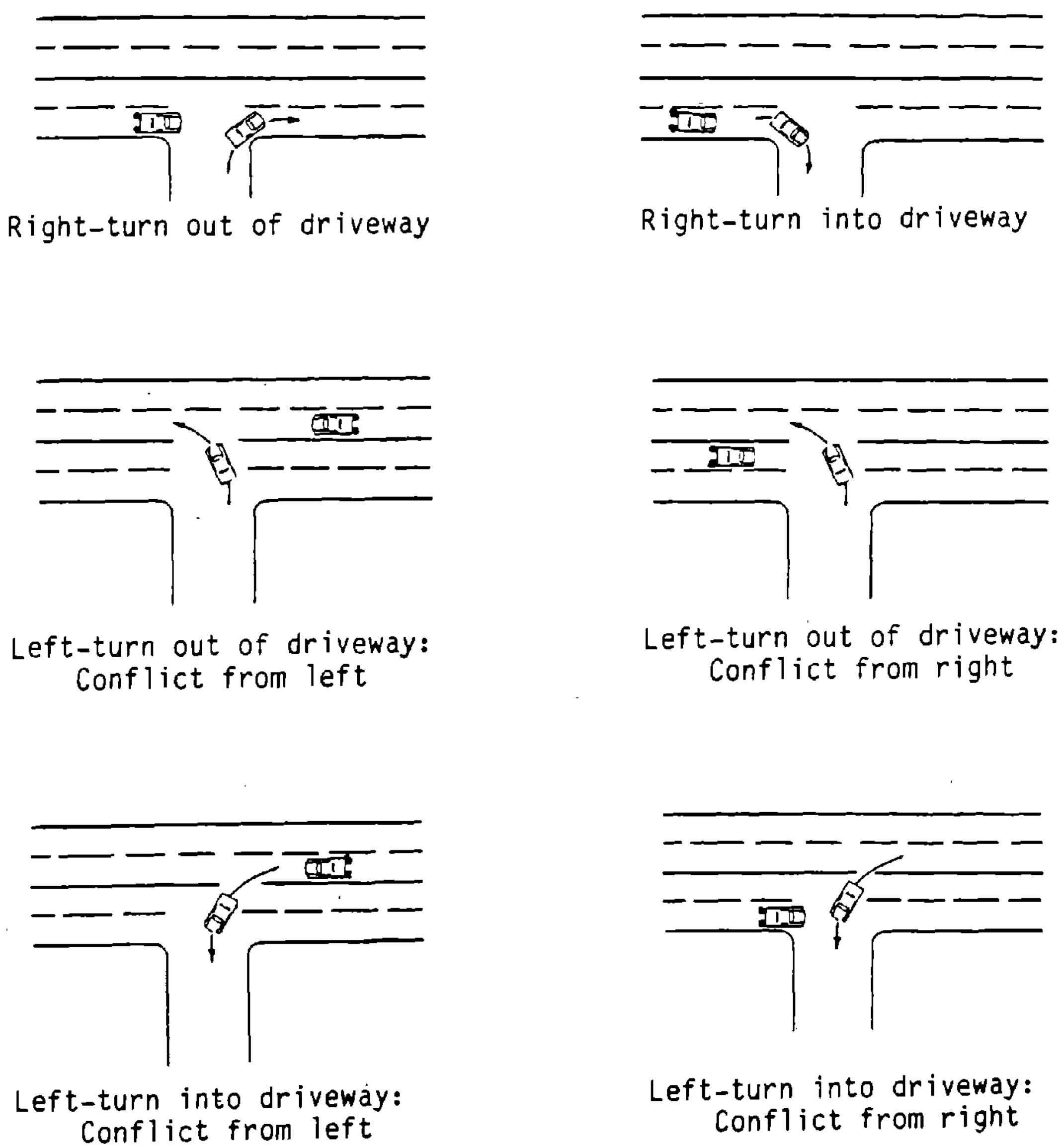


Figure 22. Examples of driveway conflicts.

CHAPTER 4 - HOW TO TRAIN OBSERVERS

The importance of training observers to recognize and categorize traffic conflicts consistently cannot be overemphasized. The training effort is modest (1 to 2 weeks), but essential to ensure that accurate and reliable conflict data are collected. The training program is described in this section.

Who To Train

Persons selected to observe conflicts must be extremely conscientious and trustworthy. They will be on their own much of the time, without supervision. They must be trusted to record what they see, and not to fabricate data.

The job is both demanding and tedious. Once learned, the observational method is not difficult. Some people will find it boring and seek greater challenges. The ideal observer is one who can maintain alertness and enthusiasm for the task, and who can find challenge in it on a day-to-day basis.

Age and sex present no inherent barriers. The majority of persons are trainable. There may be some for whom the task is too great, but there are just as likely to be some for whom the task is too easy. Most importantly, some persons will have such a fixed opinion about driving and traffic behavior (probably reflecting their own habits) that they will be psychologically unable to accept the concepts of traffic conflicts which must be used. Through discussions and questions, such persons usually identify this trait before or during the training and should be given alternative assignments.

Persons presently employed as traffic technicians or paraprofessionals usually make good observers. Police officers may not be as good, because of their different outlook on motorist behavior brought about by police training and experience.

How To Train

If an agency is just beginning to implement a traffic conflict program, several persons should be trained at the same time. This is the ideal arrangement. With a group, more effort can be devoted to planning and acquiring audiovisual aids than is usually possible with just one trainee. With a group, a combination of class work, group observation, and group discussions can be effectively used along with individual tutoring. It also enables the use of comparative analysis among observers to determine who needs special attention or what topics need additional emphasis.

If just one person is to be trained, the apprentice concept is probably best. The trainee works with an experienced observer for two weeks or more, under the general direction of the traffic engineer or other person in charge.

Observer Training Program

Prior to training observers, the following materials should be assembled:

- Blackboard or equivalent.
- Count boards.
- Data collection forms.
- Copies of the Observer's Manual.[1]
- Visual aids and projection equipment including a screen.
- Study sites - signalized and unsignalized intersections near the training site.
- Videotape, if possible, of traffic movements and conflicts at nearby intersections.
- Training room.

If groups of persons are to be trained together, it is best to use a formal schedule. A suggested program is given in table 1. In summary, about two weeks of training are recommended, with most of this time devoted to field practice and review. As will be noted, the period could be shortened somewhat (approximately 5 days) if the trainees are already experienced traffic technicians. The daily activities of the training program are discussed below.

Day #1 is devoted to activities of an introductory nature, and discussion of some topics will not be needed for some groups. The topics include orientation to traffic activities in general, to the traffic conflict program, and to traffic counting. A copy of the observer's manual should be presented to each trainee and the contents of the manual reviewed. Most of the day should be spent in the classroom. The field work on this day is introductory and should be fully supervised. It should emphasize traffic counting procedures to provide trainees with a feel for traffic movements at intersections. The field work should also involve general observations and discussion of traffic behavior, certain driver actions, and potentially unsafe practices. The idea is to get the trainees thinking about how people drive, and why.

Day #2 should begin in the classroom with a review of the general definition of a traffic conflict and the most common class of traffic conflicts; i.e., the rear-end or same-direction conflicts and the opposing left-turn conflict. The concepts and operational definitions should be introduced in the classroom using lectures, films, slides and sketches, as described subsequently. The basic principles should be emphasized. Then, one or more convenient, simple, uncongested signalized intersections should be used for supervised field practice. Using signalized intersections avoids most cross-traffic conflicts, and focuses attention on the two conflict types of interest. Time should be reserved late in the day for discussion and questions back in the classroom.

Day #3 involves presentation of the definitions of cross-traffic conflicts in the classroom. Field practice is conducted at an unsignalized intersection. The format for this day is similar to that of Day 2 except that the use of actual conflict count forms is recommended. Also, the use of videotapes of conflicts taken at nearby intersections should be considered as a classroom exercise and a focus for discussion.

Table 1. Training schedule.

Period	Topic

Day 1	Introductory remarks.
	Orientation to the training program.
	General background on traffic safety.
	History of traffic conflicts.
	Overview of a traffic conflict survey.
	    What the survey is.
	    How the results are used.
	    How the survey is conducted.
	    Contents of the Observer's Manual.
	Traffic counting.
	Turning movements.
	Use of mechanical counting boards.
	Introductory field work.

Day 2	Presentation of traffic conflict definitions.
	    General definition.
	    Same-direction and opposing left-turn conflicts.
	Group field observations at a signalized intersection.
	Discussion.

Day 3	Definitions of cross-traffic conflicts. Group field observation at an unsignalized intersection. Discussion. Use of videotape to illustrate conflict situations.
Day 4	Small group field practice. Question and answer session. Special conflict types.
Day 5	Simulated limited conflict counts. Discussion. Intersections with unusual geometrics.
Day 6	Use of other data forms. Field collection of other data. Discussion.
Day 7	Simulated full conflict counts (8-hour day). Discussion.
Day 8	Review of the concepts and procedures. Analysis of Day 7 data. Discussion of problem areas.
Day 9	More field practice.
Day 10	Analysis of Day 9 data. More field practice.

Day #4 provides for the trainees to observe conflicts in the field in pairs rather than in larger groups, but the partners should be alternated. This procedure fosters the interchange of ideas between trainees that might not otherwise occur. Also, plenty of time should be allowed for discussion and consideration of conflict examples (see section on training observers to recognize conflicts). The trainees by this time should be asking very perceptive questions based on their practice to date that should be shared with all trainees. If time allows, the more specialized traffic conflicts (pedestrian, lane-change, etc.) should be introduced; otherwise, this should be done early on Day 5.

Day #5 should be devoted to a simulated conflict count, with some monitoring by the instructor but without full-time supervision. The trainees can again work in pairs, and should follow normal field practices such as maintaining a certain time schedule, alternating legs of the intersection, completing and checking the intersection conflict forms.

Day #6 is devoted primarily to the other forms and procedures to be used in the field, including the intersection inventory, and taking photographs. This may not be necessary if the trainees are traffic technicians already accustomed to these procedures. If necessary, the remainder of the day should be devoted to teaching the trainees how to collect the other data in the field.

Day #7 should be a full-scale conflict count, using all data forms. Observers should work independently. No supervision is suggested, but the instructor may want to stop by the site once or twice to answer questions.

Day #8 is set aside for a full review of all activities to date, with emphasis on problem areas. It would also be instructive to analyze the data collected the previous day and provide some interpretation. Procedures for conducting this analysis to measure observer consistency are given in the section entitled "How to Measure Consistency." If any of the trainees are experiencing individual difficulties with any of the concepts, this would be a good time to provide some special attention.

At least 2 days of additional practice is recommended. Some of the data collected at this time may actually be usable, so if there are particular intersections of interest, they should be used. As described later in this section, these data should be used to examine the consistency of counting conflicts among observers; i.e., observer reliability. Specific problem areas should be identified and additional training provided if necessary.

Visual Aids

Visual aids are highly recommended for training observers. Visual materials, including overhead transparencies, and a set of 35 mm slides were prepared as part of the FHWA training course, "Traffic Conflict Techniques for Safety and Operations," and are available through their offices. These materials essentially parallel the definitions and survey procedures presented in the observer's manual.[1]

Videotape of traffic maneuvers at local intersections is often quite useful in explaining real-life situations. With some practice, it is possible to tape conflicts as they happen, at a variety of intersections, for later use in training.

A chalkboard is indispensable as a training aid. It enables sketches illustrating various situations to be made quickly.

Training Observers to Recognize Conflicts

Examples are probably the best way to illustrate the subtleties of the Traffic Conflict Technique and to teach observers to recognize and classify conflicts accurately. Several examples are presented in this section. Each situation can easily be modified by changing timings, direction, etc., to create still other examples. In addition, the trainees should be encouraged to pose questions in the form of examples based on their field observations. Full use should be made of these examples as teaching aids in the classroom beginning on the second day of training. Inquisitiveness should be encouraged among the trainees to stimulate questions of the "what if" variety. These examples are also presented in the observer's manual for training purposes and to provide a reference source.

Examples

In all of these examples, assume the conflict observer is on the south leg, as shown in figure 23, viewing northbound traffic as it approaches the signalized intersection. In each case, the traffic situation is first described and then interpreted.

1. **The signal turns red for northbound traffic, but a driver apparently does not notice it until the last minute, then slams on the brakes.** The interpretation depends on the other traffic. If, as would normally be the case, the intersection is empty when braking begins, there is no conflict. The driver is just responding to the signal. But if a westbound vehicle is in the intersection, classify the event as a through, cross-traffic-from-right conflict. This would probably be rare, and the observer should make a special note about it on the conflict data form.

2. **A car on the right (east) approach stops, starts to pull out to make a right turn, then stops abruptly because the driver sees a northbound vehicle that just passed the observer position.** This is not a conflict from the observer perspective. Only when a northbound vehicle reacts to an impending collision is there a conflict. If, however, the northbound vehicle also braked or swerved and the car from the right had pulled far enough forward to be in his path, then a right-turn, cross-traffic-from-right conflict would be recorded.

3. **A northbound car slows and turns right. Another car, right behind it, brakes severely and then it, too, turns right.** Although this could be debated, the event should be considered to be a right-turn, same-direction conflict. If the second vehicle, however, turns into a driveway or makes a left turn, it should not be recorded as a conflict because you do not know if the second vehicle braked because of the first vehicle or because the driver

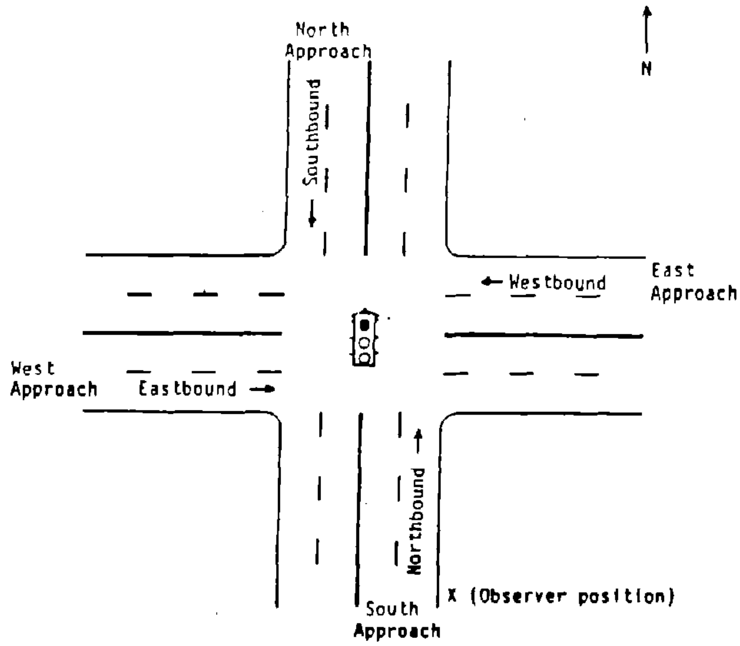


Figure 23. Intersection layout for the example traffic situations.

was going to turn. If the second vehicle proceeds through the intersection instead of turning right, always record the event as a conflict. When in doubt about any conflict situation, make a note on the conflict form.

4. **While the signal is green for north and southbound traffic, a northbound driver begins a left turn, then stops abruptly to avoid a southbound vehicle which he did not see until the last minute.** This is not a conflict. This common situation often leads to accidents, however. Especially on four-lane roads, the oncoming southbound center-lane vehicles may be stopped waiting to turn left, hiding southbound through-vehicles in the outside lane. But unless there is a left-turn phase, the through-vehicles have the right-of-way. If the left-turn vehicle does not have the right-of-way, it is not classified as a conflict. However, if this situation is observed often at an intersection, make a note on the data form.

If the observer was on the north approach and the southbound driver took evasive action to avoid a collision with the left-turning vehicle, the event would be recorded as an opposing left-turn conflict.

5. **During the green cycle on a four-lane street, an oncoming southbound vehicle makes a left turn, causing drivers in both northbound lanes to brake.** Although this could be debated, it appears most logical to count this as two opposing left-turn conflicts. Although there is only one instigating vehicle, an accident could have occurred with either northbound vehicle if the drivers had not reacted. Also, this is not a secondary conflict situation, because the two northbound vehicles reacted independently to the left turner, not to each other.

6. **A car is stopped with a flat tire on the north side of the intersection, blocking the right northbound lane for half an hour. Meanwhile, northbound traffic is slowed considerably because it is forced to maneuver around the disabled vehicle. Frequent slow-vehicle and secondary conflicts are noted.** The conflicts should be recorded unless traffic backs up (stop and go condition) through the intersection. Make prominent notes about the situation and, if possible, explain it personally to the engineer. He may decide not to use the data, but it is better to record the data, even if they will not be used, than to miss important insights about the traffic operations.

7. **Same situation as noted in example 6, except traffic flow is reduced to stop and go conditions during the green phase, and nearly every northbound vehicle brakes one or more times approaching or going through the intersection.** The Traffic Conflict Technique does not appear suitable during periods of congestion. However, the existence of traffic congestion is possibly indicative of operational deficiencies. During such times, cease making formal conflict counts, but carefully note any apparent causes for the congestion (it could be simply heavy traffic) and how long it lasts.

8. **Every 10 minutes or so, a city bus slows and stops just north of the intersection to discharge passengers. Cars behind the bus are forced to brake or swerve.** Record these events as slow-vehicle conflicts. But it is extremely important to note the cause. This may or may not be judged a hazardous situation--that is for the traffic engineer to decide--but make sure to record the information.

9. **The observer hears the squeal of brakes behind (south of) his position. Turning, he sees a heavy, slow-moving truck and, behind it, the car that had just braked.** This is not a conflict. The observer is counting only the events between him and the intersection. The purpose of the study is to learn more about the intersection. Chances are that events behind the observer (such as the slow-moving truck) have little to do with the intersection itself. But, if the observer believes the braking was due to the intersection (for example, the truck was moving slowly because the signal was going to change), a special note should be made on the data form.

10. **There is a fast-food restaurant 200 feet north of the intersection, and many vehicles slow to turn right and enter the driveway. Often, other northbound vehicles are forced to slow during, or after, the time they cross the intersection.** These incidents should be recorded as slow-vehicle conflicts if the braking vehicle is on the observer side of or in the intersection. If the braking vehicle is north of the intersection, this is not an intersection conflict and should not be recorded. In either case, if it happens frequently, make notes about it. Although there may not be an intersection problem, the observer may have located a driveway problem that bears on how the intersection operates.

11. **A car, parked at a meter ahead of the observer, pulls in front of another vehicle, causing it to brake.** This is a conflict; the question is, what kind? Arguments could be made for calling it a slow-vehicle conflict, a lane-change conflict, or even a right-turn, cross-traffic-from-right conflict.

If this does not happen very often, the classification probably does not matter very much. It is preferred practice to record it as a slow-vehicle conflict, then to note the cause.

12. **A southbound cab enters the intersection, then makes a U-turn and heads north. The driver of a northbound vehicle applies brakes to avoid a collision with the cab.** If this happens very often, make up a separate column, define these as U-turn conflicts, and count them. Otherwise, record them as slow-vehicle conflicts and note the cause.

13. **A southbound vehicle makes a left turn at the intersection crossing in the path of a through northbound vehicle. The observer hears the tires squeal and can see the front of the northbound vehicle dip forward indicating sudden deceleration, but there are no brake light indications and the northbound driver did not attempt to swerve to avoid the impending collision.** This is definitely an opposing left-turn conflict. A small percentage of vehicles have brake lights that are inoperative. To record a conflict, however, there must be some visual and/or audible evidence such as the squealing of tires to convince the observer that the driver was attempting evasive action.

14. **The signal turns red for northbound traffic causing a northbound vehicle to slow, then come to a full stop. At the last second a following northbound driver slams on the brakes, the vehicle skids, and finally comes to a stop just before reaching the lead vehicle stopped on the approach.** By definition, this is not a conflict because the lead vehicle stopped legally for a red signal. For a same-direction conflict to occur, the signal phase must be green. However, as accidents related to this maneuver occur at intersections, the observer should note the event on the conflict form. Sudden braking or swerving by a following vehicle may indicate a signal visibility, sunglare, or related problem, especially if the event is repeated a number of times during the survey. These events, along with any unusual circumstances, should always be recorded.

How to Handle Unusual Intersection Geometrics

The basic operational definitions previously described refer to relatively standard intersection geometrics. The engineer and observer should be aware of the fact that certain modifications will be required for other geometrics. Suggestions are given here for some of the more common departures from normality that may be encountered. These examples should be presented during the training, typically at the end of the fifth day.

Right-Turn and Left-Turn Lanes

If an approach leg contains a right-turn and/or a left-turn lane, more lane changing than usual will be observed. The observer should not mistakenly record these swerves as rear-end conflict situations. However, the observer should be alert for lane-change conflicts, which are otherwise rare at most intersections.

Driveways at Three-Leg Intersections

Many three-leg intersections have a driveway where a fourth leg would normally be. Unusual conflict situations may occur, especially if the intersection is signalized and there is appreciable driveway traffic (which is not signal controlled). Observers should be alert for such movements, and record them as notes or under appropriate column headings on the conflict data form.

One-Way Streets

If the street under study carries one-way traffic, observation is simplified because only the approach leg needs to be monitored. Also, there will be no opposing left-turn conflicts. On the other hand, if the cross street is one-way, the observer obviously needs to watch for cross traffic from only one direction--again, a simplification.

Traffic Circles

Each approach to a traffic circle is similar to an approach to a one-way street. Likewise, traffic within the circle is somewhat like traffic on a one-way street with frequent intersections. It differs, however, in that there is more frequent lane changing. In this respect, it is like a series of weaving sections. Thus, lane-change conflicts will be seen frequently.

Five-Leg Intersections

Intersections with more than four approaches are more complicated, but no new concepts are required. Cross-traffic conflicts will have to be clearly labeled according to the approach leg used by the cross traffic. If the intersection is one with major merging/diverging movements (i.e., where traffic on one approach splits fairly evenly between other legs and vice versa), three observers will be required. Also, the engineer should define for the observers the straight-through path, as opposed to right- and left-turn movements, even though a straight-through movement may require a slight turn.

Offset-Intersections

The major difficulty with offset-intersections is whether to consider them as two three-leg intersections separated by a short weaving section or as a single four-leg intersection with a longer than normal clearance interval. In the latter case, observation of opposing left-turn conflicts involving vehicles on the offset legs may be difficult for the observers to see from their normal vantage points. If so, rather than observing from the right side of the approach leg, using the left side may be advantageous.

How to Ensure Consistent Reporting of Conflicts Among Observers

Definition of Consistency

Consistency in recording traffic conflicts among observers is of critical importance to ensure reliable and accurate conflict data for safety analysis. The term "consistency" is defined as observer reliability; i.e., there should be a small difference, if any, among different observers recording the same event. For example, assume that two observers, sitting in different vehicles on the same intersection approach, count opposing left-turn conflicts for three 25-minute periods. At the end of the third counting period, a comparison of the counts is made. Observer #1 recorded 5, 7, and 2 opposing left-turn conflicts during the three periods. Observer #2 recorded exactly the same number of conflicts for each period which indicates perfect observer reliability or consistency. If, however, observer #2 recorded 0, 1, and 0 conflicts during the three periods, observer reliability is extremely poor. In this case, the reason for the differences must be identified and corrected through additional training or replacement of personnel.

How To Minimize Observer Differences

Minimizing observer differences is achieved through proper training, as previously described. In addition, the observers must be alert, motivated, and of the right temperament to conduct repetitive conflict counts without losing interest or concentration. The engineer must be sensitive to the attitudes and problems of the observers. Not everyone has the qualities to be a traffic conflict observer. Some observers may perform well initially but lose interest after a few days or weeks. The engineer must work closely with conflict observers and be willing to help and motivate them when necessary. Of course, replacing observers must always be an alternative.

How to Measure Consistency

Maintaining consistency among conflict observers requires periodic comparisons of observer conflict counts. The comparisons should be conducted during and immediately after the training program. Thereafter, comparisons should be made approximately every three months or more frequently if new observers are added to the staff.

Several methods can be used to determine observer reliability and one suggested procedure is given here. To conduct the comparison, it is first necessary to assign two or more observers to the same observer location to count conflicts at the same time. The observers should be in different vehicles, but located in close proximity to each other so each observer is capable of seeing the same traffic events. Conflict counts should then be made simultaneously for 10 to 12 periods, where each period is typically a 20- or 25-minute recording interval.

Analysis of the results should begin by visually comparing the counts for each conflict type by period, as well as the total count by type of conflict. If the observers recorded exactly the same number by conflict type for each period, further analysis is not necessary as observer reliability is perfect.

In practice, there are usually some differences in the counts among observers. The question is--How much difference is acceptable? Several mathematical procedures are offered to answer this question.

If the number of observers is small; i.e., 2 to 4, pair-wise comparisons can be made by computing the correlation coefficient. Simple correlation techniques, such as the one needed for this comparison, are available in all statistical packages for mainframe and personal computers, and for programmable calculators. An example of the calculations is presented in the appendix of this guide.

For purposes of illustration, figure 24 shows a plot of the counts of two observers who were simultaneously and independently conducting conflict surveys in Kentucky.[6] In this case, the correlation coefficient, r, is 0.87. A correlation coefficient of 1 indicates perfect agreement in the count, whereas a value of 0 indicates no agreement. Correlations of 0.95 and above are desirable. In the example illustrated in figure 24, one observer was found to have a careless attitude in conducting the counts and was transferred to other duties.

For larger groups of observers, consistency can be examined by calculating the mean and standard deviation of the conflicts by type for the group. Procedures for making these calculations are given in the appendix of this guide, but are also standard computer and calculator routines. As a general rule, if an observer's counts are consistently more than one standard deviation above or below the group mean, he should be singled out for additional training.

As an example, during the last day of training, suppose 8 observers counted conflicts independently for 25-minute periods on one approach of a four-leg signalized intersection. At the end of 6 observation periods the counts were totaled by conflict type. The results for opposing left-turn conflicts indicated that the group mean was 8.5 conflicts per period with a standard deviation of 1.2 conflicts per period. Using one standard deviation as a guideline, the observer counts should be within the range of 7.3 to 9.7 (8.5 ± 1.2) conflicts. In this example all but two of the observer counts were within this range. One observer recorded an average of 5.1 left-turn conflicts while the other observer recorded 10.3 conflicts. Comparisons of other conflict types revealed that the same two observers had counts consistently below and above the group mean. These results indicate that one observer saw too few conflicts and one saw too many. A review of the results with each person revealed a misunderstanding of several basic concepts. The misunderstandings were cleared up in a discussion session and additional practice was used to ensure the problem was corrected.

Consistency of Classifying Conflicts by Type

The simultaneous collection of conflict data at a location by two or more observers allows not only for examining differences in conflict counts, but also the consistency with which observers classify conflicts by type. This is important, since observers may recognize a traffic event as a conflict but may disagree as to the conflict type. When such differences are found to occur among observers, the engineer should discuss the type of conflict with the two observers, determine how each observer interprets a given traffic event, and clear up any confusion or misunderstanding. It may be helpful or necessary for the engineer to use videotapes of such conflicts and/or observe events in the field with the observers to adequately resolve the issue.

Confusion and inconsistencies in conflict counts may result from a variety of situations. Examples include:

1. An opposing left-turn conflict is confused with a left-turn, cross-traffic-from-right conflict. In both cases an oncoming through vehicle is offended by a left-turn vehicle. In the first case (opposing left-turn conflict) the offending vehicle was traveling toward the through vehicle and turns left in front of it. In the second case (left-turn, cross-traffic-from-right conflict), the offending vehicle turns left from the right-hand cross street into the path of the through vehicle.

2. An opposing right-turn-on-red conflict can only occur at a signalized intersection which has a protected left-turn phase (i.e., left-turn arrow). Such a conflict, therefore, should not be counted at signalized intersections with no separate left-turn phase.

All special conflict types and other events of interest to the engineer must be clearly defined for the conflict observers to avoid confusion.

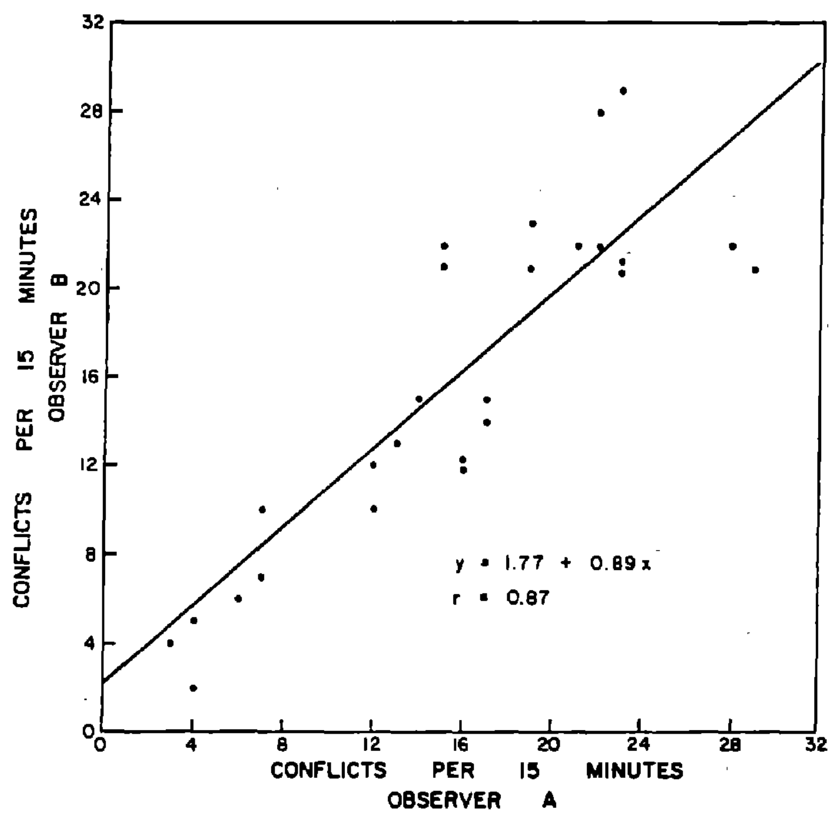


Figure 24. Test for observer reliability in conflict counts.

Summary

In summary, to maintain consistency among conflict observers, the engineer must:

1. Ensure proper training and coordination with data collectors.

2. Periodically examine observer conflict counts.

3. Use simultaneous, independent data collection by two or more observers assigned to the same location, analyze the results, and resolve inconsistencies.

4. Provide clear instructions and definitions of various conflict types, particularly for those uncommon or special conflict types or traffic events which are of interest at a given location.

Additional Training

After the observers are trained, it is best to keep them in practice. As a minimum, the observers should count conflicts several days each month to ensure that concepts, definitions, and their ability to accurately recognize and record conflicts are retained. After a substantial layoff; i.e., long illness, reassignment to other work. Some retraining and practice is worthwhile.

CHAPTER 5 - CONDUCTING A TRAFFIC CONFLICT STUDY

The major components of a traffic conflict study are:

1. Selecting a study site.
2. Planning the survey.
3. Conducting the survey.
4. Analyzing and interpreting the data.

In this section procedures are presented for selecting study sites, and planning for and conducting a conflict survey. Data analysis and interpretation techniques are covered in subsequent chapters.

When to Conduct a Traffic Conflict Study

As previously discussed, a traffic conflict study can be conducted for a variety of purposes including determining the magnitude of the problem, diagnosing the problem, and evaluating countermeasures. However, because the field survey requires personnel and time commitments, it is not practical or possible to conduct a conflict study at every location. Guidelines for deciding when and when not to conduct a conflict study are presented in the following paragraphs.

Where and When to Use Traffic Conflicts

At present traffic conflict studies should be used for analysis of signalized and unsignalized intersections. Most of the research and reported highway agency applications at intersections have been on weekdays, during daylight hours, and on dry pavement, but there is no reason to believe the technique should be limited to these conditions. The conflict technique may be applicable to other roadway elements, however, additional efforts are necessary to develop and validate definitions and data collection procedures, and to establish accident-conflict relationships.

Problem intersections are identified by a variety of methods including high accident lists, police notification, citizen complaints, and political requests. Traffic conflict studies are particularly suited to intersections that have been identified for study by any of these methods. A traffic conflict study should be conducted when any of the following conditions exist:

- Accident data indicate the intersection is hazardous, but an analysis of the accident reports does not identify specific causal factors.

- There have been complaints concerning unsafe conditions and/or operational problems, but the accident history is insufficient to determine if there is a safety problem and conventional traffic studies do not identify the problem.

- There have been complaints indicating a sudden increase in accidents or a particularly serious or fatal accident. The primary advantage of using conflict studies at these intersections is that the safety problem can be identified (if one exists) and corrective action taken without having to wait for additional accidents to occur.

- Accident-based studies are inappropriate because of temporary or recent modifications at the intersection.

- There is a need to determine the effectiveness of corrective action taken at a hazardous intersection without having to wait years before an accident-based evaluation can be conducted.

- An accident analysis cannot be conducted to identify hazards because the data are either not available or are of poor quality; e.g., citizen reports.

- Conventional analyses have been conducted, but the engineer wants additional information that supports making major changes (and large expenditures of funds) at an intersection.

Due to the numerous applications of traffic conflicts, there are usually many more intersections identified for study than can be investigated. For this reason the field observation checklist shown in figure 25 was developed.

To assist the engineer in deciding if a traffic conflict study at an intersection is warranted, it is recommended that a trained conflict observer conduct a brief (perhaps 1-hour) review of the intersection and answer the questions posed on the checklist. The field review should be made during the day(s) and time of day, if any, suggested in the complaint. The observer should stand adjacent to each approach leg for 10 to 15 minutes observing traffic movements, then use his judgment to answer the checklist questions. Note that no conflict counts are made at this time. The questions (1 through 11) are designed to determine if conditions exist which are indicative of conflict situations. Questions 12 and 13 are included to determine if accidents have occurred, irrespective of what the accident files may show. Question 15 is useful in helping the engineer to decide if other special events or studies such as driver compliance are needed.

As a general rule if the answers to the questions are no, a traffic conflict study should not be conducted. Positive answers indicate that a traffic conflict study would be useful.

Note that the field observation checklist shown in figure 25 is completed prior to scheduling a conflict survey. This checklist should not be confused with the On-Site Observation Report (discussed on page 44) which is completed at the end of a conflict survey.

When Not to Use Traffic Conflicts

Based on past experiences, traffic conflict studies should not be conducted when any of the following conditions exist.

- During periods of forced flow (level of service F) when congestion creates stop and go conditions. Numerous traffic conflicts occur during congestion, but the danger of an impending collision is minute as traffic speeds are very low.

- To justify safety or operational treatments that are not related to an abnormally high conflict pattern. Unless the treatment(s) are implemented to reduce higher than expected daily conflict counts, there is little chance, if any, that a conflict study will indicate that the treatment is warranted.

- At low-volume intersections where the number of vehicle interactions is limited. While no standards have been developed, a general guideline is when the sum of the entering volumes is less than 1,000 vehicles per day. It should be noted that the conflict technique is technically applicable to low-volume intersections, but the large time requirements necessary to collect useful samples are not usually practical.

- Finally, the Traffic Conflict Technique is not recommended for general use as a surveillance tool to study all intersections in an effort to identify hazardous locations. Again, there are no technical restrictions to this application, but the large time and personnel requirements preclude most agencies from adopting this approach.

FIELD OBSERVATION CHECKLIST

Location________________________________ Date________________

Observer________________________________ Time________________

	No	Yes	Comments If yes, specify approach leg(s).
1. Are left-turn vehicles restricting the normal path or speed of through vehicles with right-of-way?	___	___	___
2. Are right-turn vehicles restricting the normal path or speed of through vehicles with right-of-way?	___	___	___
3. Is there a large volume of oncoming left-turn vehicles crossing the path of through vehicles with right-of-way?	___	___	___
4. Do some through vehicles with right-of-way appear to slow down as they approach or travel through the intersection?	___	___	___
5. Is the speed or normal path of any through vehicles with right-of-way affected by vehicle movements on the right-hand approach (if a right-hand approach exists)? If yes, specify approach and movement, e.g., right turn, left turn, or through.	___	___	___
6. Is the speed or normal path of any through vehicles with right-of-way affected by vehicle movements on the left-hand approach (if a left-hand approach exists)? If yes, specify right turn, left turn, or through.	___	___	___
7. Do some vehicles turning right from the left-hand approach cross the centerline into the path of through vehicles?	___	___	___
8. Do some through vehicles with right-of-way change lanes as they approach or go through the intersection?	___	___	___
9. Do vehicles turning into or out of driveways affect the speed or normal path of through vehicles?	___	___	___
10. Do pedestrian movements affect the speed or normal path of:			
a. Through vehicles with right-of-way?	___	___	___
b. Right-turn vehicles?	___	___	___
c. Left-turn vehicles?	___	___	___
11. Do bicycle movements affect the speed or normal path of:			
a. Through vehicles with right-of-way?	___	___	___
b. Right-turn vehicles?	___	___	___
c. Left-turn vehicles?	___	___	___
12. Are there tire skid marks on the approach?	___	___	___
13. Is there vehicle accident debris (small pieces of crushed glass, chrome, plastic, etc., and/or scar marks on trees, utility poles, embankments, or other roadside objects) on the shoulder or roadside?	___	___	___
14. Are there any other unusual traffic flow problems or traffic conflict patterns? If yes, specify observed problem.	___	___	___
15. Are there any violations of existing traffic control devices or regulations such as:			
a. Running-red-light?	___	___	___
b. Failing to stop or yield right-of-way?	___	___	___
c. Parking?	___	___	___
d. Speed limits?	___	___	___
f. Right-turn-on-red?	___	___	___
g. Other________________	___	___	___

General Comments____

____

____

Figure 25. Field observation checklist.

Planning A Traffic Conflict Survey

Prior to conducting a conflict survey, the traffic engineer must obtain the following information:

- List of study sites.
- Intersection approach legs of interest.
- What data to collect; e.g., conflicts, special events, volumes.
- Amount of data to collect.
- Recording period.
- When to collect the data.
- Number of observers needed.

Guidelines for planning the field survey are given below.

List of Study Sites

The engineer should generate a list of intersections for study from high-accident lists, citizen complaints, police requests and other usual sources. A tentative data collection schedule should be developed for each location. Upon assigning the observer a location for study, the engineer should always provide a list of backup sites in the event unforeseen problems; e.g., utility work, an accident, or severe weather, occur at the primary site. This practice minimizes lost time when unexpected problems occur.

Intersection Approaches of Interest

At three- and four-leg signalized intersections, observations are usually made on all approaches. At unsignalized intersections, observations are made only on approaches where vehicles have right-of-way; i.e., on the nonstop approaches. Generally, this practice is desirable for most problem identification and diagnostic studies. There are exceptions when only one or two approaches should be selected. For example, to identify and quantify the source of a reported rear-end accident situation in one direction of travel, the conflict survey could be limited to that approach. Also, in some countermeasure evaluations, it is not necessary to examine all approaches if the countermeasure addresses only 1 or 2 approaches. The engineer should identify the approaches of interest and inform the observer to reduce time lost due to unnecessary data collection.

What Data to Collect

Generally, the conflict observer will collect the basic conflict types (presented in the section on definitions) plus secondary conflicts. Of course, the observer should make notes concerning other conflicts or unusual events that occur during the observation periods. In some cases, the general nature of the problem; e.g., U-turns, adjacent driveways, etc., are suspected by the engineer. It is important that this information be given to the observer so he is aware of these atypical conditions and will record them. Insights as to what unusual conflicts may occur at an intersection usually are indicated in the complaint or request for study. Another useful source is the Field Observation Checklist which should be completed before the conflict survey is scheduled.

The engineer must also specify if the observer should collect special events such as vehicle-pedestrian interactions created by turning vehicles and right-turn-on-red pedestrian conflicts. Again, indications that these events occur at a particular intersection are often contained in citizen complaints and police hazard reports, but variable selection also depends on the purpose of the study. For example, if a countermeasure has been installed to reduce red-light violations, then it is appropriate to collect these data in addition to the conflict data.

Typical safety and operational investigations require that other data such as traffic volumes and roadway inventory be obtained. Prior to or after the conflict survey, the observer can obtain or update existing roadway inventory information as well as take photographs of the location. Also, when traffic volume information is not available or is out-of-date, it is often expedient to assign two observers--one to count conflicts and one to record traffic volume. Based upon the availability of this information in existing files, the engineer should provide a list of data needs to the observer.

Amount of Data to Collect

Procedure for Estimating Sample Size

The amount of conflict data that should be obtained depends on the types of conflicts of interest, the traffic volumes, the type of intersection, and the precision required. To determine the number of observation hours needed to estimate the mean number of hourly traffic conflicts of a specific type at an intersection within a range of $\pm$ p percent and with confidence $1 - \alpha$, the following formula should be used.[4]

$$n = (100\ t/p)^2 \quad \sigma e^2 / \bar{Y}^2$$

where n = number of hours of observation needed.

t = statistic from the normal distribution defined by α, the level of significance. For example, t = 2.58, 1.96, 1.65, and 1.28 for α = 0.01, 0.05, 0.10, and 0.20 respectively.

p = percent of the hourly mean; e.g., if the hourly mean is 6 conflicts and p is 50 percent, the precision of the estimate is 6 $\pm$ 50 percent or 3 to 9 conflicts per hour.

σe^2 = hourly variance estimated from previous conflict studies.

$\bar{Y}$ = hourly mean number of conflicts of a specific type.

Applications of the formula are shown in table 2. The mean and variance estimates given in table 2 were obtained from 15-minute conflict samples collected at intersections with the following characteristics:

- Signalized and unsignalized.
- Three- and four-leg approaches.
- Low speed $<$40 mi/h and high speed $\geq$ 40 mi/h.
- Two- and four-lane roadways.

Table 2. General observation requirements for intersections.

Conflict Type	Mean Hourly Conflicts	Estimated Hourly Variance	Hours of Observation*
Left-Turn, Same-Direction	7.14	21.53	4.6
Slow-Vehicle	3.21	5.58	5.9
Right-Turn, Same-Direction	4.89	11.20	5.1
Opposing Left-Turn	0.77	1.18	21.6
Left-Turn, From-Left	0.78	1.01	18.1
Cross-Traffic, From-Left	0.39	0.42	30.0
Left-Turn, From-Right	0.59	0.78	24.5
Cross-Traffic, From-Right	0.31	0.35	39.3
Right-Turn, From-Right	0.71	1.11	23.9
All Same-Direction	15.48	74.82	3.4

* Hours of observation required to estimate the mean hourly count within ± 50 percent with 90 percent confidence.

Source: NCHRP 219, pg. 12.[4]

As the type of intersection control can greatly affect the type of conflict and the hourly mean for that conflict type, these general requirements should be used only when no other estimates are available.

Shown in table 3 are mean hourly counts and estimated hours of observation required for various conflict types for four-leg approaches by type of intersection control and traffic volume level. These estimates are based on data collected by Migletz, et al, and variance estimates obtained from previous research.[5,4]

General Guidelines for Data Collection

Based on the estimates shown in table 3, the following guidelines are offered for determining the amount of data to collect.

Signalized Intersections - The data collection requirements for the major conflict types found at signalized intersections (same-direction and opposing left-turn conflicts), can be met in about 1 day of observation. This assumes two observers are used and count for approximately twelve 20-minute periods, alternating between opposing approaches every half-hour.

Because cross-traffic and lane-change conflicts at signalized intersections are rare, it is not practical to obtain minimum sample sizes for these conflict types.

Unsignalized Intersections - Data requirements for the predominant conflict pattern, same-direction, can be met in 1 day of observation by one observer. It is assumed the observer would alternate between the two approaches with right-of-way and collect data for twelve 20-minute periods. At lower volume intersections two observers should be used.

Table 3. Estimated observation requirements for four-leg intersections by type of control and volume level.

Signalized Intersections With Four Approaches				
	10,000 to 25,000 Vehicles per day		Greater than 25,000 Vehicles per day	
Conflict Type	Mean Hourly Conflicts	Hours of Observation	Mean Hourly Conflicts	Hours of Observation
Left-Turn, Same-Direction	12.25	1.6	7.60	4.1
Slow-Vehicle	34.36	0.1	60.82	0.1
Lane-Change	0.69	*	1.66	*
Right-Turn, Same-Direction	11.32	1.0	19.88	0.3
Opposing Left-Turn	2.64	1.8	2.00	3.2
Left-Turn, From-Left	0.04	*	0.06	*
Cross-Traffic, From-Left	0.03	*	0.01	*
Right-Turn, From-Left	0.03	*	0.01	*
Left-Turn, From-Right	0.05	*	0.04	*
Cross-Traffic, From-Right	0.02	*	0.03	*
Right-Turn, From-Right	0.34	*	0.24	*
Opposing Right-Turn-on-Red	0.01	*	0.02	*
All Same-Direction	58.61	0.3	89.96	0.1

Unsignalized Intersections With Four Approaches				
	2,500 to 10,000 Vehicles per day		10,000 to 25,000 Vehicles per day	
Conflict Type	Mean Hourly Conflicts	Hours of Observation	Mean Hourly Conflicts	Hours of Observation
Left-Turn, Same-Direction	6.42	5.7	12.07	1.6
Slow-Vehicle	9.26	0.7	13.80	0.3
Lane-Change	0.01	*	0.25	*
Right-Turn, Same-Direction	5.26	4.4	5.61	3.9
Opposing Left-Turn	0.33	*	0.82	19.1
Left-Turn, From-Left	0.31	*	0.36	*
Cross-Traffic, From-Left	0.61	12.3	0.30	*
Right-Turn, From-Left	0.05	42.0	0.02	*
Left-Turn, From-Right	0.45	*	0.39	*
Cross-Traffic, From-Right	0.48	16.5	0.30	3.8
Right-Turn, From-Right	0.50	48.4	0.82	18.0
All Same-Direction	20.96	1.9	29.01	1.0

Notes: * Indicates that the observation requirements exceed 2 weeks.

Hours of observation required to estimate the mean hourly count within ± 50 percent with 90 percent confidence.

Conflicts are based on sample counts for all four approaches at signalized intersections and two approaches with right-of-way at unsignalized intersections. The counts were taken during the day, on dry pavement, and do not include secondary conflicts.

Source: Based on References 4 and 5.

Minimum sample sizes for the other conflict types would require two observers for 1 week for some cross-traffic conflicts, and more than 2 weeks for other patterns.

Example

These guidelines are based on hourly averages which may vary considerably from site to site. Less observation would be required at sites with higher than average counts. For example, assume two observers collected conflict data at a four-leg unsignalized intersection with a total entering volume of 5,000 vehicles per day. The variable of interest to the engineer was through, cross-traffic-from-left conflicts. After 10 (25-minute) periods of counting (or 4.17 hours), 12 through, cross-traffic-from-left conflicts were observed. Adjusting the count to an hourly average -

$$(12 \text{ conflicts} / 10 \text{ periods}) \quad (60 \text{ minutes/hour} / 25 \text{ minutes/period})$$

$$= 2.88 \text{ cross-traffic-from-left conflicts per hour.}$$

This is much higher than the average of 0.61 conflicts shown in table 3.

Applying the sample size formula, where

$$t = 1.65, \ \alpha = 0.10$$

$$p = 50 \text{ percent}$$

$$\sigma e^2 = 0.42 \text{ (from table 2)}$$

$$\bar{Y} = 2.88 \text{ from the sample}$$

$$n = \frac{\left(\frac{100 \ 1.65}{50}\right)^2 (0.42)}{(2.88)^2}$$

$$n = 0.55 \text{ hours}$$

This result means that the observers have collected enough data in a 1-day sample. In fact, substituting n = 4.17 hours of observation in the sample size equation and solving for p, the result is 18. Therefore, it can be stated with 90 percent confidence that the mean is contained in the internal 2.88 ± 18 percent or between 2.36 and 3.40 cross-traffic-from-left conflicts per hour.

By applying the same principles, the engineer can calculate estimated sample sizes for other conflict types. Often it is not feasible to collect a sufficient sample size for some of the conflict categories; e.g., some of the cross-traffic conflicts. When the cross-traffic conflicts are the variables of interest, it is best to pool (add together) all the cross-traffic conflict types before estimating sample size requirements. Even with this adjustment, the engineer may have to accept less precision than is desirable.

Recording Periods

Whether the survey lasts several hours or several days, the observation periods are usually defined in terms of 1-hour blocks. In a typical 1-hour block, the observer views conflicts for a 20- or 25-minute period, records the counts, zeros the count board, then observes conflicts for another 20- or 25-minute period. Thus, a 1-hour block consists of two recording periods and two breaks. The longer the recording period, the more data are collected per hour spent in the field. A continuous recording period of more than 25 minutes is discouraged because the observer needs periodic short breaks to maintain concentration.

Typical recording intervals are 20- or 25-minute periods. A 20-minute period is suggested when the observer has to alternate between adjacent approach legs at the end of each count. A 25-minute period is recommended when more than one observer is used, thus eliminating the need to alternate between adjacent approaches every half-hour. At some rural intersections, however, a 25-minute period is desirable because the 5-minute break is usually sufficient time to alternate between approaches.

The number of recording periods needed is determined by the hours of observation required and the length of the recording interval. For example, if the hours of observation needed is 4.1 and the recording interval is 25 minutes, the number of recording periods required is -

$$= \frac{(4.1 \text{ hours})\ (60 \text{ minutes/hour})}{(25 \text{ minutes/period})}$$

$$= 9.8 = 10 \text{ periods.}$$

When to Collect Conflict Data

It should be kept in mind that traffic conflicts are indicative of hazardous situations involving interactions between road users. Generally, traffic conflicts will occur most frequently when traffic volumes are heavy. The most effective time for conflict observations is during the morning and afternoon peak periods, unless traffic becomes totally congested. Other good times at many locations are noon peaks and during the late mid-afternoon. To represent actual traffic conditions, conflict observations should typically be made at different times throughout the day.

Accident data or other information such as citizen complaints or police hazard reports may suggest other times are more appropriate for the problem being investigated. Conflict data are normally obtained during weekdays--any weekday is appropriate. If safety problems are reported at other times such as on weekends, the conflict counts should be obtained during these periods.

Number of Observers Needed

The number of observers needed to conduct a conflict survey is dependent upon a number of factors including the type of control, the amount of conflict and other data needed, the type of study, and the number of trained observers available.

Usually one observer should be used at unsignalized intersections while a minimum of two observers are desirable for signalized intersections. In cases where large sample sizes are needed, it may be desirable to use two observers at unsignalized intersections and four observers at signalized intersections.

If volume or other data such as vehicle delay is needed, one observer is required to make the conflict counts and one observer should be used to collect the delay data. For some low volume conditions, one observer can usually record conflicts and turning movements accurately, but as a general rule, the conflict observer should only record conflicts. Assigning too many tasks to the conflict observer could affect the reliability of the counts and should always be avoided.

Conducting the Conflict Survey

After determining the type and amount of data needed, the study intersections should be scheduled for observation. At this time the engineer must rely on the trained observers to conduct the counts and collect any other data specified.

Sample data collection forms are included in the appendix of this guide, as well as in the observer's manual. One form of particular note is the On-Site Observation Form, which should always be completed by the observer after the conflict counts have been completed. Observer notes on this form are often helpful in interpreting the conflict results.

Procedures for the observers to use in preparing for the survey, arriving at the study location, and conducting the survey are detailed in the observer's manual. If a before and after conflict study is planned, the engineer should remind the observer to record the location of the observation position so the same point can be used in the after study.

When an agency first initiates a traffic conflict program or when new observers are hired, it is desirable to provide the observer with a detailed data collection schedule. A sample schedule is shown in table 4. The sample schedule is for one observer collecting conflict data for 20-minute periods at an unsignalized intersection. In this case, the observer must alternate between the two approaches with right-of-way.

CHAPTER 6 - DATA REDUCTION

The conflict data, as collected in the field, must be compiled and presented in a format suitable for analysis and interpretation. The procedures needed to prepare the raw conflict counts for analysis are presented in this section.

For purposes of illustrating the process, the manual method is used in this discussion. If conflict studies are conducted on a routine basis, it is cost-effective to automate most of the steps.

Table 4. Sample conflict observation schedule.

Time	Activity
0700-0710	Preparation at site.
0710-0730	Observe conflicts on Approach A.
0730-0740	Record data and move to Approach B.
0740-0800	Observe conflicts on Approach B.
0800-0810	Record data and move to Approach A.
0810-0830	Observe conflicts on Approach A.
0830-0840	Record data and move to Approach B.
0840-0900	Observe conflicts on Approach B.
0900-0930	Record data, break, and move to Approach A.
0930-1130	(4 observation periods alternating between study approaches as shown above).
1130-1215	Lunch break.
1215-1230	Photograph approach legs and move to Approach A.
1230-1430	(4 observation periods alternating between study approaches as shown above).
1430-1500	Record data, break and move to Approach A.
1500-1730	(5 observation periods alternating between study approaches as shown above).
1730-1800	Complete on-site observation reports, check conflict form for errors and missing information, and update roadway inventory.

Note: A 5-minute deviation is allowed in the count start time, but conflicts must be observed for 20 minutes each period.

Initial Review

At the conclusion of the field survey, the observer has the responsibility of adding the columns, checking the data forms for missing data and entries recorded in the wrong column. When the data are returned to the office for analysis, the engineer should immediately review the forms for completeness and obvious errors. Observer comments, especially regarding unusual or unexpected conflicts or traffic events should be discussed while the items are still fresh in the mind of the observer. Many simple mistakes can readily be corrected at this time, but not after a few days when details are forgotten.

Some of the items to check are:

- Accountability for all forms. Are any missing and, if so, why?
- Proper completion of heading information. Are all blanks filled? Are approach directions and observation times consistent on all forms? Is the observer's name on the form?
- Are all data entries completed? Are they legible? Do they make sense; e.g., if the study intersection is signalized a high number of through, cross-traffic conflicts should be questioned. Also, there should not be secondary conflicts in any column or recording period when there are no primary conflicts.
- Are there comments? Are they clear and understandable? Are there any observer questions that should be discussed with the observer?

It is desirable practice at this time to make a cursory review of the data to determine if the sample sizes obtained are sufficient for analysis. Procedures for estimating sample sizes for traffic conflict counts were discussed in chapter 5 (page 39) of this guide.

Data Summations

The raw conflict counts are used to produce certain sums and rates which are needed for analysis. The steps for summarizing the data are outlined below.

Step 1 - Total the Raw Counts for Each Approach Leg

Data reduction begins with the field conflict forms. The observers should add the raw conflict counts by type of conflict and write the totals in the space provided at the bottom of the form. Separate totals should be provided for each conflict type and for each related secondary conflict type. If the one-way approach volume was collected, the total volume recorded should be entered in the space provided. Finally, the total conflicts and total secondary conflicts for each conflict category should be combined and the total entered in the space provided on the form.

These summations should be conducted separately for each intersection approach. An example of a completed field conflict form for one approach leg is shown in figure 26.

In the event that more than one data form was used on an approach leg, the totals should be placed on the last data form; i.e., do not record totals for each sheet.

One purpose of the summary is to estimate the total daily number of traffic conflicts by type for each approach leg. For example, assume that an observer counted conflicts on one approach leg in the afternoon. The next day the observer used another form to record conflicts on that same approach leg in the morning. As the conflict data represent 1 day of recording, the totals should include the data on both forms, but the totals should be recorded only at the bottom of the second form.

A departure from the normal summarization process occurs when conflict data are recorded for several days or more on the same approach leg. In this situation, two cases are possible and each requires a different summary technique.

Case 1 - Multiple Day Counts with Non-Overlapping Count Times on Each Day. In this case, conflict data are recorded at different time periods each day. For example, assume that a 20-minute recording period was used and the observer is alternating every half-hour between two opposite approach legs. On the first day, the observer begins the counts at 8:00 a.m. on one approach, then moves to the opposite approach and begins counting at 8:30 a.m. The process is repeated throughout the day. On the next day, the observer again begins counting at 8:00 a.m., but this time, began on the opposite approach. Thus, for the two days of counting, none of the counts have overlapping time periods for a given approach.

Because the conflict samples were taken for different time periods, the counts only represent one day of counting. In this case, the counts should be summed for both days and the totals for each conflict category should be shown only on the last count form.

Case 2 - Multiple Day Counts with Overlapping Count Times Each Day. In this case, conflict data are recorded for the same time periods each day. For example, in this situation, the observer begins counting on the same approach at the same time each day.

The samples taken on the same approach at the same time are not representative of one day of counting. To obtain totals for each conflict category, it is first necessary to add the counts for each repeated or overlapping time period, then divide by the number of times or days the count was taken at the same time period. For example, assume a 2-day count began at 8:00 a.m. each day on the same approach. On the first day, 4 left-turn, same-direction conflicts were recorded during the first 20-minute recording interval. On the second day, 6 left-turn, same-direction conflicts were recorded during the same 20-minute period. The average conflict count per day for the

INTERSECTION TRAFFIC CONFLICTS

Location *Oak and Pine Streets* Leg Number *3 (WB)*

Day *Thursday* Date *Nov. 12, 1987* Observer *BP* Length of Recording Period *25 Minutes*

C = Conflict SC = Secondary Conflict

Count Start Time (Military)	Time Period	Approach Volume	Left-Turn Same Direction		Right-Turn Same Direction		Slow Vehicle		Lane Change		Opposing Left-Turn		Right-Turn From-Right		Left-Turn From-Right		Through From-Right		Right-Turn From-Left		Left-Turn From-Left		Through From-Left		~~Right-Turn On-Red~~ NA						Other
			C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	
730	1	127	9	2	2	0	3	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0							
930	2	86	6	1	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
1130	3	62	5	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0							
1400	4	67	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
1500	5	72	6	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
~~1600~~																															
1700	6	77	7	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0							
Total		491	37	3	6	0	15	0	0	0	2	0	1	0	1	0	0	0	0	0	0	0	1	0							
C + SC			40		6		15		0		2		1		1		0		0		0		1								

Comments *Observed large demand for left turns.*
Opposing left-turn drivers take chances to avoid delay.
1600 count stopped due to a heavy downpour.

Figure 26. Example of a completed conflict data form.

first time period is (4 + 6) / 2 = 5 left-turn, same-direction conflicts. The average values should be recorded and totaled on a third conflict sheet. Note that totals are not needed for each day on the field data forms.

Step 2 - Combine Counts on all Approaches to Produce Totals for the Intersection

When conflict data are recorded simultaneously on two or more approach legs, these data should be added to produce total conflict counts for the intersection. The totals for each intersection approach leg provide valuable information for diagnostic purposes but, at present, cannot be used to determine the magnitude of the problem. In this step, the conflict counts by time period and type of conflict for each approach leg should be added together and the results recorded on the intersection conflict summary form. The purpose of this summary is to produce a total number of conflicts by type for the intersection. At signalized intersections with four approach legs, the conflict data for the four approaches should be added together and the totals recorded on the conflict summary form. At unsignalized intersections, the conflict data for the two approaches with right-of-way would be totaled on the summary form. A copy of the blank summary form is included in the appendix.

An example of a completed conflict summary form is presented in figure 27. Note that the observations were made during the same time periods so the conflict totals include both approach legs at this unsignalized intersection.

In cases where the conflict data are recorded at different times on each approach, the conflict data should not be combined in this step. The data should be summarized as outlined in steps 3 though 5.

Step 3 - Combine Conflict Categories

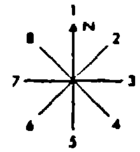
While the individual conflict categories provide detailed information that is useful in pinpointing specific problem areas or suggesting certain countermeasures, some conflict categories should be combined on the summary form to examine the magnitude of the problem. For example, all same-direction conflicts should be combined, as well as all through, cross-traffic conflicts. These categories are shown in the right-hand columns in figure 27. The same-direction conflict category consists of adding the following conflict types:

- Left-turn, same-direction.
- Right-turn, same-direction.
- Slow vehicle.
- Lane-change.

The through, cross-traffic category is obtained by summing the through, cross-traffic-from-left and the through, cross-traffic-from-right conflict types.

Other combinations may be useful for some intersections. For example, combining left-turn, same-direction and opposing left-turn conflicts may be helpful in quantifying safety problems related to the absence of a left-turn lane and/or a left-turn phase at signalized intersections. In other cases the engineer may want to combine all cross-traffic conflicts or all pedestrian conflicts. The decision should be based on a number of factors including the

INTERSECTION TRAFFIC CONFLICTS SUMMARY



Location Oak and Pine Streets Leg Number(s) 3 & 7 (EB & WB)

Day Thursday Date Nov. 12, 1987 Observer(s) BP, LN Length of Recording Period 25 Minutes

C = Conflict SC = Secondary Conflict

Count Start Time (Military)	Time Period	Approach Volume	Left-Turn Same Direction		Right-Turn Same Direction		Slow Vehicle		Lane Change		Opposing Left-Turn		Right-Turn From-Right		Left-Turn From-Right		Through From-Right		Right-Turn From-Left		Left-Turn From-Left		Through From-Left		Right-Turn On-Red (NA)		All Same Direction		All Through Cross-Traffic		Other
			C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	
730	1	218	15	2	2	0	4	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0			21	2	0	0	
930	2	167	11	1	1	0	6	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0			18	1	1	0	
1130	3	135	9	0	3	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0			17	0	1	0	
1400	4	129	8	0	2	0	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0			13	0	0	0	
1500	5	131	16	0	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			16	0	0	0	
1700	6	157	18	2	3	0	6	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0			27	2	0	0	
Total		937	71	5	12	0	29	0	0	0	4	0	3	0	2	0	1	0	0	0	1	0	1	0			112	5	2	0	
C + SC			76		12		29		0		4		3		2		1		0		1		1				117		2		
Daily Count Conflicts only			309.9		54.1		128.6		0		17.4		13.8		8.3		4.8		0		4.8		5.4				492.6		10.2		
Rate Per 1,000 Veh C+SC			81.1		12.8		31.0		0		4.3		3.2		2.1		1.1		0		1.1		1.1				124.9		2.1		

Figure 27. Example of a completed intersection conflict summary form.

problem under investigation and the available sample size. In combining categories, the engineer should always be certain that the categories are related in a logical fashion to either the existing intersection conditions; e.g., absence of a left-turn lane, or to the countermeasure; e.g., increase green time on the main street. It is never proper to randomly combine categories just to have a large sample of traffic conflicts.

It is important to note that no grand total; e.g., all conflicts, is calculated. A grand total is meaningless, as it is not useful for diagnostic or evaluation purposes.

If the conflict data are recorded simultaneously on the approaches, the conflict categories should be combined, using the intersection conflicts summary form, to produce intersection totals. If the data are not collected simultaneously, the conflict categories should be combined separately for each approach leg.

Step 4 - Determine Daily Conflict Counts

To determine the magnitude of the problem (compare the site counts to counts obtained at other similar sites), it is necessary to adjust the primary conflict counts equivalent to an 11-hour day. The purpose of this adjustment is to provide a standard for comparing conflict counts. This comparison allows the engineer to identify abnormally high conflict types at any study intersection with similar traffic control, and volume characteristics.

The adjustment process consists of estimating the number of primary conflicts, by type, that occur during the nonobservation periods, then adding the observed conflicts and the estimated conflicts to produce the total number of daily conflicts for the intersection. The daily conflict count is an estimate of the primary conflicts, by type, that occur during an 11-hour weekday. The standard 11-hour day begins at 7:00 a.m. and ends at 6:00 p.m.

A crude estimate of the daily conflict count may be obtained by multiplying the proportion of observed conflicts to the actual recording time by 11 hours. For example, the 71 left-turn, same-direction conflicts shown in figure 27 were recorded by two observers during six 25-minute observation periods. The 6 periods represent 150 minutes (6 times 25) of observing conflicts at the 2 intersection approach legs. An 11-hour day has 660 minutes (11 times 60). Assuming the 71 conflicts are distributed uniformly throughout the day, the daily number of conflicts is:

$$\text{Daily conflicts} = \frac{71 \times 660}{150} = 312.4$$

While simple to use, this procedure produces incorrect estimates when there is a considerable difference in the counts from period to period; e.g., peak period compared to off-peak periods. In addition, inaccuracies also occur when the recording periods are not spread out during the day.

The recommended adjustment method is to assume that conflicts occur in the nonobservation periods under similar conditions to those that occur in the immediate before and after observation periods. For example, in figure 27, 15 left-turn, same-direction conflicts occurred during the observation period 7:30 to 7:55 a.m. During the period 9:30 to 9:55 a.m., 11 conflicts were observed. The conflicts that occurred in the nonobservation period--between 7:55 and 9:30 a.m.--would receive a proportional amount of the average number of conflicts that were observed during the recording periods. Thus, between 7:55 and 9:30 a.m., the estimated number of conflicts would be:

$$\text{Number of conflicts between 7:55 and 9:30 a.m.} = \frac{C_1 + C_2}{2} \times \left(\frac{\text{total time nonobservation period}}{\text{recording period}}\right)$$

where C_1 = 15 conflicts in period 1

C_2 = 11 conflicts in period 2

from 7:55 to 9:30 = 95 minutes

recording period = 25 minutes

Therefore, the estimated number of conflicts is:

$$= \frac{15 + 11}{2} \times \frac{(95)}{(25)}$$

$$= 49.4 \text{ conflicts}$$

The estimated number of primary conflicts in the other nonobservation periods are calculated in a similar manner. Between 7:00 a.m. and the first period, it is assumed that the number of conflicts was proportional to the conflicts in the first recording period. For example, the estimated number of conflicts from 7:00 to 7:30 a.m. is:

$$= 15\ (30/25) = 18.0 \text{ conflicts}$$

The total daily number of primary conflicts for the intersection is obtained by adding the number of conflicts for the observation and nonobservation periods. An example of the calculations for the left-turn, same-direction conflict counts (for the data shown in figure 27) is presented in table 5. In this case, the crude estimate of 312.4 conflicts closely approximates the 309.9 conflicts obtained by the recommended method.

Manual calculation of the daily conflict counts is time-consuming and prone to error. To eliminate these problems, the computer program, shown in the appendix, was developed. The program is quite flexible; it can handle any number of observation periods, any start times, recording intervals of any duration, and any number of primary conflict types. The only inputs are the name of the conflict types, the number of observation periods, the length of an observation period, and the conflict count start times and raw counts. An example output, for the first 3 primary conflict patterns shown in figure 27, is presented in table 6.

The computed daily conflict counts for all primary conflict types including the combined categories are entered on the summary form as shown in figure 27.

Table 5. **Method to obtain daily conflict counts.**

Time	Proportional Number of Conflicts	Number of Conflicts
0700-0730	15(30/25)	18.0
0730-0755	15	15.0
0755-0930	(15+11)/2(95/25)	49.4
0930-0955	11	11.0
0955-1130	(11+9)/2(95/25)	38.0
1130-1155	9	9.0
1155-1400	(9+8)/2(125/25)	42.5
1400-1425	8	8.0
1425-1500	(8+10)/2(35/25)	12.6
1500-1525	10	10.0
1525-1700	(10+18)/2(95/25)	53.2
1700-1725	18	18.0
1725-1800	18(35/25)	25.2
Total 11 hours		309.9

The conflict counts shown in figure 27 were obtained by two observers who recorded conflicts during the same time periods. If one observer had obtained the data by alternating between the two approaches of interest, the start times for the approaches would not be identical. In situations where the start times for the approaches are different, the daily conflict count for the intersection is obtained by calculating the daily conflicts separately for each approach, then adding the results.

Step 5 - Calculate the Conflict Rate per 1,000 Vehicles

The conflict rate, as defined in this section, is the number of conflicts of a given type that occur for every 1,000 entering vehicles.

As shown in figure 28, the one-way approach volume for an intersection leg is the total number of vehicles entering the intersection from the observer location during each recording period. To obtain the total number of entering vehicles for the intersection, the approach volumes are added in the manner previously discussed for adding conflict data.

Table 6. Output of computer program which produces daily conflict counts.

Adjustment of Raw Conflict Counts to Daily Conflict Counts

Period	Start Time	Conflict Count
1	730	15
2	930	11
3	1130	9
4	1400	8
5	1500	10
6	1700	18

Total number of left-turn same-direction conflicts = 71

Daily left-turn same-direction conflict count = 309.9

* * * * * * * *

Adjustment of Raw Conflict Counts to Daily Conflict Counts

Period	Start Time	Conflict Count
1	730	2
2	930	1
3	1130	3
4	1400	2
5	1500	1
6	1700	3

Total number of right-turn same-direction conflicts = 12

Daily right-turn same-direction conflict count = 54.1

* * * * * * * *

Adjustment of Raw Conflict Counts to Daily Conflict Counts

Period	Start Time	Conflict Count
1	730	4
2	930	6
3	1130	5
4	1400	3
5	1500	5
6	1700	6

Total number of slow-vehicle conflicts = 29

Daily slow-vehicle conflict count = 128.6

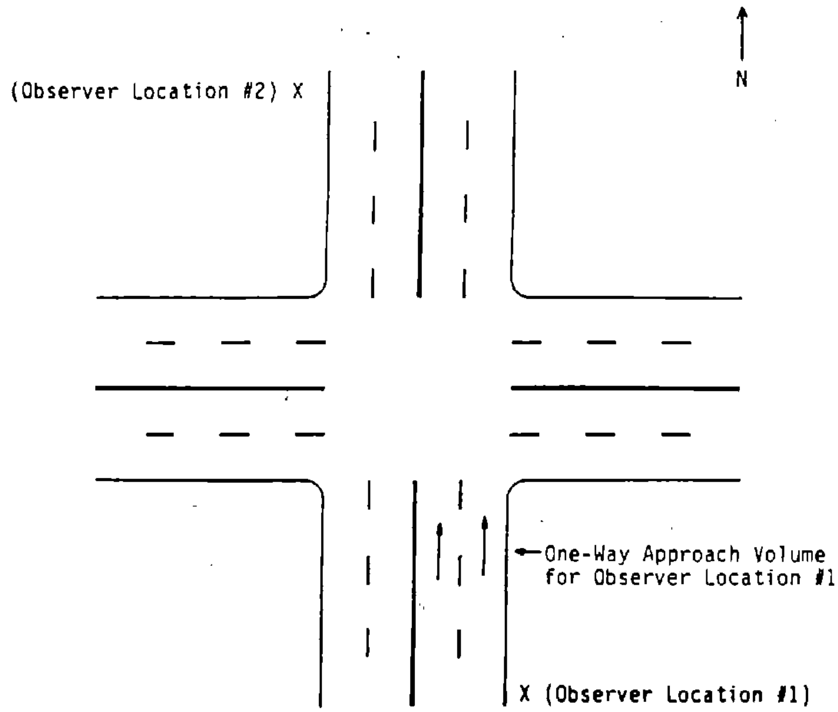


Figure 28. Site diagram showing one-way volume for an approach leg.

The calculation of the conflict rates is straightforward. For example, assume 71 left-turn, same-direction conflicts were recorded during a conflict survey. In addition to conflicts, the engineer directed the observers to record the one-way approach volumes during each observation period. Assume that the total one-way approach volume was 937 vehicles. The conflict rate is:

$$\text{Conflict Rate} = \frac{\text{Number of conflicts by type}}{\text{One-way approach volume}} \times 1{,}000$$

$$= \frac{71}{937} \times 1{,}000$$

= 75.8 left-turn, same-direction conflicts per 1,000 vehicles.

If secondary conflicts were included, the rate is 81.1 conflicts per 1,000 vehicles.

Although the conflict rate is not needed for analysis purposes, it is helpful in explaining study results to administrators and to the public. By expressing the results in terms of the rate of occurrence of conflicts, one has a better understanding of how often a particular event happens as opposed to a raw count which is difficult to interpret.

Conflict rates are usually calculated by adding the number of primary conflicts and the number of secondary conflicts for each conflict type. Volume data may be recorded by the observer during the conflict count or estimated using turning maneuver counts if they are available. The conflict rates shown in figure 27 include primary and secondary conflicts. The one-way approach volumes were recorded by the observers during the six counting periods.

Graphic Summations

An understanding of traffic engineering data is often enhanced if the results can be expressed pictorially. Because traffic conflict studies are new to many people, it is often helpful to use graphic presentations to express the study findings. One useful source is photographs of the intersection, especially of problem areas; e.g., traffic queues waiting to turn left, sight distance restrictions, or nearby driveways. Another source is a conflict diagram which typically includes the abnormal conflict pattern(s) displayed on an intersection layout. An example conflict diagram is presented in the next chapter of this guide.

Photographs of the intersection can easily be taken by the observer during the day of the survey. Conflict diagrams should only be prepared after the data have been analyzed and the abnormal patterns identified.

CHAPTER 7 - DATA ANALYSIS AND INTERPRETATION

Once conflict data are compiled, the type of analysis and subsequent interpretation of the results is dependent upon the purpose of the study. The analysis and interpretation methods for determining the magnitude of the problem, diagnosing the problem and selecting countermeasures, and for evaluating the effectiveness of improvements are presented in this section.

Determining the Magnitude of the Problem

In an accident-based analysis, a safety problem is generally defined as an abnormal occurrence of accidents or severe accidents, or an abnormally high accident rate. Differentiation between normal and abnormal is decided by each highway agency based on a number of factors including the type of roadway element, traffic volume, geometric design, type of traffic control, and available resources.

While the ultimate goal of a highway safety program may be to eliminate accidents, and accident potential, most traffic engineers realize that total elimination of accidents is not possible as highway elements are only one of the factors that are involved in the causal process. A more realistic approach, and one that is commonplace, is to group roadway elements by type of location and collect accident data on each highway type. Mean or average accident frequencies or rates are calculated, then an abnormally high limit or critical value is determined statistically. Locations with abnormally high frequencies or rates are selected for indepth analysis. The major purpose of the procedure is to identify and target limited safety funds to those locations that are much worse, from a safety standpoint, than other similar locations.

In the past, one major problem with using traffic conflicts for analysis was determining the magnitude of the problem; i.e., how many conflicts suggest a safety problem? There were few average conflict values for intersections and no abnormal limits were established. Research by Migletz, et al, provided abnormally high conflict counts for signalized and unsignalized intersections with four approach legs, and a process that can be used to develop daily counts and abnormal limits for other intersection designs and traffic volume levels.[5] The use of these data to examine the magnitude of the problem is presented next.

How To Identify Abnormally High Conflict Counts

Similar to the way accident data are used to identify locations with abnormally high accident frequencies or rates, traffic conflict data can be used to determine if a study location has an abnormally high occurrence of traffic conflicts.

Average, as well as abnormally high conflict counts, were developed for four-leg intersections by collecting traffic conflicts at a sample of intersections with similar types of control and traffic volume. The counts were made using the standard procedures presented in this guide. Average daily conflict counts for each conflict type were calculated from the sample, then abnormal limits were determined statistically. The results for unsignalized and signalized intersections are shown in tables 7 and 8, respectively.

Practical application of these tables is straightforward. The conflict data summarized in figure 27 provide an illustrative example. Assume the conflict data were collected at an unsignalized intersection with four approach legs. The total entering volume was estimated to be 15,000 vehicles per day. Based on the conflicts observed at the intersection, the daily count for left-turn, same-direction conflicts was estimated to be 309.9. From table 7, the daily average and 90th percentile values for left-turn, same-direction conflicts are 132.7 and 275.0, respectively, for similar intersections in the 10,000 to 25,000 volume class.

Comparison of the values indicates that daily left-turn, same-direction conflicts at the study location are well above the average expected value of 132.7 for similar locations. Also, if the 90th percentile is accepted as abnormally high, the study site exceeds this criterion (e.g., 309.9>275.0). If the daily count of left-turn, same-direction conflicts at the study intersection is abnormally high, corrective action is warranted to reduce or eliminate the pattern.

Once the daily conflict counts are computed at a study site, the counts should be compared to the average and abnormal values shown in the tables. Conflict types with abnormally high counts are identified as problems that warrant corrective action.

A comparison of the conflicts at the study site (from the figure 27 data) to similar intersections (from table 7) is shown in table 9. The results indicate that two conflict types--left-turn, same-direction and opposing left-turn--have abnormally high counts. The next step in the analysis process is to use the conflict data as a diagnostic tool to identify possible causes of these patterns.

Table 7. Mean and abnormal daily conflict counts for four-leg, two-way stop, unsignalized intersections.

Total Volume: 2,500 to 10,000 Vehicles Per Day

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count 90th Percentile	95th Percentile
1. Left-Turn, Same-Direction	70.645	1,005.0	110.0	130.0
2. Slow-Vehicle	101.861	9,648.2	225.0	295.0
3. Lane-Change	0.105	0.050	-	-
4. Right-Turn, Same-Direction	57.912	2,197.3	120.0	150.0
5. Opposing Left-Turn	3.640	8.300	7.5	9.0
6. Left-Turn-From-Left	3.366	7.790	7.0	9.0
7. Cross-Traffic-From-Left	6.698	42.0	1.5	19.0
8. Right-Turn-From-Left	0.567	0.828	-	-
9. Left-Turn-From-Right	4.993	72.7	16.0	23.0
10. Cross-Traffic-From-Right	5.228	11.6	10.0	12.0
11. Right-Turn-From-Right	5.546	12.1	10.0	12.0
1 thru 4 Same-Direction	230.523	17,929.2	410.0	490.0
7 plus 10 Through-Cross-Traffic	11.926	75.2	24.0	29.0

Total Volume: 10,000 to 25,000 Vehicles Per Day

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count 90th Percentile	95th Percentile
1. Left-Turn, Same-Direction	132.745	11,643.4	275.0	350.0
2. Slow-Vehicle	151.831	5,921.8	255.0	290.0
3. Lane-Change	2.797	22.6	-	-
4. Right-Turn, Same-Direction	61.695	1,156.5	105.0	125.0
5. Opposing Left-Turn	8.982	39.8	17.0	21.0
6. Left-Turn-From-Left	3.913	6.452	7.0	9.0
7. Cross-Traffic-From-Left	3.250	4.644	6.0	7.5
8. Right-Turn-From-Left	0.165	0.077	-	-
9. Left-Turn-From-Right	4.333	21.2	10.0	14.0
10. Cross-Traffic-From-Right	3.327	4.297	6.0	7.5
11. Right-Turn-From-Right	8.972	99.4	21.0	29.0
1 thru 4 Same-Direction	319.068	28,650.5	540.0	640.0
7 plus 10 Through-Cross-Traffic	6.577	15.7	12.0	14.0

Note:
- Conflict counts are the total number of conflicts per 11-hour day (7 a.m. to 6 p.m.) for the two approaches with right-of-way. The counts were obtained on weekdays, on dry pavement, and do not include secondary conflicts.
- Blanks indicate these conflict types are so rare that any number observed at an intersection should be considered abnormal.

Table 8. Mean and abnormal daily conflict counts for four-leg signalized intersections.

Total Volume: 10,000 to 25,000 Vehicles Per Day

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count 90th Percentile	95th Percentile
1. Left-Turn, Same-Direction	134.724	10,298.3	270.0	340.0
2. Slow-Vehicle	377.938	4,928.9	470.0	500.0
3. Lane-Change	7.621	52.8	17.0	22.0
4. Right-Turn, Same-Direction	124.476	2,445.1	190.0	220.0
5. Opposing Left-Turn	29.057	211.2	49.0	56.0
6. Left-Turn-From-Left	0.463	0.466	1.3	1.9
7. Cross-Traffic-From-Left	0.289	0.240	-	-
8. Right-Turn-From-Left	0.333	0.188	0.8	1.1
9. Left-Turn-From-Right	0.515	0.125	1.0	1.2
10. Cross-Traffic-From-Right	0.229	0.118	0.7	1.0
11. Right-Turn-From-Right	3.707	2.839	6.0	7.0
12. Opposing Right-Turn-on-Red	0.094	0.058	-	-
1 thru 4 Same-Direction	644.760	25,338.4	860.0	930.0
7 plus 10 Through-Cross-Traffic	0.519	0.215	1.1	1.4

Total Volume: Greater than 25,000 Vehicles Per Day

Conflict Type	Mean Conflict Count	Variance	Abnormally High Conflict Count 90th Percentile	95th Percentile
1. Left-Turn, Same-Direction	83.644	11,613.7	265.0	360.0
2. Slow-Vehicle	669.051	23,994.7	870.0	940.0
3. Lane-Change	18.211	160.6	35.0	43.0
4. Right-Turn, Same-Direction	218.625	7,587.5	470.0	510.0
5. Opposing Left-Turn	22.001	377.7	48.0	60.0
6. Left-Turn-From-Left	0.631	0.824	1.7	2.5
7. Cross-Traffic-From-Left	0.140	0.135	-	-
8. Right-Turn-From-Left	0.062	0.022	-	-
9. Left-Turn-From-Right	0.417	0.261	1.1	1.4
10. Cross-Traffic-From-Right	0.290	0.215	-	-
11. Right-Turn-From-Right	2.603	2.268	4.6	5.4
12. Opposing Right-Turn-on-Red	0.227	0.124	-	-
1 thru 4 Same-Direction	989.531	67,198.4	1,340.0	1,460.0
7 plus 10 Through-Cross-Traffic	0.430	0.335	1.1	1.5

Note:
- Conflict counts are the total number of conflicts per 11-hour day (7 a.m. to 6 p.m.) for all four approaches. The counts were obtained on weekdays, on dry pavement, and do not include secondary conflicts.
- Blanks indicate these conflict types are so rare that any number observed at an intersection should be considered abnormal.

Table 9. **Identification of abnormally high conflict patterns.**

Conflict Type	Daily Counts For Similar Locations Mean Count	90th Percentile	Daily Counts At Study Site
1. Left-Turn, Same-Direction	132.745	275.0	309.9*
2. Slow-Vehicle	151.831	255.0	128.6
3. Lane-Change	2.797	-	0.0
4. Right-turn, Same-Direction	61.695	105.0	54.1
5. Opposing Left-Turn	8.982	17.0	17.4*
6. Left-Turn-From-Left	3.913	7.0	4.8
7. Cross-Traffic-From-Left	3.250	6.0	5.4
8. Right-Turn-From-Left	0.165	-	0.0
9. Left-Turn-From-Right	4.333	10.0	8.3
10. Cross-Traffic-From-Right	3.327	6.0	4.8
11. Right-Turn-From-Right	8.972	21.0	13.8
1 thru 4 Same-Direction	319.068	540.0	492.6
7 plus 10 Through-Cross-Traffic	6.577	12.0	10.2

* Denotes abnormally high conflict pattern.

A Word of Caution About Abnormally High Conflict Counts

The daily mean and abnormal conflict counts shown in tables 7 and 8 were determined from conflict data collected in the field at a sample of 46 intersections located in the Kansas City area. The intersections have the following characteristics:

- Four-leg approaches.
- Minimal pedestrian traffic.
- No unusual sight distance restrictions.
- No unusual signal timing or phasing.
- No appreciable grade.
- No turn restrictions or one-way streets.
- No part-time parking restrictions.

The traffic conflict data at the intersections were collected on weekdays between the hours of 7:00 a.m. and 6:00 p.m. The data were collected on dry pavement. The daily counts do not include secondary conflicts. At unsignalized intersections, the daily counts represent a total for both approaches with right-of-way. The daily counts are for all four approaches at signalized intersections.

When using the values in tables 7 and 8, the engineer should check to be certain the study site has characteristics which are similar. Also, of equal importance is that the conflict data were collected and analyzed in the manner described in this guide.

Before concluding that the conflict patterns are abnormal at a study location, the engineer should take the following action:

1. Check observer consistency and collect the data again if differences are discovered.

2. Check the intersection characteristics of the study site to be certain that conditions; e.g., signalization, volume level, and geometry are similar to the Kansas City locations.

3. Although no conclusive evidence exists, there may be important regional differences that affect conflict counts. If traffic conflict studies consistently produce average daily counts or variances higher or lower than those shown in tables 7 and 8, regional differences may exist. In this case, expected and abnormal values will have to be developed for a sample of intersections in the area. This process is outlined later in this chapter.

Considerations in Defining Abnormal Limits

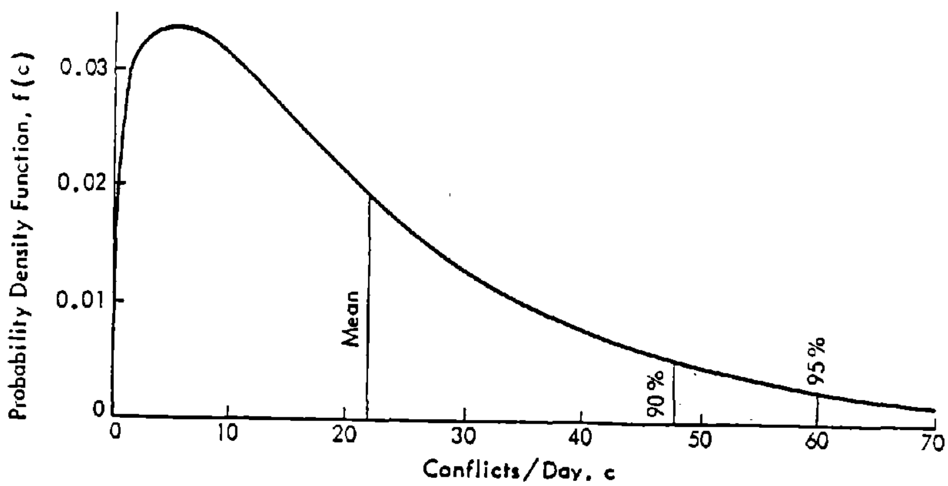
In an earlier example, the 90th percentile was arbitrarily selected as an abnormal condition. The choice of a limit such as the 90th percentile means that about 10 percent of the intersections will have conflict counts higher than the 90th percentile values.

While no definitive rule exists, the choice of an upper limit should be based on several factors including the available resources; i.e., personnel and safety budget. For example, an engineer could decide to define abnormally high as all counts which exceed the average or mean daily count. If personnel were available to conduct all the studies and the safety budget were large enough to undertake measures to reduce conflicts that exceeded the average value, this approach may have merit. However, the reality is that only a small proportion of the intersections in most jurisdictions can be studied, and a much smaller proportion will receive corrective action. Sites which have conflict counts near or slightly above the mean may receive treatment in lieu of other locations which are much more hazardous. To judiciously allocate resources to receive the greatest safety benefits, it is necessary to examine and treat the worst cases. Upper limits, such as the 90th percentile, represent a practical method for limiting safety funds to locations which are, by comparison to other sites, more hazardous.

How to Establish Abnormal Values for Other Percentiles

The abnormally high daily conflict counts shown in tables 7 and 8 were established for the 90th and 95th percentiles. The process for determining the values for other percentiles is shown in the following example.

Traffic conflict data tend to have skewed distributions with a larger tail at the higher conflict-count values. A typical distribution is shown in figure 29. The Gamma probability distribution is appropriate for these data.



Source: Reference 5.

Figure 29. Distribution of opposing left-turn conflicts for high-volume signalized intersections.

Parameters of the Gamma distribution, t and s, are defined in terms of their mean (or expected value) and variance. Thus,

t = mean/variance

s = t x mean

To determine the 80th percentile conflict count for the opposing left-turn conflict category for signalized intersections with traffic volumes exceeding 25,000 vehicles per day, the following procedure should be followed.

From table 8, the mean value for opposing left-turn conflicts is 22.0 and the variance is 377.7. Thus,

t = 22.0 / 377.7 = 0.05825

s = 0.05825 x 22.0 = 1.28

The Chi-Square distribution can be used to estimate the percentile values. Thus,

$$v = 2s = 2 \times 1.28 = 2.56$$

Note that v is the degrees of freedom.

From table 10, χ^2_{80} with v = 2.56 is found by interpolating as shown below:

v	χ^2_{80}
2	3.219
2.56	y
3	4.642

Thus, $y = 0.56\ (4.642 - 3.219) + 3.219 = 4.02$.

The 80th percentile value is:

$$C_{80} = \frac{\chi^2_{80}}{2t}$$

$$= 4.02 / (2 \times 0.05825)$$

$$C_{80} = 34.5 \text{ daily conflicts}$$

In a similar manner, the 80th or other percentile values can be calculated for the other conflict types.

How to Develop Daily Conflict Values for a Particular Area or Intersection Characteristic

As previously mentioned, if conflict studies consistently produce mean daily counts and variances above or below the values shown in tables 7 and 8, there may be regional differences in driver behavior or environmental conditions that influence the counts. Also, some engineers may need average and abnormal conflict values for other intersection types such as three-leg signalized or three-leg one-way, or conflict types, such as pedestrian, or bicycle conflicts. In either case, it is necessary to develop new daily conflict values based on local highway and environmental conditions.

The process for developing average and abnormal daily conflict counts for any geographic area or intersection characteristic is outlined in the following example.

For purposes of illustration, assume that the engineer wants to develop mean and abnormal conflict counts for a three-leg signalized intersection with entering traffic volumes between 7,500 and 12,000 vehicles per day. The process for developing the mean and abnormal counts consists of the following steps.

Table 10. Chi-Square values.

V Degrees of Freedom	α-level 0.20	0.10	0.05	0.01
1	1.642	2.706	3.841	6.635
2	3.219	4.605	5.991	9.210
3	4.642	6.251	7.815	11.345
4	5.989	7.779	9.488	13.277
5	7.289	9.236	11.070	15.086
6	8.558	10.645	12.592	16.812
7	9.803	12.017	14.067	18.475
8	11.030	13.362	15.507	20.090
9	12.242	14.684	16.919	21.666
10	13.442	15.987	18.307	23.209
11	14.631	17.275	19.675	24.725
12	15.812	18.549	21.026	26.217
13	16.985	19.812	22.362	27.688
14	18.151	21.064	23.685	29.141
15	19.311	22.307	24.996	30.578
16	20.465	23.542	26.296	32.000
17	21.615	24.769	27.587	33.409
18	22.760	25.989	28.869	34.805
19	23.900	27.204	30.144	36.191
20	25.038	28.412	31.410	37.566
21	26.171	29.615	32.671	38.932
22	27.301	30.813	33.924	40.289
23	28.429	32.007	35.172	41.638
24	29.553	33.196	36.415	42.980
25	30.675	34.382	37.652	44.314
26	31.795	35.563	38.885	45.642
27	32.912	36.741	40.113	46.963
28	34.027	37.916	41.337	48.278
29	35.139	39.087	42.537	49.588
30	36.250	40.256	43.773	50.892
35	41.778	46.059	49.802	57.342
40	47.269	51.805	55.758	63.691
45	52.729	57.505	61.656	69.957
50	58.164	63.167	67.505	76.154
60	68.972	74.397	79.082	88.379
70	79.715	85.527	90.531	100.425
80	90.405	96.578	101.879	112.329
90	101.054	107.565	113.145	124.116
100	111.667	118.498	124.342	135.806
120	132.806	140.233	146.567	158.950
140	153.854	161.827	168.613	181.840
160	174.828	183.311	190.516	204.530
180	195.743	204.704	212.304	227.056
200	216.609	226.021	233.994	249.445

Step 1 - Select a Sample of Similar Sites

Sites with similar characteristics, i.e., three-leg, signalized, and carrying between 7,500 and 12,000 vehicles per day should be selected from the available sites in the area. At least 10 sites should be chosen. While the sample sites must be signalized, have 3 approach legs, and carry between 7,500 and 12,000 vehicles per day, there can be some differences in other physical features. For example, some sites may have two lanes while others have three lanes. A left-turn lane may exist at a few sites while many of the intersections will not have turn lanes.

Step 2 - Collect Conflict Data

For each intersection selected in Step 1, traffic conflict data must be obtained. Based on previous experience, at least three observers should collect the data, i.e., one observer on each approach. The observers should obtain samples simultaneously for 1 day at each intersection using the data collection procedures described in this guide.

Step 3 - Estimate Daily Conflict Counts for Each Intersection

Using the intersection conflict summary sheets and the computer program discussed in the section on data reduction, compute daily conflict counts for each intersection and each conflict type. While the daily counts should be adjusted to reflect an 11-hour day, the engineer may choose to use both primary and secondary conflicts in developing the daily count. This choice is up to the engineer.

Step 4 - Calculate the Mean and Variance for Each Conflict Type

After the daily counts for each conflict type at each sample intersection have been calculated, the mean and variance of the daily counts for the sample intersections must be computed. For example, to calculate the mean number of left-turn, same-direction daily conflicts for a sample of 10 intersections, one would add the number of daily left-turn conflicts at each site and divide by 10, the number of sites. The process for calculating the variance is included in the appendix.

Step 5 - Calculate Abnormally High Limits

In this step the engineer must define an abnormally high limit by selecting an upper percentile value, e.g., 80th, 90th, etc. Assume that the mean number of left-turn, same-direction conflicts for the 10 similar sites was 126.2, the variance was 9,827.1, and the engineer selected the 90th percentile as an abnormally high limit. The 90th percentile daily number of conflicts is:

$$t = \text{mean/variance} = 126.2 / 9{,}827.1 = 0.01284$$

$$s = t \times \text{mean} = 0.01284 \times 126.2 = 1.62$$

$$v = 2s = 2 \times 1.62 = 3.24$$

From table 10, χ^2_{90} with v = 3.24 is found by interpolating.

v	χ^2_{90}
3	6.251
3.24	y
4	7.779

Thus, y = 0.24 (7.779 - 6.251) + 6.251 = 6.62

$$C_{90} = \frac{\chi^2_{90}}{2t}$$

$$C_{90} = 6.62 / (2 \times 0.01284)$$

$$C_{90} = 257.8 \text{ conflicts}$$

Thus, the 90th percentile is 257.8 left-turn, same-direction conflicts per 11-hour day. Abnormal limits for the other conflict types are calculated in a similar manner.

After calculating the mean and abnormal limits, the engineer now has a standard to compare all other similar intersections that may be selected for study. Should the daily counts at any study location exceed the abnormal limits, it can be concluded that the study site has an abnormally high conflict pattern.

Diagnosing Safety Problems

After abnormally high conflict patterns are identified at an intersection, the traffic conflict and other data are used to diagnose possible causal factors. Some of the other data used in this analysis includes:

- Geometric design features as shown on the site diagram.
- Traffic volume data.
- Results of the on-site observation report.

Also, the results of the conflict survey may identify other studies that should be conducted such as delay, capacity, or traffic signal study. The process for using these data to diagnose safety problems is illustrated in the following example.

The Diagnostic Process

The first step in the diagnostic process is to review the conflict data for each approach, but this time, the engineer is concerned with the abnormally high conflict types. Note that the counts with the highest frequency are not always identified as abnormal. The conflict forms and on-site inspection report completed by the observer often have important insights concerning the causes of specific conflict types; e.g., right-turn, same-direction conflicts may occur predominantly on one approach with a large right-turn volume and no right-turn lane. In this case, the right-turn conflict was identified as the abnormal pattern. The site diagram confirms that there is no right-turn lane on the approach. A traffic turning movement count quantifies the amount of traffic that turns right.

An additional example is useful in illustrating the diagnostic process. Returning to the conflict data summarized in figure 27, two conflict types were found to be abnormally high (as shown in table 9); i.e., left-turn, same-direction and opposing left-turn. Using this information, the engineer should return to the raw conflict data (see figure 26 for one approach) and the on-site observation report. Notes taken by the observers clearly indicated that the large volume of left turns from both mainline approaches was causing drivers to accept short gaps to prevent a rear-end collision situation on this two-lane road. The site diagram revealed that there were no turn lanes.

Using traffic conflicts as a diagnostic tool often identifies factors that may go undetected in a conventional safety and operational analysis. This is especially true of rear-end type accidents which may appear to be spread out throughout the day and not related to any particular approach or turning movement. Because traffic conflicts are dynamic events that are related to accidents, the observer has an opportunity to record the cause for many conflicts. For example, slow-vehicle conflicts, which are related to rear-end collisions, may be influenced predominantly by one source; e.g., a nearby driveway, or several factors; e.g., a nearby driveway and a capacity restriction downstream. With accident data, the engineer can only speculate as to what the possible causes of the rear-end accident problem is--with conflict data, the engineer can usually identify the unique cause or causes.

Using Conflicts to Confirm Accident Problems

The previous section discussed using conflict data alone to diagnose safety and operational problems. However, even in cases where reliable accident data are available, traffic conflict data can be of considerable value for:

- Confirming that a problem does indeed exist, and that accidents of a certain type were not just random occurrences, but are the result of a real safety or operational problem.

- Providing more detailed information about the accident problem such as (1) likely causes of the accidents, and (2) the vehicle maneuvers associated with the accidents.

Confirming an Accident Problem

Some traffic engineers believe that the presence of accidents is automatically indicative of a safety problem which should be corrected through roadway improvements. However, most highway officials recognize that some accidents occur at random due largely to driver error, (driver falls asleep or is drunk) vehicle malfunction (brake failure or tire blowout), or even sudden or unexpected weather problems (e.g., ice storm or dense fog). For many of these causes, engineering solutions are not justified. Accident reports often do not contain information necessary for an analyst to know whether a roadway deficiency was partly to blame.

If an accident pattern is observed at a location, the collection of conflict data can be valuable in identifying whether unsafe vehicle maneuvers are prevalent at the site, which may indicate a safety problem. Consider, for example, a signalized intersection with six opposing left-turn accidents in the previous 2 years (three per year). A conflict count was conducted at the site during the same time of day and days of the week on which a majority of the accidents occurred. The conflict count revealed that opposing left-turn conflicts were twice as high as would normally be expected for signalized intersections with similar traffic volumes. This result helped to confirm that a true problem existed, and that corrective action was justified.

On the other hand, assume that the rate of left-turn conflicts was about average or below average for similar sites. In this case, it is likely that there may not be a current problem related to left-turn vehicles at the site. Shifts in traffic patterns, random occurrence of some of those previous left-turn accidents, or other reasons could partly explain the lack of an observable problem.

Thus, if a site has an abnormal accident history, but relatively low incidence of related conflicts, the engineer should conduct other engineering studies to determine if identifiable site deficiencies can be found. For example, high-vehicle speeds on an approach may be associated with a few severe accidents each year, although conflict counts may not necessarily appear abnormal. A study of spot speeds and the speed distribution at the site could be useful with counts of traffic volume and turning movements to verify whether a high potential exists for opposing left-turn and/or rear-end accidents.

Supplementing Accident Data

When an accident pattern is found to be abnormally high at a location, traffic conflict data may also be useful for obtaining additional information on the likely accident causes and maneuvers leading to the accidents and thus, the site deficiencies. This can best be explained by the following examples:

Example 1 - An abnormally high incidence of driveway-related accidents was found on two intersection approaches. The accident reports did not specify which driveways were involved, but indicated that most of the accidents involved vehicles which were rear-ended as they are turning right into driveways. A conflict survey revealed that a fast food restaurant was associated with 80 percent of the driveway conflicts. Further, it was observed that vehicles turning right into two driveways almost came to a complete stop in the traffic lane before turning into the driveway, due to the small turning radius of the driveways and narrow driveway openings. A recommendation was made to widen the two driveways and provide larger turning radii.

Example 2 - Four pedestrian accidents occurred at a signalized intersection during the past three years. The accident report forms contained inconsistent information on who was at fault in the accidents, since there were no witnesses in three of the accidents (and the drivers and pedestrians each claimed the other to be at fault). A traffic conflict study was conducted at the intersection which included counts of motorist signal violations and pedestrian compliance with the WALK/DON'T WALK signal. An abnormally high incidence of vehicle-pedestrian conflicts was observed, and problems were also found from RTOR motorists not stopping before making a right turn on red which resulted in several of the vehicle-pedestrian conflicts. Also, many pedestrians were crossing at scattered locations on three of the intersection approaches and not in close proximity to the intersection. A recommendation was made to install NO TURN ON RED signs on all four approaches due to the high pedestrian volumes throughout most of the day. Pedestrian barriers (railings) were recommended for channelizing pedestrian crossings into the crosswalk area. Selective police enforcement was also suggested at the intersection to discourage pedestrian and motorist violations.

Example 3 - Accident data were compiled at an unsignalized intersection on a four-lane road (controlled by stop signs on the minor road). Of the six accidents reported the previous year at the intersection, three occurred on the westbound approach of the four-lane roadway, which included two lane-change accidents and one rear-end accident. Further, these four accidents were reported to have occurred approximately 150 to 200 feet back from the intersection, between 3:00 and 3:30 p.m. on weekdays, which are typically low volume periods. A traffic conflict study was conducted at the intersection on two consecutive weekdays covering the morning and afternoon periods. On the first day (Tuesday) conflicts were low and no unusual events were observed. However, on the following day (Wednesday) at approximately 3:05 p.m., a westbound bread truck stopped in the right lane next to a grocery store. The driver spent the next 12 minutes unloading bakery goods and carrying them into the store. During that period, traffic became stopped behind the parked truck in the right lane, and numerous vehicles crossed into the left lane, causing several lane-change conflicts. At 3:17 p.m., the bread truck was driven from the location and traffic was almost immediately back to normal. The next day, the city traffic engineer called the store owner and the bread company and explained the traffic problems caused by the driver stopping in the lane to make deliveries. An alternative unloading space in a nearby alley was discussed, and the company manager and driver agreed to use the alley for unloading. Over the next two years, no rear-end or lane-change accidents occurred on the westbound approach.

Summary

In summary, diagnosing safety problems with conflict data need not be highly complicated. In fact, the observation of traffic at a site during critical periods may provide valuable insights into the causes of problems. If accident data are available, conflict data can often fill the gaps of missing information which is not included on the accident report form. Thus, conflict data and other relevant engineering study data can often provide answers as to why the accidents are likely occurring and then give insights into the selection of the most appropriate roadway improvements.

Conflict Diagrams

After abnormally high traffic conflict patterns have been identified and specific site deficiencies have been pinpointed, it is often useful to display the study results in the form of a conflict diagram. The diagram should be simple; preferably, the abnormal conflict patterns should be drawn on an updated site diagram. Thus, not only is the abnormal type of conflict evident, but the related deficiencies can be identified easily when the study results are presented to administrators or the public. It is preferred practice to prepare the diagram prior to countermeasure selection so it can be used in selecting treatments.

To be meaningful to the public, the conflict patterns are usually expressed in terms of conflict rates; i.e., conflicts per 1,000 vehicles. A typical conflict diagram is shown in figure 30. Note that only the abnormal conflict types appear on the diagram. The conflict diagram shown in figure 30 was used by a diagnostic team to develop appropriate countermeasures. As a result of the team review, recommendations were made to:

- Add separate left-turn lanes.
- Modify the signal timing.
- Add pedestrian signals.

Using the Results of Conflict Studies to Select Countermeasures

After abnormal conflict patterns and specific related causal factors have been identified, the conflict data can be used to aid in the selection of countermeasures to eliminate or reduce the safety and/or operational problem.

During countermeasure selection, the engineer should be aware of the fact that some countermeasures implemented to reduce a particular conflict type may increase the frequency of other conflict types. For example, adding a left-turn phase at a signalized intersection may significantly reduce opposing left-turn conflicts, but rear-end type conflicts may increase due most likely to the increase in the delay of through traffic. This situation is analogous to the effects some countermeasures have on accident types.

To assist the engineer in selecting countermeasures based on the results of a conflict study, two countermeasure selection tables were developed. General countermeasures for unsignalized and signalized intersections are shown in tables 11 and 12, respectively. The tables provide a list of possible causes and general countermeasures for each type of traffic conflict. The information in the tables is based on the results of previous conflict and accident studies conducted at intersections. The data are presented as a general guideline and not as a specific warrant for any conflict pattern.

To illustrate the use of these tables, refer to the opposing left-turn conflict in table 12, page 70. For this conflict type, three possible causes are:

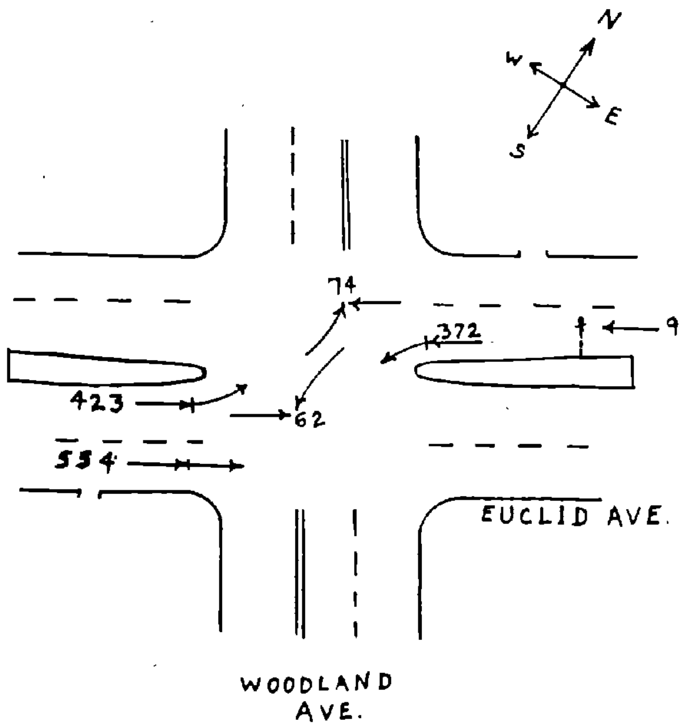


Figure 30. Typical traffic conflict diagram.

- Large volume of left-turn traffic with insufficient number of adequate gaps.

- Inadequate signal timing.

- Inadequate sight distance of left-turn traffic to oncoming through vehicles.

Thus, if an intersection is found to have an abnormally high incidence of left-turn conflicts, the engineer should conduct an indepth investigation at the site along with other relevant studies (e.g., signal timing study, sight-distance study, study of traffic volumes and turning movements, or study of gaps in through traffic for left-turning vehicles) to determine the site deficiencies. After the deficiencies are identified, table 12 provides a list of countermeasures which may be appropriate for each possible cause.

Assume, for example, that a slight vertical grade just north of an intersection causes a sight obstruction to northbound motorists who are attempting to turn left and cannot adequately see southbound through vehicles. Also, a high volume of left-turn traffic exists with an insufficient number of adequate gaps. Using table 12, possible causes numbers 1 and 3 apply. For the first possible cause (i.e., large volume of left-turning traffic with insufficient gaps), the following five general countermeasures are given:

1. Provide left-turn phasing.
2. Prohibit left turns.
3. Reroute left-turn traffic.
4. Channelize left-turn movement.
5. Install dual left-turn lanes (on multilane approaches only).

Table 11. General countermeasures by type of traffic conflict for unsignalized intersections.

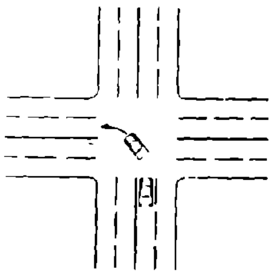
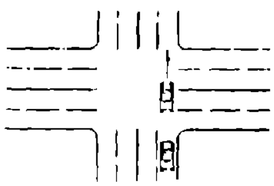
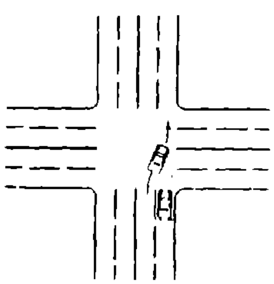
Conflict Type	Possible Cause	General Countermeasure
 Left-Turn, Same-Direction	1. Absence of left-turn storage lane.	1. Add left-turn storage lane. 2. Prohibit left turns on the approach.
	2. Poor sight distance of left-turn vehicle to oncoming through traffic.	1. Remove obstacles or sight obstructions. 2. Add left-turn lanes. 3. Reduce speed limit on the approaches if justified by spot speed study. 4. Prohibit left turns.
	3. Large volume of left-turning and/or opposing through vehicles.	1. Add left turn lanes. 2. Add traffic signals if warranted (see MUTCD), and consider the need for also installing signals with separate left-turn phasing.
 Slow Vehicle, Same-Direction	1. Excessive speeds of some vehicles on the approach.	1. Reduce speed limit on approaches if justified by spot speed study. 2. Provide police enforcement of the speed limit.
	2. Hidden intersection (i.e., poor sight distance to intersection).	1. Install advance warning signs. 2. Remove sight obstructions.
	3. Large traffic volumes.	1. Add traffic signals if warranted (see MUTCD). 2. Widen roadway approach and/or provide additional lanes. 3. Limit number of driveways on intersection approaches.
 Lane-Change	1. Proper travel lanes not clearly defined for through or turning motorists.	1. Provide lane-use pavement markings and/or repaint lane lines. 2. Install overhead lane designation signs. 3. Channelize intersection. 4. Install overhead street name signs and/or advance route or guide signs.
	2. Roadway tapers past the intersection.	1. Install overhead lane designation signs. 2. Provide lane-use markings. 3. Provide advance signing warning of roadway taper ahead.
	3. Other roadway design deficiencies.	1. Widen lanes. 2. Install turn lanes. 3. Remove on-street parking. 4. Provide proper roadway alignment.

Table 11. General countermeasures by type of traffic conflict for unsignalized intersections (continued).

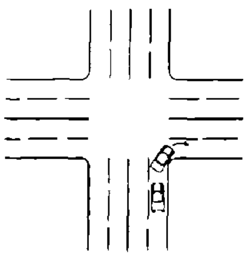
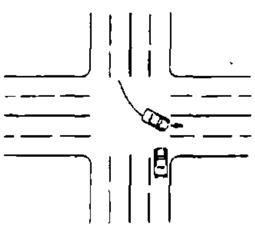
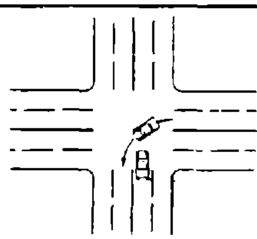
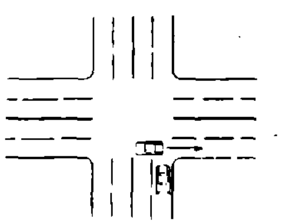
Conflict Type	Possible Cause	General Countermeasure
 Right-Turn, Same-Direction	1. Large right-turn volume.	1. Widen roadway approach and/or provide separate right turn lane.
		2. Increase curb radii.
		3. Add traffic signals if warranted (see MUTCD).
		4. Channelize intersection.
	2. Inadequate intersection design.	1. Increase curb radii.
		2. Provide channelization.
		3. Repaint lane lines and pavement arrows.
		4. Install overhead lane designation signs.
	3. Excessive speeds of some vehicles on the approach.	1. Reduce speed limit on the approaches if justified by spot speed study.
		2. Provide police enforcement of the speed limit.
 Opposing Left-Turn	1. Large volume of left-turn traffic with insufficient number of adequate gaps.	1. Add traffic signals if warranted (see MUTCD) and consider the need for also installing separate left-turn phasing with signals.
		2. Add left-turn lanes.
		3. Prohibit left turns (reroute left-turn traffic).
	2. Inadequate sight distance of left-turn traffic to oncoming through vehicles.	1. Remove sight obstructions.
		2. Reduce speed limit on the approaches.
	3. Excessive speeds of some vehicles on the approach.	1. Reduce speed limit on the approaches if justified by spot speed study.
		2. Provide police enforcement of the speed limit.
  Left-Turn and Through, Cross-Traffic	1. Restricted sight distance.	1. Install traffic signals (see MUTCD).
		2. Install stop or yield signs (see MUTCD).
		3. Channelize intersection.
		4. Reduce speed limit on approaches.
		5. Install or improve nighttime lighting.
		6. Install advance warning signs (see MUTCD).
		7. Restrict parking near corners.
		8. Remove other sight obstructions.
	2. Large intersection traffic volumes.	1. Install traffic signals (see MUTCD).
		2. Install stop signs or yield signs (see MUTCD).
	3. High approach speed.	1. Reduce speed limit on the approaches if justified by spot speed study.
		2. Provide police enforcement of speed limit.

Table 11. General countermeasures by type of traffic conflict for unsignalized intersections (continued).

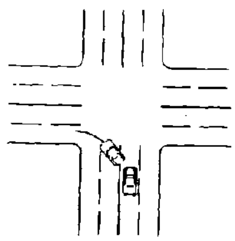
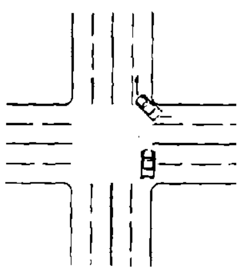
Conflict Type	Possible Cause	General Countermeasure
 Right-Turn, Cross-Traffic-From-Left	1. Narrow roadway.	1. Widen approach width and/or add a lane.
	2. Inadequate intersection geometrics or sight distance.	1. Increase curb radius.
		2. Channelize intersection.
		3. Provide improved pavement lane lines and turn arrows.
		4. Remove sight obstructions.
		5. Provide overhead lane designation signs.
		6. Widen intersection approach.
	3. Heavy right-turn or through traffic volumes.	1. Install traffic signal if warranted (see MUTCD).
		2. Install stop signs or yield signs (see MUTCD).
		3. Widen roadway and/or add right-turn lane.
 Right-Turn, Cross-Traffic-From-Right	1. Inadequate sight distance and/or geometrics at the intersection.	1. Remove sight obstructions and/or roadside obstacles (e.g., mailboxes, poles, newsstands, trash cans.
		2. Prohibit on-street parking near intersection (e.g., within 100 feet).
		3. Reduce speed limit on approaches if justified by spot speed study.
		4. Install advance warning signs for through motorists.
	2. Excessive speeds of some vehicles on the approach.	1. Reduce speed limit on approaches if justified by spot speed study.
		2. Provide police enforcement of the speed limit.
	3. Large volume of through and/or right-turning traffic.	1. Add traffic signals if warranted (see MUTCD).
		2. Install stop signs and/or yield signs (see MUTCD).
		3. Widen intersection.

Table 11. General countermeasures by type of traffic conflict for unsignalized intersections (continued).

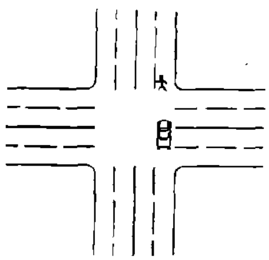
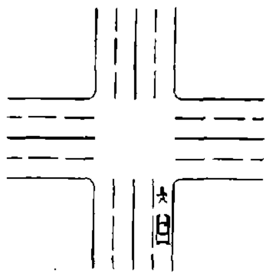
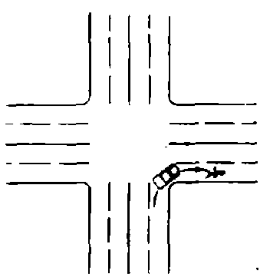
Conflict Type	Possible Cause	General Countermeasure
	1. Excessive delay to pedestrians prior to getting adequate gaps in traffic.	1. Install traffic signals with pedestrian WALK/DON'T WALK signals (see MUTCD signal warrants). 2. Install stop signs. 3. Provide pedestrian overpass or underpass (if justified based on high pedestrian volumes with high traffic speeds or volume). 4. Install pedestrian refuge islands (wide streets with two-way traffic).
	2. Children crossing in school zones.	1. Provide adult crossing guards. 2. Install pedestrian overpass or underpass. 3. Install school regulatory flashers (e.g., SPEED LIMIT 25 MPH WHEN FLASHING). 4. Use school zone signs and pavement markings. 5. Remove on-street parking near the intersection (e.g., within 100 feet).
Pedestrian	3. High vehicle speeds.	1. Provide police enforcement of speed limit. 2. Install pedestrian overpass or underpass. 3. Install traffic signals with WALK/DON'T WALK signals if warranted (see MUTCD signal warrants).
	1. Large volume of pedestrians and right-turn vehicles.	1. Install traffic signals with pedestrian WALK/DON'T WALK signals (all MUTCD signal warrants). 2. Install stop signs. 3. Move crosswalks farther from intersection. 4. Add warning signs for pedestrians (e.g., PEDESTRIANS WATCH FOR TURNING VEHICLES). 5. Add regulatory signs for motorists (e.g., YIELD TO PEDESTRIANS WHEN TURNING) at the intersection.
	2. Substantial number of school children crossing and large right-turn vehicle movement.	1. Provide adult crossing guards during school crossing periods. 2. Provide police enforcement at the intersection. 3. Educate children about safe crossing behavior (e.g., using such films as "Willie Whistle" and "Keep On Looking"). 4. Provide pedestrian overpass or underpass.
Right-Turn, Vehicle-Pedestrian	3. Inadequate sight distance and/or intersection geometrics.	1. Remove sight obstructions and/or roadside obstacles (e.g., mailboxes, poles, newsstands, trash cans). 2. Move crosswalk further away from intersection. 3. Install pedestrian warning signs and/or motorist regulatory signs.

Table 11. General countermeasures by type of traffic conflict for unsignalized intersections (continued).

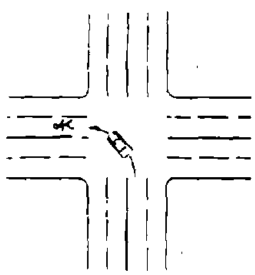
Conflict Type	Possible Cause	General Countermeasure
 Left-Turn, Vehicle-Pedestrian	1. Large volume of pedestrians and left-turn vehicles.	1. Prohibit left turns. 2. Provide traffic signals with WALK/DON'T WALK signals if warranted (see MUTCD signal warrants). 3. Convert to one-way street network (if justified by surrounding area-wide pedestrian and traffic volume study). 4. Install warning signs for pedestrians (e.g., PEDESTRIANS WATCH FOR TURNING VEHICLES).
	2. Substantial number of school children crossing and large left-turn vehicle movement.	1. Provide adult crossing guards during school crossing periods. 2. Provide police enforcement at the intersection. 3. Educate children about safe crossing behavior (e.g., using such films as "Willie Whistle," and "Keep on Looking"). 4. Provide pedestrian overpass or underpass. 5. Install pedestrian refuge islands for wide two-way streets.
	3. Inadequate sight distance and/or intersection geometrics.	1. Remove sight obstructions and/or roadside obstacles (e.g., mailboxes, poles, newsstands, trash cans). 2. Prohibit left turns. 3. Install pedestrian warning signs and/or motorist regulatory signs.

Table 12. General countermeasures by type of traffic conflict for signalized intersections.

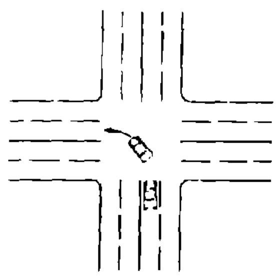
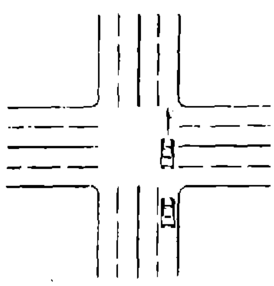
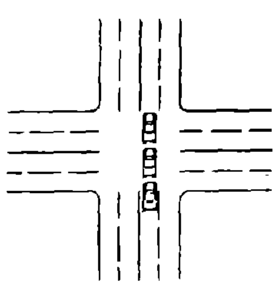
Conflict Type	Possible Cause	General Countermeasure
 Left-Turn, Same-Direction	1. Absence of left-turn storage lane.	1. Add left-turn storage lane. 2. Prohibit left turns on the approach (only if justified based on high through volumes and low left-turn movements).
	2. Large volume of left-turning vehicles.	1. Add left-turn lanes. 2. Add exclusive left-turn phasing with left-turn lanes.
	3. Inadequate sight distance of left-turn vehicle to oncoming through traffic.	1. Remove obstacles or sight obstructions. 2. Add left-turn lanes. 3. Add exclusive left-turn phasing with left-turn lanes. 4. Reduce speed limit on the approaches. 5. Prohibit left turns.
	4. Inadequate signal timing.	1. Adjust amber phase. 2. Provide progression through a series of signalized intersections. 3. Adjust signal phasing to give more green time to left-turn traffic. 4. Provide left-turn phasing. 5. Provide signal actuation.
 Slow Vehicle, Same-Direction	1. Improper signal timing.	1. Provide signal progression. 2. Adjust signal timing to provide better cycle length and/or allocation of green time. 3. Install signal actuation.
	2. Poor visibility of traffic signals.	1. Relocate signal heads. 2. Install large (12-inch) signal lenses. 3. Use additional signal heads. 4. Install backplates, visors, etc., on traffic signals to improve contrast and visibility.
 Slow Vehicle, Same-Direction Secondary	3. Excessive speeds of some vehicles on the approach.	1. Reduce speed limit on approaches. 2. Provide police enforcement of speed limit.
	4. Large traffic volumes.	1. Widen roadway approaches and/or provide turn lanes. 2. Limit driveways and other access points on intersection approaches. 3. Retime signals and/or provide signal progression. 4. Provide channelization (clear lane designation, traffic islands, etc., as needed). 5. Install proper lane delineation.

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

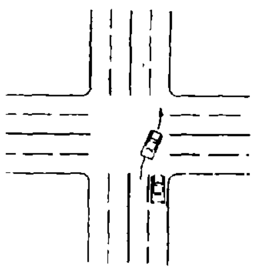
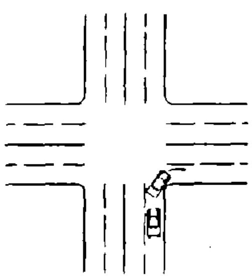
Conflict Type	Possible Cause	General Countermeasure
 Lane-Change	1. Proper travel lanes not clearly defined for through or turning motorists.	1. Provide lane-use pavement markings and/or repaint lane lines. 2. Install overhead lane designation signs. 3. Channelize intersection. 4. Install overhead street name signs and/or advance route or guide signs.
	2. Roadway tapers past the intersection.	1. Install overhead lane designation signs. 2. Provide lane-use markings. 3. Provide advance signing warning of roadway taper ahead.
	3. Other roadway design deficiencies.	1. Widen lanes. 2. Install turn lanes. 3. Remove on-street parking. 4. Provide proper roadway alignment.
 Right-Turn, Same-Direction	1. Large right-turn volume.	1. Provide separate right-turn lane. 2. Retime signal to increase green time for right-turn vehicles. 3. Increase curb radii. 4. Channelize intersection (e.g., traffic islands). 5. Permit right-turn-on-red.
	2. Inadequate intersection design.	1. Increase curb radii. 2. Provide channelization. 3. Repaint lane lines and pavement arrows. 4. Install overhead lane designation signs.
	3. Poor signal visibility.	1. Relocate signal heads. 2. Install large (12-inch) signal lenses. 3. Use additional signal heads. 4. Install backplates, visors, etc., traffic signals to improve contrast and visibility.

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

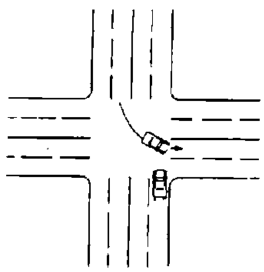
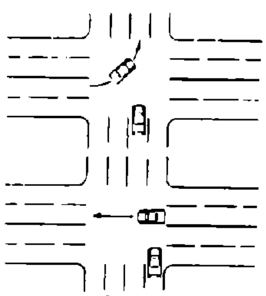
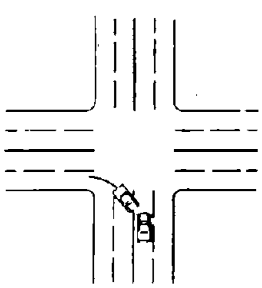
Conflict Type	Possible Cause	General Countermeasure
 Opposing Left-Turn	1. Large volume of left-turn traffic with insufficient number of adequate gaps.	1. Provide left-turn phasing. 2. Prohibit left turns. 3. Reroute left-turn traffic. 4. Channelize left-turn movement. 5. Install dual left-turn lanes (on multilane approaches only).
	2. Inadequate signal timing.	1. Retime signal to provide more appropriate distribution of green time (e.g., split phasing). 2. Provide left-turn signal phasing. 3. Add all-red phase.
	3. Inadequate sight distance of left-turn traffic to oncoming through vehicles.	1. Remove sight obstructions. 2. Provide left-turn signal phasing. 3. Reduce speed limit on opposing approaches.
 Left-Turn and Through, Cross-Traffic	1. Signal timing sometimes causes moderate or long delays to side street vehicles.	1. Retime signals to provide more appropriate allocation of green time. 2. Install signal actuation. 3. Police enforcement of red light violations.
	2. Poor visibility of signals (for side street vehicles).	1. Relocate traffic signal heads. 2. Install large (12-inch) signal lenses. 3. Use additional signal heads. 4. Install backplates, visors, etc., on traffic signals to improve contrast and visibility of signals.
 Right-Turn, Cross-Traffic-From-Left	1. Narrow roadway.	1. Widen approach width and/or add a lane.
	2. Inadequate intersection geometrics or sight distance.	1. Increase curb radii. 2. Channelize intersection. 3. Provide improved pavement lane lines and turn arrows. 4. Remove sight obstructions. 5. Provide overhead lane designation signs. 6. Widen intersection approach.

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

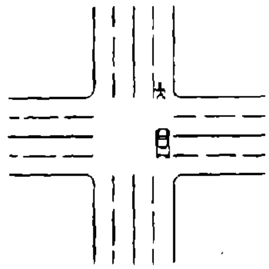
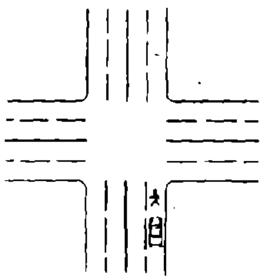
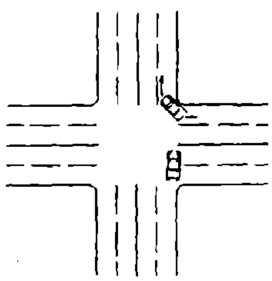
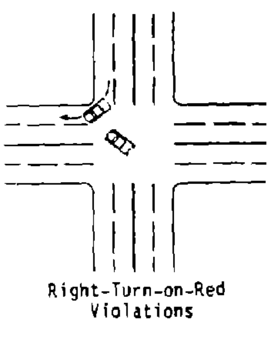
Conflict Type	Possible Cause	General Countermeasure
	1. Pedestrians cannot see signal.	1. Install a pedestrian WALK/DON'T WALK signal.
	2. Children crossing in school zones.	1. Provide adult crossing guards.
		2. Install pedestrian overpass or underpass.
		3. Use pedestrian signals.
		4. Install school regulatory flashers (e.g., SPEED LIMIT 25 MPH WHEN FLASHING).
		5. Provide school zone signs and pavement markings.
	3. Excessive delay to pedestrians prior to getting the WALK interval.	1. Retime signal to be more responsive to pedestrian needs (e.g., shorter cycle lengths).
		2. Provide pedestrian push-buttons.
		3. Install pedestrian overpass or underpass (if justified based on high pedestrian volumes with high traffic speeds or volumes).
		4. Provide pedestrian refuge islands (wide, two-way streets with modified signal timing).
	4. Lack of pedestrian compliance due to other causes.	1. Use police enforcement.
Pedestrian		2. Install pedestrian warning signs.
		3. Provide pedestrian refuge islands (wide, two-way streets) in conjunction with modified signal timing.
		4. Remove on-street parking near intersection (e.g., within 100 feet).
	1. Violation of NO TURN ON RED (NTOR) signs located on far side or inconspicuous to motorists.	1. Increase sign size to improve visibility.
		2. Relocate signs to near signal placement.
		3. Use double NTOR signs for redundancy.
		4. Remove roadside clutter (to make NTOR sign more conspicuous).
		5. Provide or improve intersection lighting (for nighttime RTOR problem).
	2. Violation of NTOR signs due to confusing or inappropriate part-time RTOR prohibition.	1. Prohibit RTOR only during the hours of heavy pedestrian travel (i.e., use NTOR WHEN PEDESTRIANS ARE PRESENT signing).
		2. Utilize full RTOR prohibition on the approach.
		3. Utilize variable message NTOR sign (illuminated signal to be activated only during periods when RTOR is prohibited).
	3. Long cycle lengths resulting in excess waiting time for right-turn motorists causing violation of NTOR signs.	1. Improve pedestrian signal display.
		2. Retime the traffic signal to provide better operations.
Right-Turn-on-Red Violations		3. Install presence detectors at traffic actuated approaches to provide more efficient signal operation.
		4. Remove unwarranted traffic signals.

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

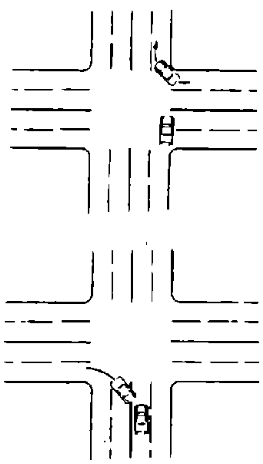
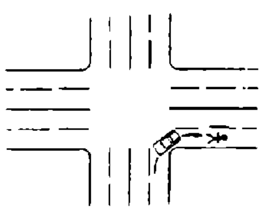
Conflict Type	Possible Cause	General Countermeasure
 Right-Turn-on-Red Cross-Street	1. Unusual or confusing signal timing.	1. Install NO TURN ON RED sign if warranted. 2. Retime traffic signal. 3. Install part-time RTOR prohibition sign or variable message NO TURN ON RED display. 4. Install RIGHT TURN ON RED AFTER STOP sign to encourage full stops.
	2. Inadequate sight distance or geometrics.	1. Prohibit RTOR if warranted. 2. Install offset or angled stop bars. 3. Relocate crosswalk further from intersection. 4. Install RIGHT TURN ON RED AFTER STOP sign to encourage full stops. 5. Remove roadside clutter. 6. Widen intersection approach.
 Right-Turn-on-Red Pedestrian	3. Large volumes of pedestrians and right-turn volume.	1. Install NO TURN ON RED sign if warranted. 2. Install pedestrian overpass or underpass (particularly if child pedestrian volumes are high). 3. Install NO TURN ON RED WHEN PEDESTRIANS ARE PRESENT signing. 4. Provide exclusive pedestrian phase. 5. Install regulatory YIELD TO PEDESTRIAN sign. 6. Install PEDESTRIANS WATCH FOR TURNING VEHICLES warning sign. 7. Provide offset or angled stop bars.

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

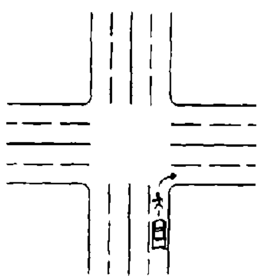
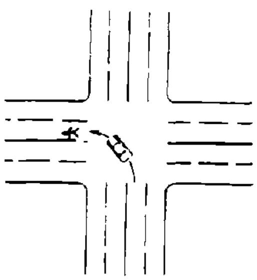
Conflict Type	Possible Cause	General Countermeasure
 Right-Turn, Vehicle-Pedestrian	1. Large volume of pedestrians and/or right-turn vehicles.	1. Add special pedestrian signal phasing, (e.g., exclusive protected signal interval). 2. Add warning signs for pedestrians (e.g., PEDESTRIANS WATCH FOR TURNING VEHICLES). 3. Add regulatory signs for motorists (e.g., YIELD TO PEDESTRIANS WHEN TURNING) on the intersection approach. 4. Install NO TURN ON RED signs (see MUTCD). 5. Convert to one-way street network (if justified by surrounding area-wide pedestrian and traffic volumes study.
	2. Substantial number of school children crossing and large right-turn vehicle movement.	1. Provide adult crossing guards during school crossing periods. 2. Provide police enforcement at the intersection. 3. Educate children about safe crossing behavior (e.g., using such films as "Willie Whistle," and "Keep on Looking"). 4. Provide pedestrian overpass or underpass. 5. Install NO TURN ON RED signs.
	3. Inadequate sight distance and/or intersection geometrics.	1. Remove sight obstructions and/or roadside obstacles (e.g., mailboxes, poles, newsstands, trash cans). 2. Move crosswalk further away from intersection. 3. Provide special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval). 4. Install NO TURN ON RED signs (see MUTCD). 5. Install pedestrian warning signs and/or motorist regulatory signs (see MUTCD).

Table 12. General countermeasures by type of traffic conflict for signalized intersections (continued).

Conflict Type	Possible Cause	General Countermeasure
 Left-Turn, Vehicle-Pedestrian	1. Large number of pedestrians and/or left-turn vehicles.	1. Prohibit left turns.
		2. Provide separate left-turn phase and WALK/DON'T WALK signals.
		3. Add special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval).
		4. Convert one-way street network (if justified by surrounding area-wide pedestrian and traffic volume study).
		5. Install warning signs for pedestrians (e.g., PEDESTRIANS WATCH FOR TURNING VEHICLES).
	2. Substantial number of school children crossing and large left-turn vehicle movement.	1. Provide adult crossing guards during school crossing periods.
		2. Provide police enforcement at the intersection.
		3. Educate children about safe crossing behavior (e.g., using such films as "Willie Whistle" and "Keep on Looking").
		4. Provide pedestrian overpass or underpass.
		5. Install pedestrian refuge islands for wide two-way streets.
	3. Inadequate sight distance and/or intersection geometrics.	1. Remove sight obstructions and/or roadside obstacles (e.g., mailboxes, poles, newsstands, trash cans).
		2. Provide special pedestrian signal phasing (e.g., exclusive protected pedestrian signal interval).
		3. Install pedestrian warning signs and/or motorist regulatory signs (see MUTCD).

For the possible cause of inadequate sight distance, three countermeasures are listed:

1. Remove sight obstructions.
2. Provide left-turn signal phasing.
3. Reduce speed limit on opposing approaches.

Note that providing left-turn signal phasing is listed for both of the possible causes. Thus, a total of seven different countermeasures may be considered along with others which might apply to the intersection of interest. It is important to remember that the treatments listed in the tables only include a general listing of some possible countermeasures, and NOT all the countermeasures that may apply. Agency experience with various countermeasures and unique site characteristics must also be considered in selecting the most appropriate treatment(s) for a given location.

Referring to the previous example with seven candidate countermeasures, the local highway official concluded that:

- Prohibiting left turns and/or rerouting left-turn traffic would simply cause left-turn motorists to attempt a left turn at two intersections downstream. It is possible that an even more serious problem would occur at those sites. This alternative was therefore rejected.

- Dual left-turn lanes and a channelized left-turn movement already existed at the intersection, which ruled out those two alternatives.

- Removing the sight obstruction would require totally reconstructing the intersection, the intersection approach, and altering the grade of the road, which was considered too expensive and impractical.

- Reducing the speed limit on the approach could be accomplished at low cost. However, the speed limit was currently set at 40 mi/h with an 85th percentile speed of 42 mi/h on a suburban arterial relatively free of roadside businesses and driveways. It was felt that lowering the speed limit to 35 or 30 mi/h was not justified and that a lower speed limit would have little effect on actual traffic speeds. This alternative was also rejected.

Providing a separate, exclusive left-turn phase at the intersection for the two intersection approach legs was considered to be practical and was also justified based on intersection capacity. Although average vehicle delay was expected to increase slightly for through traffic, delay and safety of left-turn traffic was expected to improve considerably.

Using Traffic Conflict Data in Effectiveness Evaluations

One unique application of the Traffic Conflict Technique is that conflict observations can be made immediately before and after a change is made without having to wait years for accidents to occur. By using traffic conflicts as an evaluation tool, the engineer can determine if a treatment was effective in eliminating or reducing abnormal conflict patterns and related traffic events.

Procedures for traffic engineers to use to conduct effectiveness evaluations with nonaccident based measures have been well documented in the Federal Highway Administration Procedural Guide entitled "Highway Safety Evaluation."[7] No attempt will be made to duplicate that effort in this guide, however, problems unique to using traffic conflicts are discussed.

An effectiveness evaluation begins with the development of an evaluation plan. The plan includes:

- Select site(s).
- Identify measures of effectiveness.
- Select experimental design.
- Determine how much data should be collected.

In selecting sites for evaluation using traffic conflicts, it is important that the planned countermeasures or treatment be logically related to the type of conflict data that will be obtained.

As a general rule, unless the treatment is expected to have at least a 15 percent effect (reduction) on a particular conflict pattern or combination of conflict types, an effectiveness evaluation probably should not be conducted. This statement is based primarily on sample size requirements for most conflict types.

If the treatment can be implemented in a short time period; i.e., a month or less, a simple before and after experimental design should provide reliable results. If the implementation period is long or includes possible seasonal changes, then the before and after with control design should be selected.

As discussed earlier in this guide, the sample size requirements for some conflict categories; e.g., the cross-traffic conflicts, are so large that most engineers cannot afford the time or personnel to collect a sufficient sample. Effectiveness evaluations using traffic conflicts should only be made when the engineers can obtain a sufficient sample size, otherwise, the conclusions drawn are likely to be erroneous.

Finally, the statistical tests used to determine effectiveness must be given careful consideration. Conflict data are clearly not normally distributed as shown in figure 29. The use of a parametric test such as the student's t or analysis of variance first requires that the raw conflict data be transformed. The proper transformation for conflict data is:

$$Y' = \lambda^{-1} \ln \{ \sqrt{1 + \lambda^2 Y} + \lambda\sqrt{Y} \}$$

Where, Y' = transformed count

λ = variance $Y/\bar{Y}$

Y = each count

$\bar{Y}$ = average count

The parametric test is then performed on the transformed data. While manual calculations can be made, these steps are more efficiently accomplished with statistical programs such as SPSS or SAS.

When conducting an effectiveness evaluation using traffic conflicts, it is preferred practice to consult with a statistician when the evaluation plan is being prepared.

CHAPTER 8 - PREDICTING ACCIDENTS USING TRAFFIC CONFLICTS

As previously mentioned, in a 1985 study by Migletz, et al, relationships between certain accident types and corresponding conflict types were developed and validated.[5] Procedures were developed for using traffic conflict counts to predict the expected number of accidents for several accident categories. A summary of the procedures is presented in this section.

While accident prediction using traffic conflicts is desirable, the technique has very limited application at present. The limitations are not due to the Traffic Conflict Technique, but to the contract budget and time constraints placed on previous research. Technically, a much broader class of intersections could be used in the sample in order to develop accident/conflict ratios that could be used on a widespread basis. The real application of predicting accidents is in the future when use of traffic conflicts is widespread and large samples can be pooled to establish relationships for all conflict and accident types for the most common intersection classes.

Accident/conflict ratios have been developed and validated for the four-leg intersection groups and the accident patterns shown in table 13. The engineer can use these ratios and the procedures given below to estimate accidents provided the study location is similar to the intersection classifications shown in table 13 and the conflict data were obtained and analyzed using the procedures in this guide. Extrapolation beyond the accident types given in table 13 or applicability of the results to other intersection designs is strongly discouraged.

The accident/conflict ratios and variances for classes of intersections were developed to enable estimation of the expected rate of accident occurrence given the rate of conflict occurrence. The estimation relation is:

Number of accidents expected to occur on a system during a certain period of time	=	Number of conflicts occurring on the system in that time	x	Accident/ conflict ratio for that system

In symbols, the equations for estimating accidents and the variance of the estimate is written as:

$$A_o = C_o R$$

$$Var(A_o) = Var(C)Var(R) + C_o^2 Var(R) + R^2 Var(C)$$

Table 13. Accident/conflict ratios for four-leg intersections.

Type of Collision	Type of Control	Total Volume VPD	Number of Intersections N	Mean Accident/ Conflict Ratio[a] R	Standard Deviation[a] S	Variance[b] Var(R)
Left-Turn, Same-Direction	Two-Way Stop	10,000 to 25,000	10	15.024×10^{-6}	31.810×10^{-6}	101.204×10^{-12}
Same Direction	Signalized	›25,000	12	1.428×10^{-6}	1.500×10^{-6}	0.189×10^{-12}
	Signalized	10,000 to 25,000	14	2.663×10^{-6}	3.703×10^{-6}	0.979×10^{-12}
Opposing Left-Turn	Signalized	›25,000	12	671.087×10^{-6}	1002.990×10^{-6}	83.832×10^{-9}
	Signalized	10,000 to 25,000	14	184.906×10^{-6}	187.500×10^{-6}	2.511×10^{-9}
	Two-Way Stop	10,000 to 25,000	10	212.456×10^{-6}	293.010×10^{-6}	8.586×10^{-9}
Through, Cross-Traffic	Two-Way Stop	10,000 to 25,000	10	735.425×10^{-6}	1088.780×10^{-6}	118.544×10^{-9}
	Two-Way Stop	2,500 to 10,000	9	489.229×10^{-6}	302.292×10^{-6}	10.153×10^{-9}

[a] (Accidents/3-years) divided by (conflicts/3-years)

[b] [(Accidents/3-years) divided by (conflicts/3-years)]^2

where

A_o = expected number of accidents,

C_o = expected number of daily conflicts obtained from the field study at the intersection, and

R = estimate of the accident/conflict ratio for that class of intersections.

In practice, to estimate the accident rate at a given intersection, one would proceed as follows:

- Obtain a count of the conflicts, C, of the particular type of interest at the intersection.
- Adjust the observed conflict count, C, to a daily count, C_o.
- Estimate the daily accident rate, A_o, by using:

  $$A_o = C_o R$$

  where R is the appropriate accident/conflict ratio from table 13.
- Estimate the variability of A_o, using the formula:

  $$Var(A_o) = Var(C)Var(R) + C_o^2 Var(R) + R^2 Var(C).$$

  where Var(C) is the conflict variance from table 7 or 8 and Var(R) is the accident/conflict ratio variance from table 13.

For example, assume that conflict data were collected at a four-leg signalized intersection with an entering volume in excess of 25,000 vehicles per day. Using the procedures presented earlier in this guide, the raw conflict data were summarized and all same-direction conflicts were combined into one category. The same-direction conflicts were then adjusted to produce a daily conflict count. The following data were obtained.

C_o = 1,421 same-direction conflicts per day

R = 1.428×10^{-6}, from table 13

$Var(R)$ = 0.189×10^{-12}, from table 13

$Var(C)$ = 67,198.4, from table 8

The expected number of same-direction accidents per 11-hour day is:

$$A_o = C_o R$$

$$= 1{,}421 \times 1.428 \times 10^{-6}$$

$$= 0.00203 \text{ same-direction accidents/day}$$

The variance of the estimate is:

$$\begin{aligned} Var(A_0) &= Var(C)Var(R) + C_0^2\ Var(R) + R^2\ Var(C) \\ &= (67{,}198.4)\ (0.189 \times 10^{-12}) + (1{,}421)^2\ (0.189 \times 10^{-12}) \\ &\quad + (1.428 \times 10^{-6})^2\ (67{,}198.4) \\ &= 0.531 \times 10^{-6}\ (\text{accidents/day})^2 \end{aligned}$$

On a yearly basis, the number of same-direction accidents that occur during the daytime on dry pavement on weekdays is:

$$0.00203 \times 4/7 \times 365 = 0.42 \text{ accidents/year}$$

The standard deviation (square root of the variance) of this estimate is:

$$\sqrt{0.000000531} \times 4/7 \times 365 = 0.15 \text{ accidents/year}$$

CHAPTER 9 - ESTABLISHING PRIORITIES FOR IMPROVEMENTS

After an intersection is identified as having a potential safety problem based on an abnormally high incidence of traffic conflicts, candidate safety improvements should be proposed, as previously discussed. The next step concerns setting priorities for making improvements at these locations. The engineer must not only establish priorities at sites with high **accident** experience, but also at sites with high **conflict** rates.

Traditional economic analysis techniques (e.g., benefit-cost ratio, net benefit, and rate of return), may be required to justify the expenditure of funds for some types of projects through certain funding programs; e.g., the Hazard Elimination Program. The use of economic techniques for safety projects, however, generally relies on determining accident benefits based on expected accident reduction from the safety improvement. Currently, accident/conflict ratios have been developed for a small class of intersections; i.e., four-leg and a limited number of conflict types; i.e., same-direction, opposing left-turn, and through, cross-traffic. Accordingly, it is not possible at this time to estimate the number of all accident types from corresponding conflict types. Thus, an estimate of total accident benefits is not possible for a number of intersection classes where improvements are based only on abnormal conflict counts.

Although it is not practical in most cases to compare high **accident** locations with high **conflict** locations based on accident benefits, high conflict locations may still be routinely considered for improvements.

In a 1986 study by Zegeer, "Methods for Identifying Hazardous Highway Elements", input was received from 40 States and 17 local agencies on the programs and funding sources used to improve roadway hazards at locations which were not identified by accident experience.[8] Examples include:

- Manual on Uniform Traffic Control Devices (MUTCD)-type improvement funding program.

- Highway maintenance program.
- 3-R projects.
- Construction programs.
- Safety improvement funds.

Most State and local agencies routinely make MUTCD-type improvements without having to go through a formal economic analysis process. Adding needed warning and regulatory signs, installing newly warranted traffic signals and/or left-turn phasing, and restriping worn pavement markings are examples of normal activities conducted to help ensure improved traffic safety and operations. In many cases, sites with abnormally high rates of traffic conflicts may be improved effectively through relatively low-cost treatments; e.g., signs, signals, and pavement markings.

Highway maintenance programs are also commonly used to correct a variety of roadway problems without the need to justify each improvement from a benefit-cost analysis. Many types of maintenance activities may be helpful in reducing certain patterns of abnormal traffic conflicts at an intersection. Examples include:

- Replacing damaged or knocked down signs or signal equipment.
- Retiming traffic signals (e.g., adjusting the cycle length increasing the clearance interval, changing the allocation of green time to meet shifts in traffic volumes).
- Replacing burned out street lights.
- Repairing low shoulders next to the pavement edge.
- Cutting or trimming trees and hedges which cause reduced motorist sight distance at intersections and/or which block signs and signals.
- Replacing rigid signs and light poles with breakaway bases.

The 3-R program provides 75 percent Federal funds with 25 percent State or local funding for resurfacing, restoration, and rehabilitation of highways. Some types of traffic conflicts may result from rough or slippery pavement surfaces which may be reduced by a resurfacing treatment. In other cases, a variety of other conflict types may occur which may be reduced through safety enhancements. Improvements to traffic control devices, curbing and channelization, roadside improvements, adding sidewalks, installation of roadway lighting, widening lanes and shoulders, and even adding bikeways are all examples of improvements which can be made for safety enhancement as a part of 3-R projects.

Major construction projects provide another opportunity for correcting safety and operational problems identified by a traffic conflict study. Examples of major construction projects include increasing the number of through lanes, changing roadway alignment, adding a median, or installing turn lanes. Many of these improvements are made primarily to improve roadway capacity and reduce congestion, however, they also improve safety and can greatly reduce certain types of traffic conflicts.

Safety improvement funds may also be a source for making roadway improvements at locations with a high incidence of traffic conflicts. The 402 Safety Program (Section 402 of Title 23 of the United States Code) provides funds for a variety of highway safety activities, including:

- Collecting accident, traffic, and highway data to identify problems and evaluate improvements.
- Developing necessary technical capabilities.
- Procuring safety improvement tools and equipment.
- Providing highway safety training.

Thus, 402 funds could be used for collecting traffic conflict data, training personnel in the use of traffic conflict techniques, and analyzing conflicts data to identify safety problems, select countermeasures, and evaluate project effectiveness.

Although the Federally funded Hazard Elimination program (HES) requires justification of projects based on benefits; i.e., from accident reduction and project costs, many States and local agencies use other sources of safety funding to make improvements where they believe a safety problem exists (with or without a history of high accident experience). Many agencies recognize that hazardous locations include not only those with a high frequency and severity of accidents, but also those with the potential for high accident frequencies or severities. The high **potential** for accidents may be recognized by abnormally high rates of certain traffic conflict types, as well as:

- Locations which do not conform to American Association of State Highway and Transportation Officials (AASHTO) standards and MUTCD guidelines.

- Roadway features with a need for "yellow-book" improvements (e.g., flattening steep sideslopes, installing breakaway sign posts and light poles, clearing rigid obstacles near the roadway, or removing sight distance obstructions).

- Location characteristics or features which have commonly been associated with high accident frequency or severity (e.g., spear-end guardrails, high violation rates at STOP signs or traffic signals at intersections).

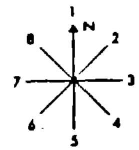
Each highway agency currently has a process (perhaps informal) for establishing priorities for projects which were not identified on the basis of accident experience. Factors considered in many of the decision-making processes include:

- Length of the implementation period.
- Potential safety effect.
- Effect on highway capacity.
- Effect on air and noise pollution.
- Effect on energy conservation.
- Citizen and political consideration.
- Effect on the area; e.g., land values or land usage.
- Effect on future maintenance costs.

These factors should also be used to establish priorities for locations that are identified as having an abnormal incident of traffic conflicts. As use of the Traffic Conflict Technique becomes widespread, it will be possible to estimate accident experience, on the basis of conflict counts, for a wide range of intersection types and conflict types. Thus, an estimate of accident reduction can be used at that time in an economic analysis to establish priorities for these projects.

In summary, even though past research studies have established a definite relationship between certain conflict types and corresponding accident types, it is not practical at this time to translate traffic conflict rates to accidents for purposes of economic analysis for a majority of intersections. Some types of safety funding requires justification of highway improvements based on accident benefits and costs, which makes it difficult for high conflict locations to compete with high accident locations for such funding. However, since high conflict sites indicate a potential for high frequency or severity of accidents, numerous other funding source and programs may be used for such improvements, including highway maintenance programs, 3-R program, MUTCD-type improvement programs, major construction programs, and others.

INTERSECTION TRAFFIC CONFLICTS



Location______________________________ Leg Number______________________

Day______________ Date____________________ Observer________ Length of Recording Period______________

C = Conflict   SC = Secondary Conflict

Count Start Time (Military)	Time Period	Approach Volume	Left-Turn Same Direction		Right-Turn Same Direction		Slow Vehicle		Lane Change		Opposing Left-Turn		Right-Turn From-Right		Left-Turn From-Right		Through From-Right		Right-Turn From-Left		Left-Turn From-Left		Through From-Left		Right-Turn On-Red						Other
			C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	
Total																															
C + SC																															
Comments																															

ON-SITE OBSERVATION REPORT

LOCATION ______________________________

DATE __________________________________ TIME ______________________________

OPERATIONAL CHECKLIST:

	No	Yes	Comments
1. Do obstructions block the drivers view of opposing vehicles?	___	___	
2. Do drivers respond incorrectly to signals, signs, or other traffic control devices?	___	___	
3. Do drivers have trouble finding the correct path through the location?	___	___	
4. Are vehicle speeds too high? Too low?	___ ___	___ ___	
5. Are there violations of parking or other traffic regulations?	___	___	
6. Are drivers confused about routes, street names, or other guidance information?	___	___	
7. Can vehicle delay be reduced?	___	___	
8. Are there traffic flow deficiencies or traffic conflict patterns associated with turning movements?	___	___	
9. Would one-way operation make the location safer?	___	___	
10. Is this volume of traffic causing problems?	___	___	
11. Do pedestrian movements through the location cause conflicts?	___	___	
12. Are there other traffic flow deficiencies or traffic conflict patterns?	___	___	

PHYSICAL CHECKLIST:

	No	Yes	Comments
1. Can sight obstructions be removed or lessen?	___	___	
2. Are the street alignment or widths inadequate?	___	___	
3. Are curb radii too small?	___	___	
4. Should pedestrian crosswalks be relocated? Repainted?	___	___	
5. Are signs inadequate as to usefulness, message, size, conformity and placement? (see MUTCD)	___	___	
6. Are signals inadequate as to placement, conformity, number of signal heads, or timing? (see MUTCD)	___	___	
7. Are pavement markings inadequate as to their clearness or location?	___	___	
8. Is channelization (islands or paint markings) inadequate for reducing conflict areas, separating traffic flows, and defining movements?	___	___	
9. Does the legal parking layout affect sight distance, through or turning vehicle paths, or traffic flow?	___	___	
10. Do speed limits appear to be unsafe or unreasonable?	___	___	
11. Is the number of lanes insufficient?	___	___	
12. Is street lighting inadequate?	___	___	
13. Are driveways inadequately designed or located?	___	___	
14. Does the pavement condition (potholes, washboard, or slick surface) contribute to accidents?	___	___	

COMMENTS:

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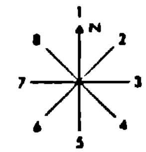
INTERSECTION TRAFFIC CONFLICTS SUMMARY



Location______________________________ Leg Number(s)______________

Day__________ Date______________ Observer(s)__________ Length of Recording Period__________

C = Conflict SC = Secondary Conflict

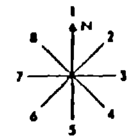
Count Start Time (Military)	Time Period	Approach Volume	Left-Turn Same Direction		Right-Turn Same Direction		Slow Vehicle		Lane Change		Opposing Left-Turn		Right-Turn From-Right		Left-Turn From-Right		Through From-Right		Right-Turn From-Left		Left-Turn From-Left		Through From-Left		Right-Turn On-Red		All Same Direction		All Through Cross-Traffic		Other
			C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	
Total																															
C + SC																															
Daily Count																															
Rate Per 1,000 Veh																															

TRAFFIC VOLUME COUNTS

Location ______________________________

Day ____________ Date ______________ Time Period ______________

Observer ______________________________



COUNT START TIME (MILITARY)	Leg No. ______			Leg No. ______			Leg No. ______			Leg No. ______		
TOTAL												

NOTES AND COMMENTS:

APPENDIX B - COMPUTER PROGRAM TO CALCULATE DAILY CONFLICTS

The computer program DAILYCON.BAS, was written to estimate the number of daily conflicts expected to occur at an intersection or for one or more intersection approach legs based on the raw conflict counts taken during the observation periods. The program assumes that the engineer has obtained conflict counts throughout the weekday including peak and off-peak flow periods. Conflicts are assumed to occur in the nonobservation periods under similar conditions to those that occur in the observation periods. The total number of daily conflicts is obtained by adding the number of conflicts recorded during the observation periods to the number of conflicts estimated to occur during the nonobservation periods. The program was written in BASIC and will run using BASIC, BASICA, or GWBASIC. A compiled version of the program DAILYCON.EXE is also included on the applications diskette.

To run program DAILYCON.BAS, type the name of your BASIC program and DAILYCON.BAS. For example, using BASICA, you would type BASICA DAILYCON and press return.

To run program DAILYCON.EXE, simply type DAILYCON and press return.

The program provides step-by-step instructions on the screen. The results are listed on the screen and, if desired by the user, can be saved in a disk file. The user is also given an opportunity to print the results before exiting the program. Prior to using the program, the raw conflict data should be summarized as described on pages 46 through 53 of this guide.

The program requests the user to input the following data:

- Type of intersection control (signalized or unsignalized).
- Whether the data are for one or more approach legs.
- The names of the approach legs.
- Name of the traffic conflict type.
- Number of observation time periods.
- Length of observation period, in minutes.
- Input count start time and conflict counts.

The program can accommodate any number of conflict types, any number of observation periods, recording periods of any duration and, any observation start times. The program terminates if the observation times are not within the standard 11-hour day (from 7:00 a.m. to 6:00 p.m.).

A sample printout is shown in table 6, page 54, of this guide. A listing of program DAILYCON.BAS is included in this appendix. Users are encouraged to make modifications to suit their particular computer systems and needs.

```
10  REM ********************************************************************
        ***   TRAFFIC CONFLICT ANALYSIS PROGRAM                           ***
        ***   VERSION 1.20   AUGUST 5, 1988   By Martin R. Parker, Jr.    ***
20  REM ***   This program estimates the number of daily conflicts for    ***
        ***   an intersection or for one or more intersection approach    ***
        ***   legs based on raw conflict data input by the user.          ***
30  REM ***   The results are listed on the screen and/or written to      ***
        ***   a disk file if directed by the user.  The user is also      ***
        ***   given an opportunity to print the results.                  ***
40  REM ********************************************************************
50 REM ***   DESCRIPTION OF THE PROGRAM   ***
60 REM $DYNAMIC
70 CLS : KEY OFF: DEFINT I, L, N, T: DIM C(10), T(10), T$(10), T!(10), TZ$(2), T
X$(2), T1(200): COLOR 3, 0: PRINT : PRINT "   Traffic Conflict Analysis Program
                                              Version 1.20        August 5, 1988"

80 PRINT : PRINT "   This program estimates the number of daily conflicts for an
 intersection          or for one or more intersection approach legs based on raw
conflict data          input by the user.";
90 PRINT "  The results are listed on the screen and/or written": PRINT "   to a
 disk file if directed by the user.  The user also is given an             oppo
rtunity to print the results."
100 COLOR 15, 0: PRINT : PRINT "   Prior to using this program you should summar
ize the raw conflict data            as described on pages 46 through 53 in the En
gineer's Guide."
110 PRINT : PRINT "   Note that if the conflict data were recorded for different
 time periods          on each approach leg, then each approach leg MUST be analy
zed separately         and the results manually added to produce the total";
120 PRINT " number of daily";
130 PRINT "   conflicts by type for the intersection.": PRINT : PRINT "   Strike
 any key to continue or type N to terminate the program.": S$ = INPUT$(1): IF S$
 = "N" OR S$ = "n" THEN 1350
140 REM ***  INPUT DATA TO INITIATE THE PROGRAM                              **
150 IF LS = 1 THEN KILL FILE$: LS = 0: IX = 0: ERASE C, T, T$, T! ELSE LS = 0: I
X = 0: ERASE C, T, T$, T!
160 CLS : COLOR 6, 0: PRINT : PRINT "   Do you want to save the results on a dis
k file?  (Y=Yes) (N=No)": Y1$ = INPUT$(1): IF Y1$ = "Y" OR Y1$ = "y" THEN 170 EL
SE FILE$ = "TEMP1": LS = 1: GOTO 210
170 PRINT : PRINT "   Input the file name and press return.  You may use up to 8
 characters           for the file name, a period (.), and a 3 character extensi
on.                   For example, myfileis.123 or xxx are valid file names."
180 INPUT "   "; N$: IF N$ = "" THEN 170 ELSE FILE$ = LEFT$(N$, 12): PRINT : PRI
NT "   The results will be written to disk file  "; : COLOR 10, 0: PRINT FILE$
190 PRINT : PRINT "   Do you want to change the file name?  (Y=Yes) (N=No)": Y3$
 = INPUT$(1): IF Y3$ = "Y" OR Y3$ = "y" THEN 200 ELSE 210
200 PRINT : PRINT "   Input the new file name and press return.": INPUT "   "; N
$: IF N$ = "" THEN 200 ELSE FILE$ = LEFT$(N$, 12): PRINT : PRINT "   The results
 will be written to disk file  "; FILE$
210 OPEN FILE$ FOR OUTPUT AS #1
220 COLOR 2, 0: PRINT : PRINT "   Select the type of intersection you studied.
                                   S = Signalized Intersection
                                   U = Unsignalized Intersection"
230 TI$ = INPUT$(1): IF TI$ = "S" OR TI$ = "s" OR TI$ = "U" OR TI$ = "u" THEN 24
0 ELSE COLOR 15, 0: PRINT : PRINT "   You MUST select one of the following inter
section types!": GOTO 220
240 PRINT : PRINT "   Are the raw conflict data for one intersection approach le
g?  (Y=Yes) (N=No)": Y2$ = INPUT$(1): IF Y2$ = "Y" OR Y2$ = "y" THEN 260 ELSE IF
 Y2$ = "N" OR Y2$ = "n" THEN 270
250 COLOR 15, 0: PRINT : PRINT "   You MUST answer the following question!": COL
OR 2, 0: GOTO 240
260 PRINT : PRINT "   Input the name of the intersection approach leg and press
```

```
return.                For example, input WB Oak Street.": INPUT "   "; NA$: IF N
A$ = "" THEN 260 ELSE 280
270 PRINT : PRINT "   Input the names of the intersection approach legs and pres
s return.              For example, input WB & EB Oak Street.": INPUT "   "; NA$:
 IF NA$ = "" THEN 270
280 PRINT : PRINT "   Input the name of the traffic conflict and press return.
                       For example, input slow vehicle or sv.
                       Do NOT use commas in the conflict name."
290 INPUT "   "; CON$: IF CON$ = "" THEN 280
300 PRINT : PRINT "   Input the number of Time Periods and press return.
                       The time periods are listed on the conflict data sheet.":
INPUT "   "; N!: PRINT
310 IF N! = INT(N!) THEN N = N!: IF N > 0 AND N < 31 THEN 330
320 COLOR 15, 0: PRINT : PRINT "   PROBABLE ERROR IN YOUR INPUT!
                                    The number of Time Periods is usually between
 4 and 15.": COLOR 2, 0: GOTO 300
330 DIM C(200), T(200), T$(200), T!(200)
340 PRINT "   Input the length of the Recording Period, in Minutes and press ret
urn.          This information is listed on the top of the conflict data sheet."
: INPUT "   "; L!: PRINT
350 IF L! = INT(L!) THEN L = L!: IF L > 5 AND L < 121 THEN 400
360 COLOR 15, 0: PRINT "   Is this value correct?  (Y=Yes) (N=No)
                            If you use this value the results may be erroneous."
370 XS$ = INPUT$(1): IF XS$ = "Y" OR XS$ = "y" THEN L = L!: GOTO 390 ELSE PRINT
: PRINT : COLOR 2, 0: GOTO 340
380 REM ***  INPUT COUNT START TIMES AND RAW CONFLICT COUNTS                 ***
390 IF L < 5 OR L > 120 THEN PRINT : PRINT "   ERROR!  A recording period is usu
ally between 20 and 30 minutes.": PRINT : COLOR 2, 0: GOTO 340
400 COLOR 3, 0: CLS : PRINT : PRINT "   Input Count Start Times and Raw Conflict
 Counts                                  and press return for each entry."
410 PRINT "   Use Military Time for the Start Time.  For example,
              7:15 a.m. = 715 and 2:00 p.m. = 1400"
420 PRINT : PRINT "   Period"; "   Start Time"; "   Conflict Count"
430 REM ***  CHECK INPUT TIME FOR ERRORS                                     ***
440 TC = 0: FOR I = 1 TO N
450 PRINT TAB(6); I; TAB(15); : INPUT ; T!(I): IF T!(I) = INT(T!(I)) THEN T(I) =
 T!(I): GOTO 470
460 COLOR 15, 0: PRINT "   Input time must be in whole numbers!  Re-enter your d
ata.": PRINT : COLOR 3, 0: GOTO 450
470 TZ$(1) = STR$(T(I)): IF VAL(RIGHT$(TZ$(1), 2)) > 59 THEN 1130 ELSE IF T(I) <
 700 OR T(I) + L + 40 > 1800 THEN 1000
480 TI = T(I - 1) + L: TX$(1) = STR$(T(I - 1) + L): IF VAL(RIGHT$(TX$(1), 2)) >
59 THEN TI = T(I - 1) + L + 40
490 IF I > 1 AND TI > T(I) THEN 1040 ELSE PRINT TAB(31); : INPUT C(I)
500 NEXT: CS = 0
510 COLOR 2, 0: PRINT : PRINT "   Are these values correct?  (Y=Yes) (N=No)": YN
$ = INPUT$(1): IF YN$ = "Y" OR YN$ = "y" THEN 520 ELSE 400
520 IF N = 1 THEN 770
530 REM ***  DETERMINES MINUTES IN THE RECORDING PERIODS                     ***
540 FOR I = 1 TO N: T$(I) = STR$(T(I)): TC = TC + C(I): NEXT
550 FOR I = 1 TO N: IF T(I) < 1000 THEN 570
560 T1(I) = VAL(LEFT$(T$(I), 3)): GOTO 580
570 T1(I) = VAL(LEFT$(T$(I), 2))
580 NEXT
590 GOTO 690
600 REM ***  INPUT DATA FOR OTHER CONFLICT TYPES                             ***
610 COLOR 3, 0: CLS : PRINT : PRINT "   Input the name of the traffic conflict a
nd press return.                         For example, input slow vehicle or sv.
                                         Do NOT use commas in the conflict name."

620 INPUT "   "; CON$: IF CON$ = "" THEN 610
```

```
630 PRINT : PRINT "   Input the raw conflict counts and press return for each en
try."
640 PRINT : PRINT "   Period"; "   Start Time"; "   Conflict Count"
650 TC = 0: FOR I = 1 TO N: PRINT TAB(6); I; TAB(15); : PRINT T(I); : PRINT TAB(
31); : INPUT C(I): TC = TC + C(I): NEXT: CS = 0
660 COLOR 2, 0: PRINT : PRINT "   Are these values correct?  (Y=Yes) (N=No)": YN
$ = INPUT$(1): IF YN$ = "Y" OR YN$ = "y" THEN 670 ELSE 610
670 IF N = 1 THEN 770
680 REM ***  CALCULATES CONFLICTS FOR NONOBSERVATION PERIODS AND ADDS      ***
        ***  RESULTS TO OBSERVED COUNTS TO OBTAIN THE DAILY COUNT          ***
690 TB = T(1) - 700: IF T(1) > 759 THEN TB = ((T1(1) - 7) * 60) + VAL(RIGHT$(T$(
1), 2))
700 CB = C(1) * (TB / L)
710 FOR I = 1 TO N - 1: IF VAL(RIGHT$(T$(I), 2)) + L > 60 THEN TM = (T(I + 1) -
(T(I) + L - 40)) ELSE TM = (T(I + 1) - (T(I) + L))
720 IF TM > 59 THEN TM = ((T1(I + 1) - T1(I)) * 60) + (VAL(RIGHT$(T$(I + 1), 2))
 - (VAL(RIGHT$(T$(I), 2)) + L))
730 CM = C(I) + ((C(I) + C(I + 1)) / 2) * (TM / L): CS = CS + CM: NEXT
740 TE = (1759 - (T(N) + L)) + 1
750 IF (T(N) + L) < 1700 THEN TE = ((18 - T1(N)) * 60) - (VAL(RIGHT$(T$(N), 2))
+ L)
760 CE = C(N) + (C(N) * TE / L): CT = CB + CS + CE: IF IX = 0 THEN 790 ELSE 860
770 CT = C(1) * 660 / L: TC = C(1): IF IX = 0 THEN 790 ELSE 860
780 REM ***  PRINTS RAW DATA AND DAILY CONFLICT COUNT                      ***
790 IF Y2$ = "Y" OR Y2$ = "y" THEN AP$ = "Approach Leg of " ELSE AP$ = "Approach
 Legs of "
800 IX = 1: COLOR 6, 0: CLS : PRINT : PRINT "   **  Daily Conflict Counts for th
e "; : IF TI$ = "S" OR TI$ = "s" THEN PRINT "Signalized Intersection  **": PRINT
 TAB(8); AP$; NA$: GOTO 820 ELSE PRINT "Unsignalized Intersection  **"
810 PRINT TAB(8); AP$; NA$
820 PRINT #1, "          **  Daily Conflict Counts for the "; : IF TI$ = "S" OR
 TI$ = "s" THEN PRINT #1, "Signalized Intersection  **": PRINT #1, TAB(16); AP$;
 NA$: GOTO 840 ELSE PRINT #1, "Unsignalized Intersection  **"
830 PRINT #1, TAB(16); AP$; NA$
840 PRINT "      ____________________________________________________________"
850 PRINT #1, "                  ________________________________________________
_______": GOTO 870
860 COLOR 6, 0: CLS
870 PRINT : PRINT "      Adjustment of Raw Conflict Counts to Daily Conflict Cou
nts": PRINT
880 PRINT #1, : PRINT #1, "                 Adjustment of Raw Conflict Counts to D
aily Conflict Counts": PRINT #1,
890 PRINT "            Period       Start Time       Conflict Count": PRINT
900 PRINT #1, "                     Period       Start Time       Conflict Coun
t": PRINT #1,
910 FOR I = 1 TO N: PRINT TAB(16); I; TAB(30); : PRINT USING "####"; T(I); : PRI
NT TAB(48); : PRINT USING "####"; C(I): NEXT
920 FOR I = 1 TO N: PRINT #1, TAB(25); I; TAB(39); : PRINT #1, USING "####"; T(I
); : PRINT #1, TAB(57); : PRINT #1, USING "####"; C(I): NEXT
930 PRINT : PRINT "      Total number of "; CON$; " conflicts = "; TC: PRINT
940 PRINT #1, : PRINT #1, "                 Total number of "; CON$; " conflicts =
 "; TC: PRINT #1,
950 PRINT "      Daily "; CON$; " conflict count = "; : PRINT USING "#####.#"; C
T: PRINT : PRINT "             *    *    *    *    *    *    *    *"
960 PRINT #1, "             Daily "; CON$; " conflict count = "; : PRINT #1, U
SING "#####.#"; CT: PRINT #1, : PRINT #1, "                   *    *    *
   *    *    *    *    *"
970 REM ***  ASKS USER FOR INPUT CONCERNING OTHER CONFLICT TYPES           ***
980 COLOR 2, 0: PRINT : PRINT : PRINT "   Do you want a daily count for another
conflict type?  (Y=YES) (N=NO)": CR$ = INPUT$(1): IF CR$ = "Y" OR CR$ = "y" THEN
 610 ELSE 1170
```

```
990 REM ***  TELLS USER THAT OBSERVATION PERIODS ARE NOT WITHIN THE      ***
        ***  STANDARD DAILY RECORDING TIME OF 7:00 A.M. TO 6:00 P.M.     ***
1000 TL = 1800 - L - 40
1010 COLOR 15, 0: PRINT : PRINT "  Program cannot compute daily conflict counts
 for observation                  periods between 1800 (6:00 p.m.) and 7:00 a.
m.  Input only                    start times between 700 and ";
1020 PRINT USING "####"; TL; : PRINT ".": GOTO 1090
1030 REM ***  TELLS USER THAT THE INPUT START TIME EITHER OVERLAPS          ***
        ***  OR IS LESS THAN THE PREVIOUS OBSERVATION PERIOD                ***
1040 TT = T(I - 1) + L: TX$(1) = STR$(T(I - 1) + L): IF VAL(RIGHT$(TX$(1), 2)) >
 59 THEN TT = T(I - 1) + L + 40
1050 IF T(I) < T(I - 1) THEN 1070
1060 COLOR 15, 0: PRINT : PRINT : PRINT "   Note that the time period beginning
at "; T(I); "   overlaps the previous time period of"; T(I - 1); "to "; : PRINT
USING "####"; TT; : PRINT ".": GOTO 1140
1070 COLOR 15, 0: PRINT : PRINT : PRINT "   Note that the time period beginning
at"; T(I); "   is less than the previous time period of"; T(I - 1); "to "; : PRI
NT USING "####"; TT; : PRINT "."
1080 PRINT "   The start times MUST be in chronological order
               from 7:00 a.m. to 6:00 p.m."
1090 PRINT : PRINT "   Do you want to re-enter your data? (Y=YES) (N=NO)": X$ =
INPUT$(1): IF X$ = "y" OR X$ = "Y" THEN 400
1100 PRINT : PRINT "   Program terminated due to error in the count start times.
                       Correct the start times and run the program again.": PRIN
T : PRINT "   Press any key to continue."
1110 Y4$ = INPUT$(1): CLOSE : KILL FILE$: GOTO 1350
1120 REM ***  TELLS USER THAT INPUT TIME IS INCORRECT  ***
1130 COLOR 15, 0: PRINT : PRINT "  ERROR IN INPUT TIME! The number of minutes
in an hour                        cannot exceed 60.  Input correct time.": COL
OR 3, 0: PRINT : GOTO 450
1140 COLOR 15, 0: PRINT : PRINT "  When the recording periods overlap, then you
 MUST                             use the average value for the recording peri
od.                               Determine the average value for each";
1150 PRINT " recording": PRINT "   period on the summary sheet, then run the pro
gram again.": PRINT : PRINT "   Press any key to continue.": Y5$ = INPUT$(1): CL
OSE : KILL FILE$: GOTO 1350
1160 REM ***  ASKS IF THE USER WANTS THE RESULTS PRINTED  ***
1170 COLOR 2, 0: CLS : PRINT : PRINT "   Data processing is complete.": PRINT :
COLOR 3, 0: PRINT "   Do you want to print the results?  (Y=Yes) (N=No)": Y8$ =
INPUT$(1)
1180 IF Y8$ = "Y" OR Y8$ = "y" THEN 1190 ELSE 1250
1190 PRINT : PRINT "   Turn your printer on and move the paper to the top of the
 sheet.": PRINT "   Press any key to print the results or N to abort printing.":
 N8$ = INPUT$(1): IF N8$ = "N" OR N8$ = "n" THEN 1250
1200 COLOR 15, 0: CLS : PRINT : PRINT "   WAIT! Printing file.": CLOSE : OPEN F
ILE$ FOR INPUT AS #1: WIDTH "LPT1:", 80: OPEN "LPT1:" FOR OUTPUT AS #2
1210 FOR I = 1 TO 8000: IF EOF(1) THEN 1240
1220 LINE INPUT #1, P$: PRINT #2, P$
1230 NEXT
1240 CLOSE #1: COLOR 2, 0: CLS : PRINT : PRINT "   Printing completed.": PRINT :

1250 IF TI$ = "S" OR TI$ = "s" THEN 1290 ELSE IF Y2$ = "Y" OR Y2$ = "y" THEN 127
0 ELSE 1320
1260 REM ***  CAUTIONS USER ABOUT COMPUTING TOTAL DAILY CONFLICTS  ***
1270 COLOR 15, 0: PRINT : PRINT : PRINT "   Caution!  To obtain the TOTAL number
 of daily conflicts for                 this unsignalized intersection you M
UST calculate the number of             daily conflicts for each nonstop";
1280 PRINT " approach leg, then manually": PRINT "   add the results.": GOTO 132
0
1290 COLOR 15, 0: PRINT : PRINT : PRINT "   Caution!  To obtain the TOTAL number
 of daily conflicts for                 this signalized intersection you MUS
T calculate the number of               daily conflicts for each approach";
1300 PRINT " leg, then manually add the": PRINT "   results."
1310 REM ***  ASKS IF THE USER WANTS TO CONDUCT ANOTHER ANALYSIS  ***
1320 CLOSE #1: COLOR 2, 0: PRINT : PRINT : COLOR 14, 0: PRINT "  Do you want to
 estimate the number of daily conflicts for another              intersection o
r intersection approach leg?  (Y=Yes) (N=No)": Y9$ = INPUT$(1)
1330 IF Y9$ = "Y" OR Y9$ = "y" THEN 150
1340 IF LS = 1 THEN KILL FILE$
1350 COLOR 7, 0: CLS : PRINT : END
```

APPENDIX C - STATISTICAL TECHNIQUES

As mentioned throughout the guide, to use various procedures it is necessary to calculate mean values, variances, and the correlation coefficient. The formulas for these values are given below along with examples.

Mean

The mean value is calculated by the formula:

$$\overline{Y} = \frac{1}{N}\sum_{i=1}^{N} Y_i$$

For example, if 1, 2, 0, 5, and 6 left-turn, same-direction conflicts were recorded during a day the mean would be:

$$\overline{Y} = 1/5 \quad (1 + 2 + 0 + 5 + 6)$$

$$= 2.80$$

Variance

The variance is calculated using the formula:

$$\text{Var}(Y) = \frac{N\sum_{i=1}^{N} Y_i^2 - \left(\sum_{i=1}^{N} Y_i\right)^2}{N(N-1)}$$

If the same data is used for the above sample, the variance is:

$$\text{Var}(Y) = \frac{5\ (1^2 + 2^2 + 0^2 + 5^2 + 6^2) - (14)^2}{5\ (5-1)}$$

$$= \frac{330-196}{20}$$

$$= 6.70$$

Standard Deviation

The standard deviation, s, is the square root of the variance, thus, for the example:

$$s = \sqrt{6.70}$$

$$= 2.59$$

Correlation Coefficient

The formula for the Pearson's r is:

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

where

r = correlation coefficient

N = number of observations

X = one variable of interest

Y = second variable of interest

Assume two observers, observer X and observer Y, recorded conflicts on the same approach for 10 recording periods. The data, computations, and results are given below.

1 X	2 Y	3 X^2	4 Y^2	5 XY
5	1	25	1	5
10	6	100	36	60
5	2	25	4	10
11	8	121	64	88
12	5	144	25	60
4	1	16	1	4
3	4	9	16	12
2	6	4	36	12
7	5	49	25	35
1	2	1	4	2
60 ΣX	40 ΣY	494 ΣX^2	212 ΣY^2	288 ΣXY

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

$$= \frac{10 \times 288 - 60 \times 40}{\sqrt{(10 \times 494 - 60^2)(10 \times 212 - 40^2)}}$$

$$= \frac{480}{\sqrt{1{,}340 \times 520}} = +.58$$

B57
11

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