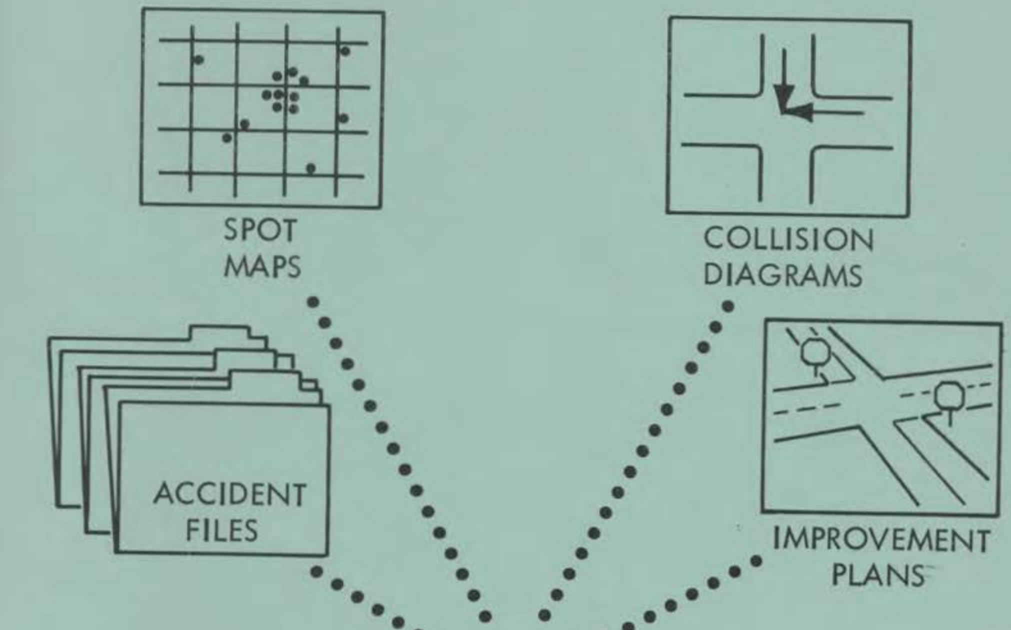
Manual on Identification, Analysis and Correction of High Accident Locations



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MISSOURI STATE HIGHWAY COMMISSION

Manual on

Identification, Analysis and Correction of High Accident Locations

This manual was prepared for second- and third-class Missouri cities by Midwest Research Institute. The work was sponsored by the Missouri State Highway Commission in cooperation with the Missouri Division of Highway Safety and the Federal Highway Administration, U.S. Department of Transportation.

The manual was written by Jerry L. Graham, Associate Traffic Engineer, and John C. Glennon, Manager, Traffic Safety Center, Midwest Research Institute. The authors wish to acknowledge the cooperative efforts of Mr. Walter Davidson, City Engineer, Clinton, Missouri; Mr. Rennald Thomas, City Engineer, Gladstone, Missouri; and Mr. Elton Cook of the Missouri State Highway Department.

November, 1975

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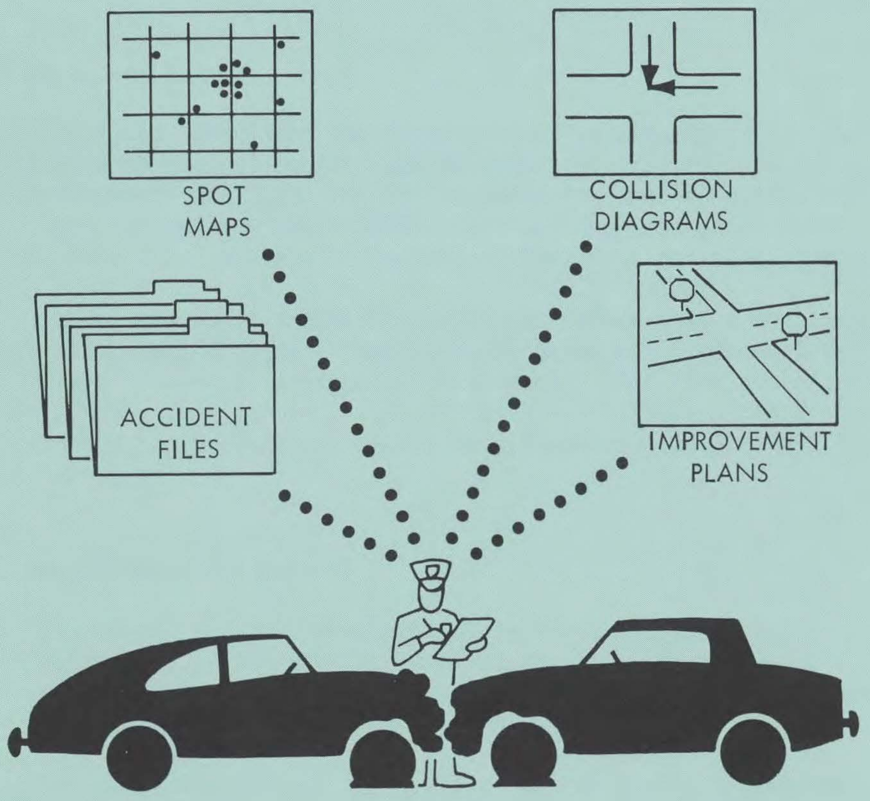


Streets and highways are vital to the well-being of a community. Inefficiencies in the street and highway system cause human suffering and death, low productivity, and higher costs. Therefore, those charged with the design, construction, and maintenance of streets and highways have the continuing responsibility of making them more safe and efficient.

Although not all accidents are due to faulty design or construction of the roadway system, a concentration of accidents at one location implies that there has been a failure of the system. Detailed study of accident records can identify these high-accident locations and point out improvements that will reduce the numbers and severity of future accidents.

Purpose and Scope

This manual describes the high-accident location analysis (HAL) system which will allow the user to identify, analyze, and correct high-accident locations. It was prepared for smaller cities in Missouri that do not have traffic engineers but recognize their need for a local capability to deal with traffic accident problems.

The HAL system is a continuing program rather than a one-time cure-all. Instructions in each chapter guide city personnel through the establishment of procedures, and specify when each procedure is done. Using this manual, city personnel with little or no training in traffic engineering can undertake a complete high-accident location analysis.

Organization of the Manual

This manual has five chapters. This first chapter briefly explains the HAL system and the benefits of using it. Chapters 2 through 5 cover each of the four basic processes of the HAL system as shown in Figure 1.

Chapter 2, "Setting Up the Traffic Records System," describes the requirements for reporting, filing, and summarizing traffic accident data. Chapter 3, "Identifying High-Accident Locations," describes the Early Warning Analysis and the Annual City-Wide Analysis, two procedures that will identify locations with high numbers

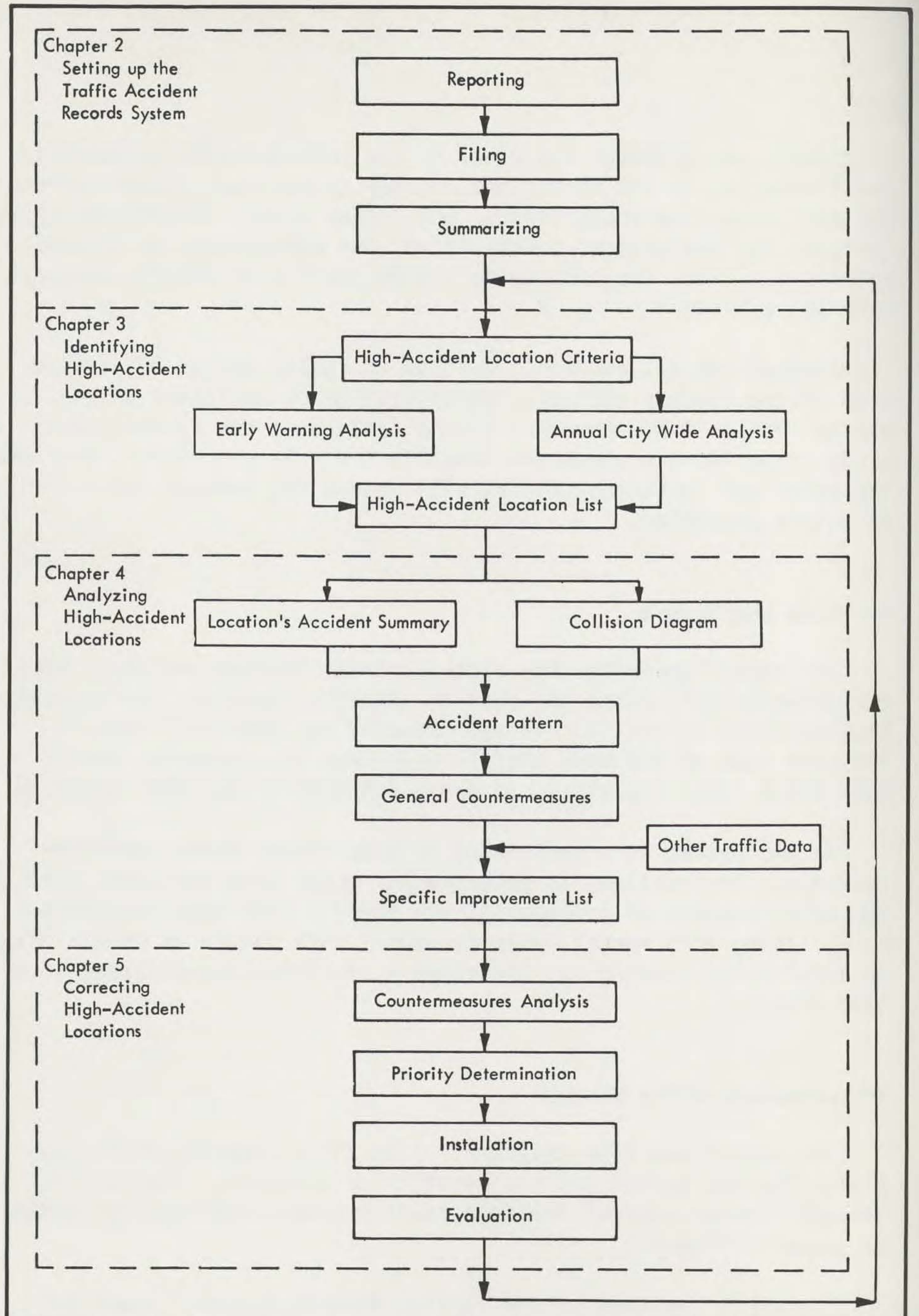


Figure 1—The High-Accident Location Analysis (HAL) System

of traffic accidents. Chapter 4, "Analyzing High-Accident Locations," gives methods for interpreting a location's accident experience to determine general countermeasures for certain accident patterns. These general countermeasures and data from traffic studies are then used to identify specific improvements for each high-accident location. Chapter 5, "Correcting High-Accident Locations," describes how alternative improvements for reducing traffic accident numbers and severity are compared to select which improvement or group of improvements to install. Methods for evaluating the improvements installed at a location and evaluating the established HAL system are also given.

How to Use the Manual

Several procedures are used to study high-accident locations. To get an idea of how the procedures relate to each other, the person in charge of the HAL system should read through the entire manual. On this first reading, the procedures within each chapter can be read over quickly, ignoring specific instructions. When the four basic processes are generally understood, the chapters can then be referred to for the details of each procedure.

Although this manual covers all basic processes needed to analyze high-accident locations, it does not contain details of improvement design. For this purpose the reader is referred to the Manual on Uniform Traffic Control Devices (MUTCD) which contains standards for many kinds of improvements, and should be used with this manual when choosing specific improvements.

Who Should be in Charge of the HAL System?

Both the police department and the engineering department should be involved in analyzing high-accident locations. The police department furnishes the required traffic accident data to the person in charge of traffic engineering functions. Although this person is normally the city engineer, if a city does not have a full-time city engineer, responsibility for maintaining the HAL system could be given to the chief of police, the police officer in charge of accident investigation, or the director of public works.

In later chapters, the term "city engineer" refers to the person in charge of the HAL system.

Purpose of Worksheets

Worksheets are provided for many of the procedures in this manual. They guide the user through each step of a procedure, and document the accident analysis. One original of each worksheet is attached to the inside back cover of this manual. Photocopies of the worksheet originals should be made when the analysis procedures are begun.

Costs and Benefits of the HAL System

The goal of reducing the number and severity of traffic accidents requires the investment of time and money. Although the cost of materials for setting up the HAL system should not exceed $150, the costs of man power needed to complete the analysis procedures is greater and may involve personnel such as the police chief or city engineer, both with many other time-consuming responsibilities. Each chapter lists the time required from each category of city personnel, as well as the cost of any required materials.

Because the use of this manual involves an investment, it is also appropriate to mention its benefits. The most obvious benefits are the reduction of the number and severity of accidents. The National Highway Traffic Safety Administration estimates (1972) for the costs of traffic accidents are:

• Fatal accident	$234,960
• Injury accident	11,200
• Property-damage-only accident	500

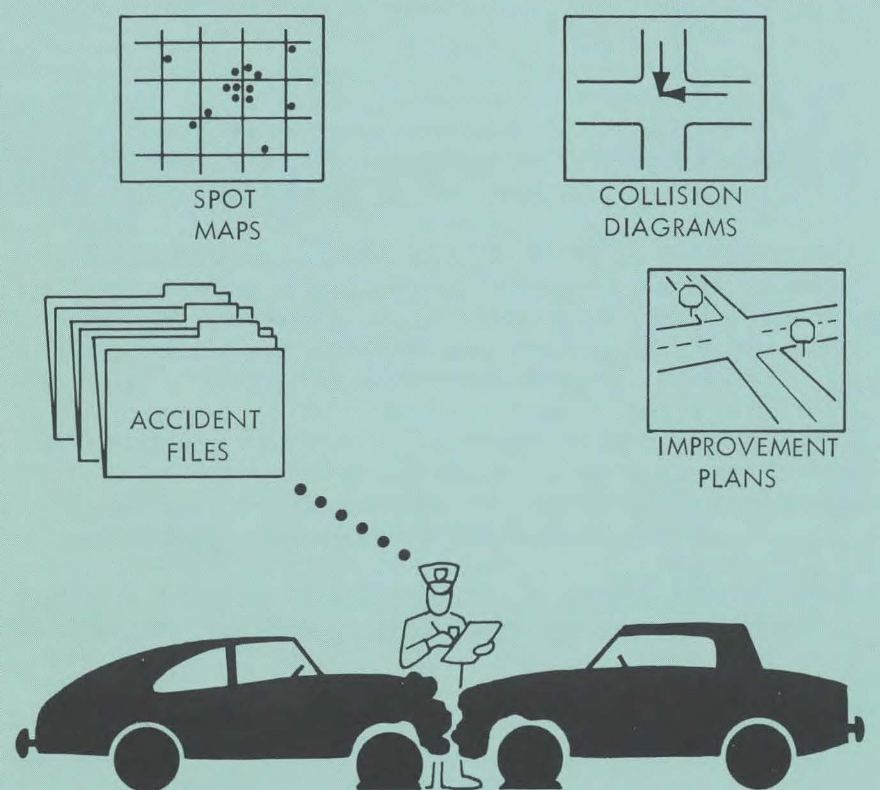
With these estimates, you can easily see the potential dollar benefit of fairly small accident reductions, not to mention the saving of life and limb. These estimates are used in Chapter 5 for computing the benefits of installing a safety improvement at a location.

Also, better use will be made of available accident reports. Although police departments spend considerable time and money in collecting and filing accident reports, the value of the accident reports is lost if they are not used to correct the causes of accidents.

Another benefit is that the system can be readily used by consultants hired by the city to make traffic analyses. When the accident data are easily available, these professionals can spend more time analyzing the causes of the accident problems and their appropriate countermeasures.

The HAL system described here is a powerful tool for your community to use in solving traffic accident problems. But, in the final analysis, the commitment of city officials and the community will determine the benefits from using the system.

CHAPTER 2—SETTING UP THE TRAFFIC RECORDS SYSTEM



Accident data must be complete, accurate, and easily found. Making sure that accident data meet these requirements for an engineering analysis is the first important process. This chapter describes guidelines on reporting, filing, and summarizing accident data.

Accident Records System — Basic Information

The Missouri State Highway Patrol furnishes cities with standard traffic accident report forms. Form No. 1 of the report is shown in Figure 2. The report has two forms and is provided in a multi-carbon format so each form is automatically filled out in triplicate. The triplicate pages are labeled "ORIGINAL" (shown in Figure 2), "STATE" or "ENGINEERING."

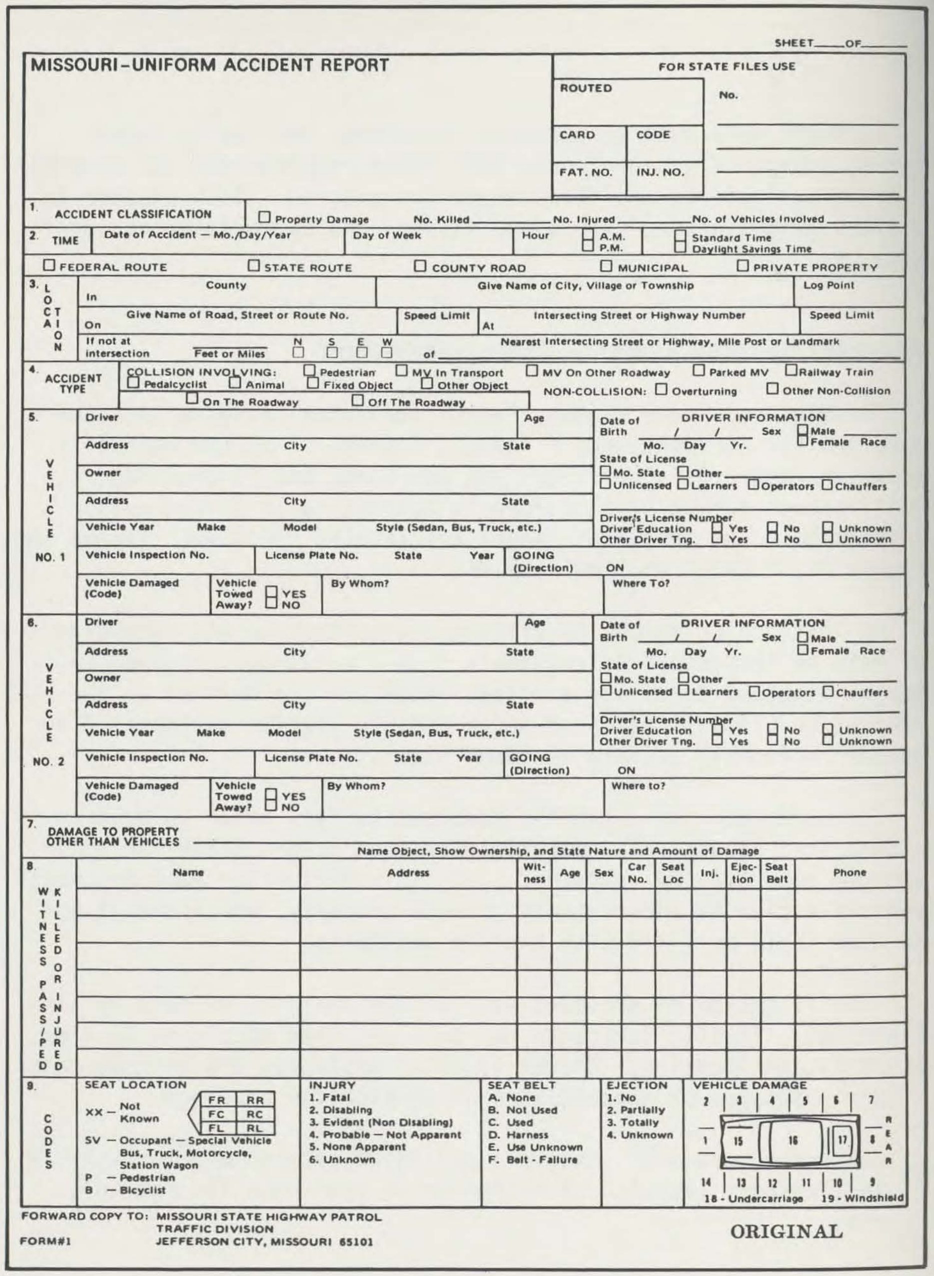
An instruction manual describing the collection and recording of data on the report is available from the Missouri Highway Patrol. Standard terms for accident reporting are defined by the "Manual on Classification of Motor Vehicle Traffic Accidents," to ensure nationally uniform accident statistics.

The *definition* of a traffic accident is "any motor vehicle accident that occurs on a trafficway or that occurs after the motor vehicle runs off the roadway . . ." This definition excludes motor vehicle accidents occurring on private property, which should not be classified or filed with traffic accidents.

Classification of accident data allows analysis of data by similarities. Traffic accidents can be classified according to type, severity, or location. Eleven types of accidents are grouped under either *collision* or *noncollision* classification headings.

Collision accidents involve a collision between a motor vehicle in transport (meaning in motion or in readiness for motion), and:

1. A pedestrian;
2. Another motor vehicle in transport;
3. A motor vehicle on another roadway;
4. A parked motor vehicle;
5. A railway train;
6. A pedalcyclist;
7. An animal


SHEET____OF____

MISSOURI-UNIFORM ACCIDENT REPORT

FOR STATE FILES USE
ROUTED | No.
CARD | CODE
FAT. NO. | INJ. NO.

1. ACCIDENT CLASSIFICATION ☐ Property Damage No. Killed ____ No. Injured ____ No. of Vehicles Involved ____
2. TIME Date of Accident — Mo./Day/Year | Day of Week | Hour ☐ A.M. ☐ P.M. | ☐ Standard Time ☐ Daylight Savings Time

☐ FEDERAL ROUTE ☐ STATE ROUTE ☐ COUNTY ROAD ☐ MUNICIPAL ☐ PRIVATE PROPERTY

3. LOCATION
In — County | Give Name of City, Village or Township | Log Point
On — Give Name of Road, Street or Route No. | Speed Limit | At — Intersecting Street or Highway Number | Speed Limit
If not at intersection ____ Feet or Miles N ☐ S ☐ E ☐ W ☐ of ____ Nearest Intersecting Street or Highway, Mile Post or Landmark

4. ACCIDENT TYPE
COLLISION INVOLVING: ☐ Pedestrian ☐ MV In Transport ☐ MV On Other Roadway ☐ Parked MV ☐ Railway Train ☐ Pedalcyclist ☐ Animal ☐ Fixed Object ☐ Other Object
☐ On The Roadway ☐ Off The Roadway
NON-COLLISION: ☐ Overturning ☐ Other Non-Collision

5. VEHICLE NO. 1
Driver | Age
Address | City | State
Owner
Address | City | State
Vehicle Year | Make | Model | Style (Sedan, Bus, Truck, etc.)
Vehicle Inspection No. | License Plate No. | State | Year | GOING (Direction) ON
Vehicle Damaged (Code) | Vehicle Towed Away? ☐ YES ☐ NO | By Whom? | Where To?
DRIVER INFORMATION
Date of Birth __/__/__ Mo. Day Yr. Sex ☐ Male ☐ Female Race
State of License ☐ Mo. State ☐ Other ____
☐ Unlicensed ☐ Learners ☐ Operators ☐ Chauffers
Driver's License Number
Driver Education ☐ Yes ☐ No ☐ Unknown
Other Driver Tng. ☐ Yes ☐ No ☐ Unknown

6. VEHICLE NO. 2
Driver | Age
Address | City | State
Owner
Address | City | State
Vehicle Year | Make | Model | Style (Sedan, Bus, Truck, etc.)
Vehicle Inspection No. | License Plate No. | State | Year | GOING (Direction) ON
Vehicle Damaged (Code) | Vehicle Towed Away? ☐ YES ☐ NO | By Whom? | Where to?
DRIVER INFORMATION
Date of Birth __/__/__ Mo. Day Yr. Sex ☐ Male ☐ Female Race
State of License ☐ Mo. State ☐ Other ____
☐ Unlicensed ☐ Learners ☐ Operators ☐ Chauffers
Driver's License Number
Driver Education ☐ Yes ☐ No ☐ Unknown
Other Driver Tng. ☐ Yes ☐ No ☐ Unknown

7. DAMAGE TO PROPERTY OTHER THAN VEHICLES ____
Name Object, Show Ownership, and State Nature and Amount of Damage

8. WITNESSES PASS/PED KILLED OR INJURED

Name	Address	Wit-ness	Age	Sex	Car No.	Seat Loc	Inj.	Ejec-tion	Seat Belt	Phone

9. CODES
SEAT LOCATION: XX — Not Known; FR RR / FC RC / FL RL; SV — Occupant — Special Vehicle Bus, Truck, Motorcycle, Station Wagon; P — Pedestrian; B — Bicyclist
INJURY: 1. Fatal 2. Disabling 3. Evident (Non Disabling) 4. Probable — Not Apparent 5. None Apparent 6. Unknown
SEAT BELT: A. None B. Not Used C. Used D. Harness E. Use Unknown F. Belt - Failure
EJECTION: 1. No 2. Partially 3. Totally 4. Unknown
VEHICLE DAMAGE: 2 3 4 5 6 7 / 1 15 16 17 8 REAR / 14 13 12 11 10 9 / 18 - Undercarriage 19 - Windshield

FORWARD COPY TO: MISSOURI STATE HIGHWAY PATROL
TRAFFIC DIVISION
JEFFERSON CITY, MISSOURI 65101
FORM#1
ORIGINAL

Figure 2—Uniform Accident Report (Form #1)

8. A fixed object; and
9. Other objects.

Noncollision accidents involve a motor vehicle in transport:

1. Overturning; and
2. Other noncollision.

The severity of accidents can be classified in three ways: injury severity, damage severity, or number of motor vehicles involved. The three most common injury severity ratings are fatal, nonfatal injury, and property-damage-only accidents.

The location of accidents can be classified either by the relationship of the accident to an intersection, such as "at intersection" or "50 ft from the intersection," or by the characteristics of the location of the accident such as "urban," "rural," or "industrial area."

The standard accident report form and standard definitions are necessary for the uniform and precise reporting of traffic accidents. The "Manual on Collecting and Recording Data on the Missouri Uniform Accident Report Form" is obtained from the Missouri State Highway Patrol, Traffic Division, Jefferson City, Missouri. The "Manual on Classification of Motor Vehicle Traffic Accidents" is available from the National Safety Council, 714 East 12th, Kansas City, Missouri 64106.

Traffic Accident Reporting

Because the police department does not normally perform engineering analysis of accident data, police officials may be unaware that their accident reporting is insufficient for high-accident location analysis. Engineering analysis of accident data is the quickest way to evaluate the effectiveness of accident reporting procedures.

Often the problems with accident reporting involve either how the location is specified or how the accident diagram is drawn and described. Check a sample of recent accident reports to discover where the present accident reports might be faulty, and to improve the way accident reports are made. The following three suggestions for spot checking are useful:

1. Check the Location Block:

   - Is the location of the accident specified to within 50 ft?

- If a road is a numbered highway and also has a street name, are the number and the name both shown? Example: Mo. 1-Antioch Road

2. Check the Accident Diagram:

   - Are the directions of travel of the involved vehicles shown?

   - Are any measurements shown in the diagram?

   - Is the location of the accident shown with reference to an intersection or other known landmark?

   - Is the north direction identified?

3. Check the Officer's Statement:

   - Does it explain what happened?

   - Does it fully identify the relationship of the accident to a nearby intersection? For example, instead of "Vehicle No. 1 was struck in the rear while stopped in traffic," the statement should say "Vehicle No. 1 was struck in the rear while stopped in traffic lined up from the traffic signal at 56th Street."

Other problems may concern the way accidents are investigated. For example, a clear standard on when to make an accident report is very important. Standard 18 of the Highway Safety Program* specifies that the local police department should be notified immediately by drivers involved in either a fatal or injury accident, or a property-damage-only accident where a damaged vehicle cannot be moved from the accident scene. The National Safety Council recommends that police make reports on all traffic accidents coming to their attention, with exceptions for minor accidents such as a scratched fender. The National Safety Council recommendation is a good guideline in most cases. If there is any doubt whether an accident is "minor," the officer should make a report.

Inconsistency of accident reporting may also cause confusion when the accident reports are analyzed. An example is the way a street is sometimes referred to by different names. For example,

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* "Accident Investigation and Reporting," *Highway Safety Program Manual*, Vol. 18 (Interim), National Highway Traffic Safety Administration (1972).

a road once crossing an orchard was called Apple Orchard Lane. Then the land was developed as a block of expensive homes, and the road was renamed Regency Manor Drive. If the reports of accidents on this street do not use the same name, they are inconsistent.

Once you have checked a sample of accident reports, recommend changes in reporting methods to eliminate any problems. The officer in charge of accident investigation should make these changes, eliminate inconsistencies, set up reporting standards, and make them clear to all investigating officers.

Traffic Accident Report Filing

Although traffic accident report files are normally kept by the police department, they may also be kept by the engineering department. A systematic plan should be established for handling accident reports so that they can be filed easily, not lost or misfiled, and handled the least number of times. The recommended filing procedure has five basic steps.

1. Check each report for completeness and accuracy;

2. Transfer relevant information to a tally sheet;

3. Plot the location of each accident on a spot map;

4. Prepare information cards for cross-files such as a driver-record file; and

5. File the accident report in the location file.

Step 1 involves checking the officer's report of the traffic accident to assure completeness and accuracy. Standards established for reporting should be followed. For example, measurements for locating the site of an accident should be to the nearest 1/100 of a mile (50 ft). Handwriting should be legible, and the accident diagram clear. Check incompleteness, contradiction, or vagueness with the investigating officer.

Steps 2 and 3 are part of summarizing accident data which is covered later in this chapter (page 22).

Step 4 is required so the police department can find accident reports other than by accident location. For example, finding an accident report by the driver's name is difficult when reports are kept in a location file. To solve this problem, set up cross-files such as the driver-record file which is arranged alphabetically by driver names. Although the cards in this file do not give arranged details of the accident, they do tell where to find the complete report in the location file. In some police departments, this file is kept as part of the criminal-record files. Cross-files can also be set up by date or accident severity.

Step 5, the last step in processing the accident report, is to file the report in the location file. Description of the location file is given in the next section. Although the way accident reports are filed may vary from city to city, the final filing procedure should always include these five basic steps.

One way that filing procedures may vary is by the department that keeps the location file. If possible, keep the location file in the engineering department. An example of the filing procedure adopted by a city that has a location file in the engineering department and a chronological file in the police department is shown in Figure 3.

It may be impractical to keep the location file in the engineering department for one of the following reasons:

1. There is not space or personnel in the engineering department to keep the location file. For a city that has fewer than 1,000 accidents per year, there should be enough space for a small (16-in. depth) two-drawer file cabinet. Also an engineering aide, clerk, or secretary who can devote 1/2 day per month is needed for filing the accident reports.

2. The police department wants to use the location file and, therefore, is willing to establish and maintain the file. It is uneconomical to have two identical files. The police file should still meet the engineering requirements for a location file, and the file should be accessible to the engineering staff.

The filing procedure shown in Figure 4 was adopted by a city that established both a location file and a chronological file in the police department.

Both example filing procedures have the five basic steps for filing traffic accident reports. You must decide at this point if your current filing procedure contains these steps and, if not, how to change it. Once you have established a filing procedure and decided where to put the location file, it is maintained as described in the next section.

STEPS TO BE DONE IN THE POLICE DEPARTMENT

1. When the accident report is received, check it for completeness and clear up any questions with the investigating officer.
2. Have the report reviewed and signed by the reviewing officer.
3. Enter the report number on the driver-record card or cards. In the block at the top left of the form enter "DR," your initials, and the date.
4. Using the appropriately colored map pin, spot the location of the accident on the traffic accident spot map. In the block at the top left of the form enter "SM," your initials, and the date.
5. Send the STATE copy of the accident report to the Missouri Highway Patrol. If the accident occurred on a state highway, make a photocopy of the report for the City Engineer and send the ENGINEERING copy to the district office of the Missouri Highway Department.
6. Send a copy of the report to the City Engineer.
7. File the ORIGINAL of the report in the chronological file.

STEPS TO BE DONE IN THE ENGINEERING DEPARTMENT

1. Tally pertinent data from the report for the monthly summary sheet. In the block at the top left of the form enter "T," your initials, and the date.
2. File the ENGINEERING copy or the photocopy of the report in the location file.

Figure 3—A Filing Procedure with the Location File in the Engineering Department

1. When the accident report is received, check it for completeness and clear up any questions with the investigating officer.

2. Have the report reviewed and signed by the reviewing officer.

3. Enter information from the report on a tally sheet. Enter "T," your initials, and the date in the block at the top left of the accident report form.

4. Enter the report number and accident location on the driver-record card. Enter "DR," your initials, and date in the block at the top left of the form.

5. Mark the location of the accident on the traffic accident spot map. Enter "SM," your initials, and the date in the block at the top left of the form.

6. Send the STATE copy of the accident report form to the Missouri Highway Patrol. If the accident occurred on a state highway, send the ENGINEERING copy to the district office of the Missouri Highway Department.

7. If the accident occurred on a state highway, photocopy the report for the location file and file the ORIGINAL copy in chronological file. If the accident occurred on a city street file the ENGINEERING copy of the report in the location file and the ORIGINAL copy in chronological file.

Figure 4—A Filing Procedure with the Location File in the Police Department

The Location File

In a location file, traffic accident reports are filed alphabetically by location, with street names and house numbers used for indexing. Set up the file with a complete year's accident data. It should eventually contain 3 years of accident data. Materials needed for the file include a small (16-in. depth) file cabinet, left and right tab 1/3-cut guide cards, and center and right tab 1/3-cut file folders.

Starting with the first accident of the year, judge accidents as intersectional or mid-block by the "intersection-related" method. This method does not classify accidents by physical boundaries, but by the direct relationship of the accident to the location. Two examples help explain this method. In the first example, one vehicle rearends another vehicle at the end of a long line of traffic waiting at a signalized intersection. This accident is classified as an intersection-related accident and filed with other reports of accidents occurring at the intersection. In the second example, a pedestrian moves into traffic on a crosswalk against a "no walk" signal, causing a vehicle to stop, and a second approaching vehicles hits the stopped vehicle. This accident is also classified as intersection-related.

If the accident is intersection-related, determine which street to use as the primary index. If two municipal streets intersect, use the street name that alphabetically comes first as the primary index. For example, referring to Figure 5, file the accident occurring at the intersection of Main Street and Wilson Street behind a left-tab guide card with the primary index of MAIN STREET in the right-tab file folder labeled with Wilson Street as the secondary index. Note that primary indexes are typed with all capital letters, and secondary indexes are typed with only initial capital letters.

If a numbered route and a municipal street intersect, file the accidents by the highest route designation, i.e., Interstate route, U.S. route, State route, County route, municipal street, because this is how they should be recorded on the accident report. Also, if possible, include the lower designation such as U.S. 69 (VIVION ROAD) on the index.

If you have more than 20 numbered streets in your city, index these streets as 1st, 2nd, 3rd, etc., and determine the primary index numerically. If there are only a few numbered streets, spell out the numbers and file them alphabetically.

In summary, use the following order to determine which street is used as the primary index.

1. Interstate Routes;
2. U.S. Routes;
3. Missouri Routes;
4. County Routes;
5. Named Municipal Streets; and
6. Numbered Municipal Streets (if there are more than 20).

For example, at the intersection of U.S. 69 and Ohio Street, use U.S. 69 as the primary index. At the intersection of Ohio Street and 56th Street, use OHIO STREET as the primary index.

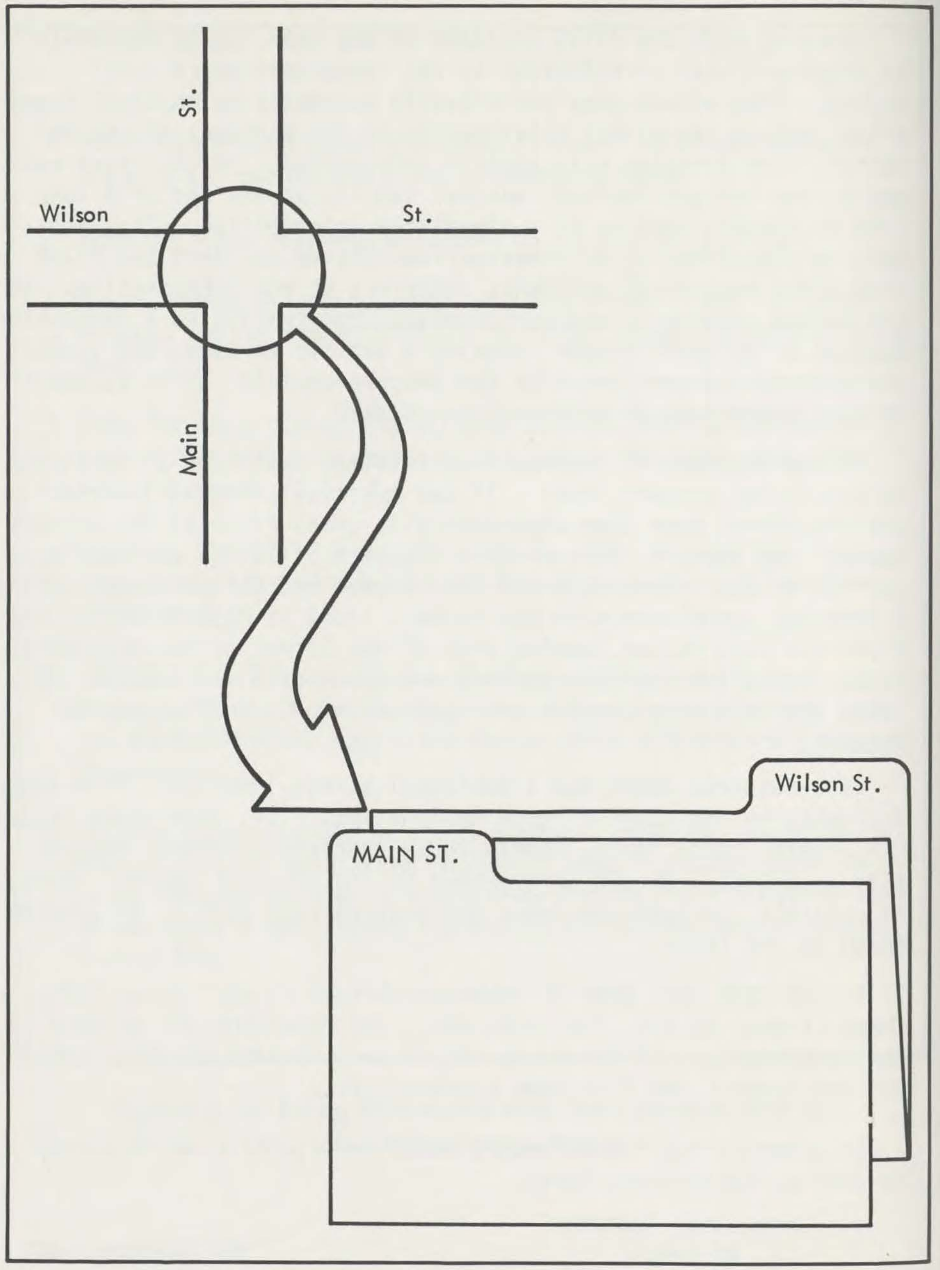


Figure 5—Filing an Intersection-Related Accident

Classify all accidents that are not intersection-related as mid-block accidents, and use the street name or route number as the primary index and the block number as the secondary index. The number of blocks included in a secondary index can vary from one block to the entire length of a street. Determine the way a street is divided into sections for indexing by the number of accidents occurring on each part of the street. When the location file is first established, file the mid-block accidents in a center-tab file folder immediately behind the guide card with the street name as the primary index. As the number of reports reaches 10, divide the street into sections according to accident concentrations. Write section designations in pencil until the entire year's reports are filed, then finalize them by typing them on the center-tab file folder. These same sections are used for the next year's file.

As the accident reports are filed, keep the most recent report at the front of each folder. To save unnecessary work, type the labels for the primary and secondary indexes only as required.

Observe the following rules in filing reports in the location file:

Rule 1. Keep all reports of accidents at the same intersection in one file folder; and

Rule 2. Use a separate folder for each individual intersection.

Although these rules seem simple, they are easily violated. For example, violations can occur because of peculiarities in a city's road pattern. Referring to Figure 6, the highlighted intersection involves three street names. The optimist would assume that all reports from this location are reported as occurring at the intersection of Artesian Avenue, Rogers Street, and Tower Street. But if some investigating officers only record two of the street names on the report, this same optimist could find the accidents filed in three folders as follows:

Folder 1 - ARTESIAN AVENUE (primary index), Rogers Street and Tower Street (secondary index).

Folder 2 - ARTESIAN AVENUE (primary index), Tower Street (secondary index).

Folder 3 - ROGERS STREET (primary index), Tower Street (secondary index).

If this intersection has a large number of accidents, you may never know if the accident reports are filed in three different places. This is a violation of Rule 1 (all accident reports from the same intersection must be in the same folder). Avoid this situation by placing warning cards in the two places where the reports could be misfiled. In Figure 6, warning cards were placed

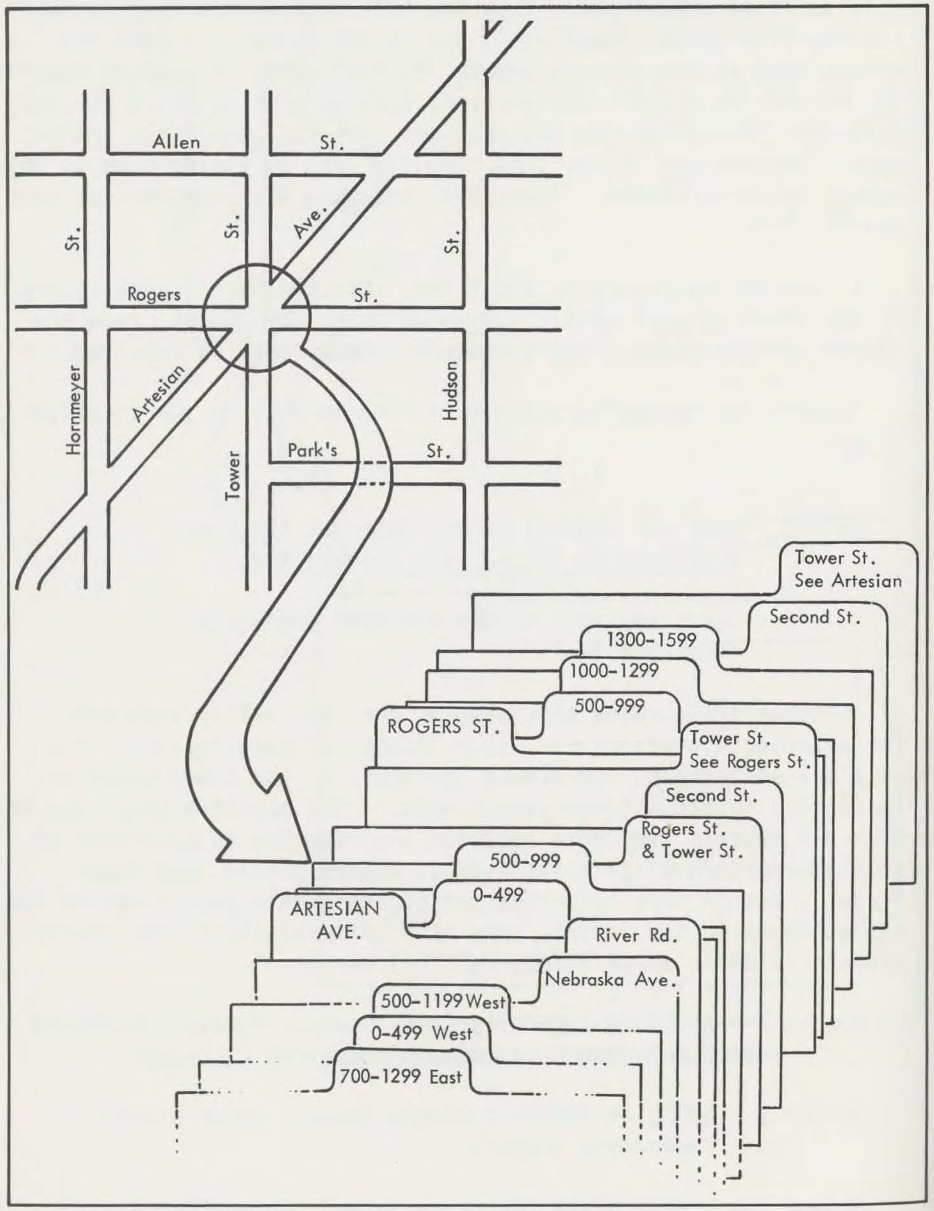


Figure 6—Filing Reports from an Intersection with Three Names

where an accident could be misfiled as ARTESIAN AVENUE and Tower Street (labeled Tower Street see Rogers Street), or as ROGERS STREET and Tower Street (labeled Tower Street see ARTESIAN).

Rule 1 can also be violated if one street has two designations such as a state route number and a street name. Thus, accidents at the intersection of Mo. 1 (Antioch Road) and U.S. 69 (Vivion Road) could be filed in four file folders as follows:

Folder 1 - U.S. 69 (primary index), Mo. 1 (secondary index).

Folder 2 - MO. 1 (primary index), Vivion Road (secondary index).

Folder 3 - U.S. 69 (primary index), Antioch Road (secondary index).

Folder 4 - ANTIOCH ROAD (primary index), Vivion Road (secondary index).

In the example above, the accidents should be filed with U.S. 69 (VIVION ROAD) as the primary index and Mo. 1 (Antioch Road) as the secondary index. Place warning cards at the locations where the accidents might be misfiled.

Rule 2 can be violated if two intersections have the same name because the two streets intersect more than once, as in Figure 7. This situation can also occur if two numbered routes join on one side of town, travel along one street, and then separate. To avoid filing reports of accidents from both intersections in the same folder, designate the two intersections more precisely. In the example, one of the intersections is called "North" and the other "South." The person in charge of accident investigation should instruct investigating officers to fill out the accident reports to clearly indicate which of the two locations was the accident site.

Although these rules require extra time when setting up the location file, a great deal of time will be saved later when finding the reports for a particular intersection.

Setting up a location file with 1 year's accident reports will normally take about 3 days for cities with less than 1,000 accidents per year. After the file is set up, the filing will require about 1/2 day per month by a clerk, secretary, or engineering aide, with some help on classifying accidents as intersection-related or mid-block. The cost of a small filing cabinet is $50 to $60, and filing materials will cost from $5 to $25.

Traffic Accident Data Summaries

Summarizing traffic accident data is an important part of any traffic records system because it is the first step in the identification process.

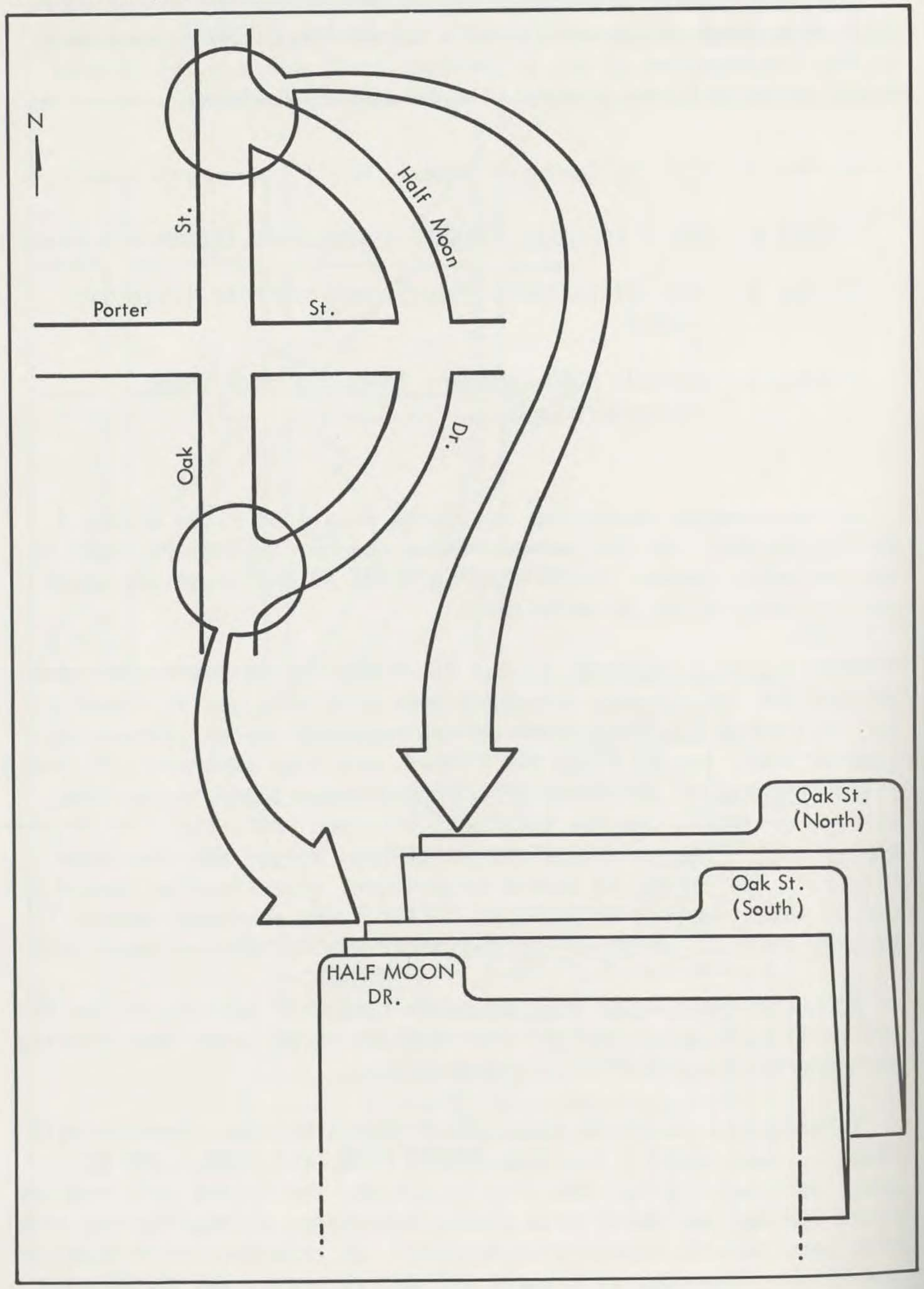


Figure 7—Identically Named Intersections

Traffic accident data are summarized many ways, including monthly or annual totals, data grouped by different categories, or mid-block classification, intersection control type, type of accident, accident severity, or time of occurrence.

In cities of 10,000 or more population, accidents should be summarized monthly and annually. Smaller cities may only need quarterly and annual summaries.

The Missouri Highway Patrol summarizes a city's accident reports by computer on a monthly and annual basis. Use these STARS (Statewide Traffic Accident Records System) summaries as monthly summaries of accident data. The STARS summaries do not include totals on private property, hit and run, or enforcement data, which the police department may want to add for its purposes.

In addition to the monthly STARS summary, some additional summarizing should be done by the city. A summary to supplement engineering analysis of high-accident locations is shown in Figure 8. This summary divides the accidents into intersection-related accidents and mid-block accidents. The accidents are also divided according to whether they occurred on a "major" or "minor" street. Major streets are through streets with traffic volumes greater than 2,000 vehicles per day.

Make monthly tallies on this summary sheet when each accident report is filed in the location file. At the end of a year, combine 12 monthly summaries for the annual summary.

Another device, which gives a quick visual summary of accident locations, is the traffic accident spot map (see Figure 9). Using pins or other markers to show the location of all traffic accidents in the city, the spot map will quickly identify which areas of the city may warrant attention. But, the map is not entirely suitable for identifying high-accident locations because it conveys only a limited amount of information about accident type.

A street map or aerial photo, ranging in scale from 1 in. = 400 ft to 1 in. = 800 ft, is desirable for the traffic accident spot map. Maps intended to convey other information, such as zoning maps, should be avoided because the supplementary information will make the map confusing to read.

Map pins are normally used to mark the accident locations. These pins, obtained from school and office suppliers, come in different sizes, colors, and shapes to show different accident types. Most often three different colored map pins are used to show:

(1) fatal accidents; (2) injury accidents; and (3) property-damage-only accidents. Other pin colors can represent pedestrian accidents or the time of the year when the accident occurred. Use no more than seven different colors of pins.

TRAFFIC ACCIDENT SUMMARY

DATE JAN. 1 – DEC. 31, 1975 ANNUAL ☒ MONTHLY ☐

INTERSECTION-RELATED ACCIDENTS

MAJOR STREET INTERSECTIONS	Right Angle	Rear End	Side-Swipe Meeting	Side-Swipe Passing	Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
MAJOR-MAJOR											
2-Way Stop	4	6	0	1	1	0	4	3	0	1	20
4-Way Stop	2	7	2	1	0	1	4	0	2	0	19
Signal	12	17	2	2	4	2	3	5	9	4	60
Officer	0	2	0	0	0	0	0	0	1	1	4
MAJOR-MINOR											
From 2-Way Stop	4	5	2	0	2	0	1	1	2	2	19
On Major St.	8	2	1	1	0	1	2	3	1	1	20
On Minor St.	3	4	3	1	0	0	0	1	2	0	14
Officer	0	1	0	0	0	0	0	1	0	0	2
SUBTOTAL	33	44	10	6	7	4	14	14	17	9	158

MINOR STREET INTERSECTIONS	Right Angle	Rear End	Side-Swipe Meeting	Side-Swipe Passing	Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
No Control	8	5	2	1	2	0	2	1	2	1	24
Yield Sign	3	1	0	0	0	0	1	0	1	1	7
2-Way Stop	7	15	4	1	1	0	3	4	0	0	35
4-Way Stop	6	12	2	0	1	0	2	5	3	2	33
SUBTOTAL	24	33	8	2	4	0	8	10	6	4	99
TOTAL INTERSECTION-RELATED ACCIDENTS	57	77	18	8	11	4	22	24	23	13	257

MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking Ped.	Vehicle Striking Pk. Car	Vehicle Striking Veh. @ Dr.	Vehicle Striking F.O.	Vehicle On St.	Train	TOTAL
Major St.	17	2	27	18	9	61	1	135
Minor St.	8	0	17	12	3	31	2	73
Alleys	2	2	1	0	1	3	0	9

Figure 8—Engineering Summary Sheet

A spot map needs a legend telling the area and time period covered by the map, and what kind of accident each pin represents. Figure 10 shows two typical legends for spot maps.

To hold the map pins, mount the spot map on a material soft enough to stick a pin in, but firm enough to keep the pin from falling out. Appropriate materials are cork, Celotex, foamboard,

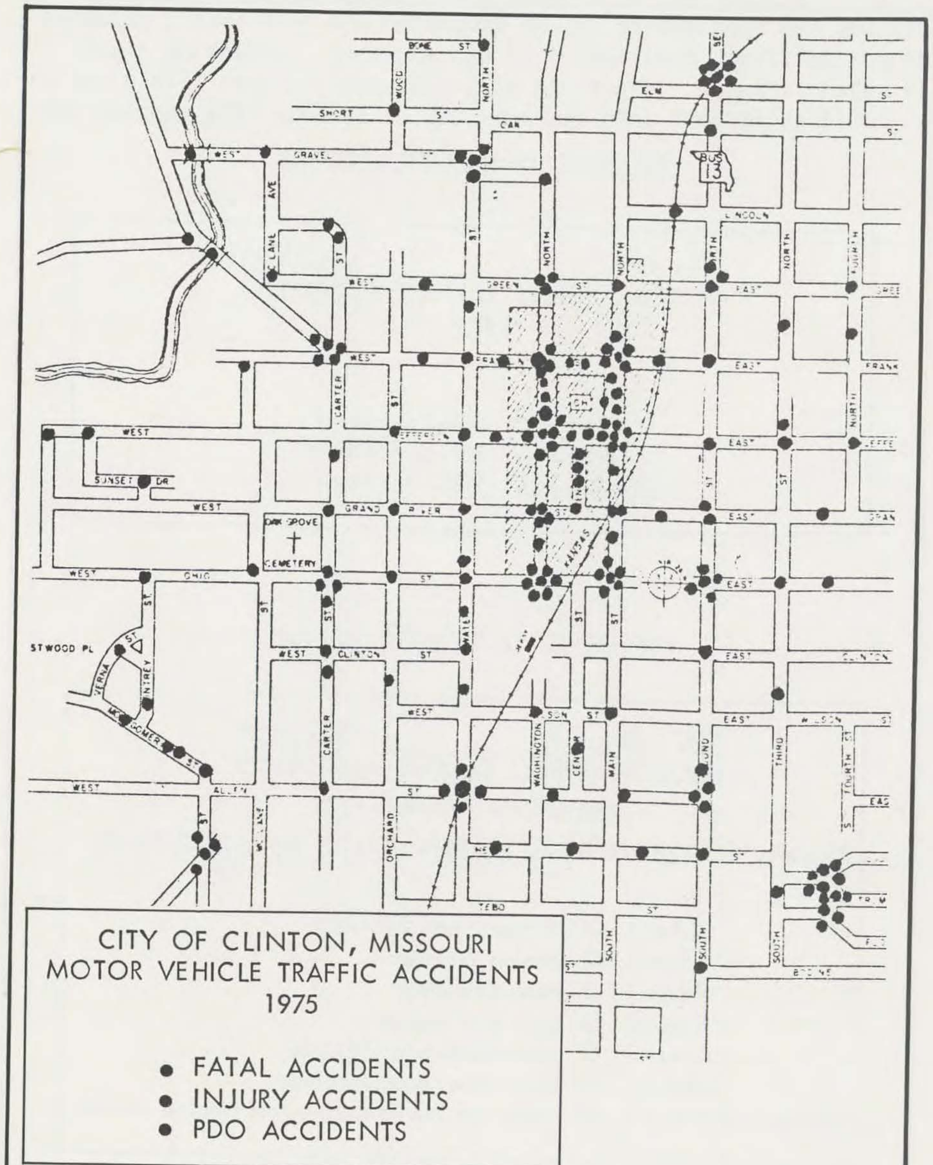


Figure 9—Traffic Accident Spot Map

and unpressed Masonite quarterboard. Secure the map to the mounting material with library or wallpaper paste.

Usually 1 year's accidents are spotted on the map. One good idea is to use two spot maps: one to show the last year's accidents, the other to spot accidents for the current year. Photograph maps at the end of the year to provide a permanent record.

NORMAL 12-MONTH LEGEND

CITY OF______________, MISSOURI
MOTOR VEHICLE TRAFFIC ACCIDENTS
1975

(Red) O Fatal Accident
(Blue) O Injury Accident
(Yellow) O PDO Accident

RUNNING 12-MONTH LEGEND

CITY OF______________, MISSOURI
MOTOR VEHICLE TRAFFIC ACCIDENTS
MAY 1974 - APRIL 1975
Property Damage and Injury Accidents During the Last 12 Months

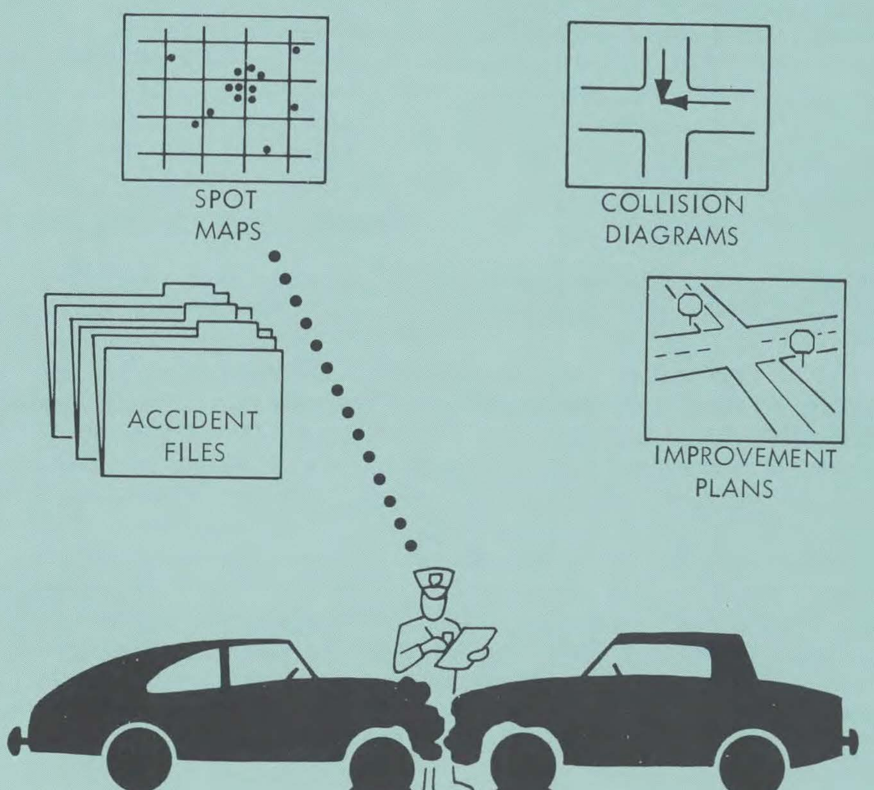
(Red) O January and February
(Yellow) O March and April
(Blue) O May and June
(Brown) O July and August
(Green) O September and October
(Black) O November and December
(Black on White) ⊖ Fatal accidents during last twelve months

Figure 10—Spot Map Legends

Running 12-month spot maps are sometimes used to prevent having only 2 or 3 months' accidents on the map in the early months of the year. Different colors are used to represent the accidents during each 2-month period. The legend for this kind of map is shown in Figure 10.

Keep spot map near the location file so accidents can be spotted by the person filing the accident reports in the location file. Normally 2 to 3 days are necessary to set up the spot map and spot 1 year's accidents. Once the map is established, spotting the accidents will require less than 2 hr per month. Mounting material for the map will cost $2 to $10, and map pins from $6 to $12.

CHAPTER 3—IDENTIFYING HIGH-ACCIDENT LOCATIONS



Because the time and money available for efforts to reduce traffic accidents are always limited by budgets and other demands on your time, you must focus on those locations that will yield the largest accident reductions for each dollar spent on improvements. To do this you must find those locations where traffic accidents are concentrated, determine how the accidents are related to the driving environment and determine the potential for reducing the location's accident experience. This chapter describes the process of identifying high-accident locations. Relating the accidents to the driving environment and determining the potential for an accident reduction are described in Chapters 4 and 5.

An orderly approach to studying accidents increases the odds for bringing about a reduction in accident numbers and severity. The Annual City-Wide Analysis and the Early Warning Analysis methods given in this chapter are systematic step-by-step procedures for identifying your high-accident locations. But first you must understand how high-accident locations are defined.

High-Accident Location Criteria

A high-accident location is judged by several different measures as shown in Figure 11.

The accident number is the basic measure. A location is often judged to be a high-accident location, based on accident number, if 10 or more accidents occur in 1 year. Although this number is flexible, it should be chosen to point out a reasonable number of high-accident locations.

Accident severity measures can be used to weight the numbers of accidents so that fatal and injury accidents are given more importance than property-damage-only (PDO) accidents. For example, we can assign a weight of six to fatal or injury accidents. This means that one fatal or injury accident is considered equivalent to six PDO accidents. The weighted number of called the equivalent-property-damage-only (EPDO) number.

Another measure of high-accident locations is the accident rate, which is the accident number divided by the exposure of vehicles to accidents. Accident rates are expressed as accidents per million entering vehicles for intersections, and as accidents per 100 million vehicle-miles for street sections.

The number-rate measure combines the accident number and the accident rate to arrive at a standard for identifying high-accident locations, which eliminates the weaknesses of the individual measures. The number of accidents alone as a criterion does not account for the exposure of vehicles to potential accidents. On the other hand, although the accident rate takes exposure into account, it may identify a low-volume intersection as a high-accident location with an unreliably low number of accidents. A combination number-rate measure establishes both a minimum number and minimum rate for identifying high-accident locations.

The last two measures listed in Figure 11 compare a location's accident experience to a local or statewide average. It is possible through statistical tests to determine if specific accident numbers or rates are significantly above average. These tests rule out locations that have high rates or numbers due to chance variations. Such statistical tests are called number-quality-control or rate-quality-control measures.

1. Accident Number -- Accident data are summarized to determine the number of accidents at a location or the number of accidents per unit of length for a section of highway. Locations and sections with more than a predetermined number of accidents are classified as high-accident locations.

2. Accident Severity -- Fatal and injury accidents are given a greater weight than property-damage-only accidents. This weighted number is called the equivalent property-damage-only (EPDO) number.

3. Accident Rate -- Accident numbers are divided by vehicle exposure to provide rates such as accidents per million entering vehicles for spot locations, and accidents per million vehicle-miles for sections of highway. Locations with higher than a predetermined rate are classified as high-accident locations.

4. Number Rate -- This is a combination of the number and rate measures. Locations with more than the prescribed minimum number of accidents and higher than the minimum accident rate are classified as high-accident locations.

5. Number Quality Control -- This is the same as the accident number measure except that locations are not considered unless their accident numbers are significantly greater than the average accident number.

6. Rate Quality Control -- This is the same as the accident rate measure, except that locations are not considered unless their rates are significantly greater than the average accident rate.

Figure 11—Accident Measures

The number of high-accident locations identified, of course, depends on the value of the criteria used. Rates can be compared with state or national averages. However, the final decision on the minimum number or rate of accidents to define a high-accident location is a local decision. The objective is to identify the locations where accident experience is above desired limits, and where further analysis and installation of improvements will reduce the number and severity of future traffic accidents. Choose the high-accident location criterion so a reasonable number of locations are selected for analysis. A reasonable number of locations is between 5 and 40, depending on the size of your city.

Some of these accident measures are used in both the Annual City-Wide Analysis and the Early Warning Analysis. For most Missouri cities, the number-rate combination using both the accident and EDPO numbers and rates is best the first time the Annual City-Wide Analysis is conducted.

Annual City-Wide Analysis

The Annual City-Wide Analysis is a procedure that uses 1 to 3 years of accident data to identify high-accident locations. This analysis is done as soon as all accidents for a calendar year have been filed in the location file. All locations, except state highways, should be considered. The only locations that can be ignored are those already identified during the year as high-accident locations by the Early Warning Analysis.

Besides the location file, current traffic volume or Average Daily Traffic (ADT) counts are needed to calculate accident rates for the Annual City-Wide Analysis. If counts are not available, contact the Missouri State Highway Department, Division of Planning, Jefferson City, Missouri, to find out if counts for your city are available. The Division of Planning normally makes counts in cities at 1- to 5-year intervals. They can also furnish expansion factors to adjust counts if they are not for the current year.

The steps of the Annual City-Wide Analysis are as follows:

Step 1: For a general view of the accident experience in your city, use the Annual Engineering Summary Sheet (Figure 8, page 24) to determine:

- The most common types of intersection accidents;

- The most common types of mid-block accidents; and

- The need for special studies such as pedestrian, railroad crossing, etc.

Step 2: Using the High-Accident Location Identification Worksheet (Figure 12), list all intersections with more than *three* accidents and all street sections with more than *five* mid-block accidents in the last year. These numbers are not high-accident location criteria, but simply give a point to start the accident analysis. Intersections are listed on one sheet and mid-block

HIGH - ACCIDENT - LOCATION IDENTIFICATION WORKSHEET

INTERSECTION ☒ MID-BLOCK SECTION ☐

LOCATION	ACCIDENTS					2 and 3 Year Ave.	EPDO No.	ADT	Exposure	Accident Rate	EPDO Rate	Identified as a High-Accident Location
	Year	Fatal	Injury	PDO	Total							
CENTER AND JEFFERSON	1974			///	3		3	7500	2,737,500	1.096	1.096	
TOTALS										Ave=	Ave=	
CLINTON AND THIRD	1974			///	3		3	2,150	784,750	3.823	3.823	yes
TOTALS										Ave=	Ave=	
JEFFERSON AND SECOND	1974			////	4		4	12620	4,606,300	0.868	0.868	
TOTALS										Ave=	Ave=	
JEFFERSON AND WASHINGTON	1974			///	3		3	9055	3,305,075	0.908	0.908	
TOTALS										Ave=	Ave=	
LINCOLN AND THIRD	1974			𝍸	5		5	2210	806,650	6.198	6.198	yes
TOTALS										Ave=	Ave=	
M-7 AND M-13 (NORTH)	1974		𝍸	////	9		34	7255	2,648,075	3.399	12.840	yes
TOTALS										Ave=	Ave=	

EPDO Number = 6 (fatal + injury) + PDO

Intersections:
ADT = sum of one-way counts of all streets entering the intersection

Exposure = ADT x 365

$$\text{Accident Rate} = \frac{(\text{number of accidents})(\text{million})}{\text{exposure}}$$

$$\text{EPDO Rate} = \frac{(\text{EPDO number})(\text{million})}{\text{exposure}}$$

Mid-block sections:
ADT = average two-way count of the street
Exposure = (ADT) (section length) (365)

$$\text{Accident Rate} = \frac{(\text{number of accidents})(100\ \text{million})}{\text{exposure}}$$

$$\text{EPDO Rate} = \frac{(\text{EPDO number})(100\ \text{million})}{\text{exposure}}$$

Figure 12—High-Accident Location Identification Worksheet

sections on another. For the intersection listing, check the square by "INTERSECTION" at the top of the form. For mid-block sections listing, check the square by "MID-BLOCK SECTION." The analysis year is listed on the first line under "YEAR." Then the number of fatal, injury, and property-damage-only (PDO) and the total accidents for the year are listed on this line.

Step 3: Calculate the accident rate and the EPDO rate for the year by completing each column of the worksheet as follows:

EPDO Number

Intersectional or Mid-Block - Add the number of fatal and injury accidents, multiply by 6, then add the number of PDO accidents.

ADT (Average Daily Traffic)

Intersectional - Sum the one-way 24-hr traffic counts for each approach entering the intersection. (If only two-way ADT's are available, use half of this number as an estimate of each entering ADT.)

Mid-Block - Enter the average two-way ADT of the section.

Exposure

Intersectional - Multiply the intersectional ADT by the length of the study period in days. For a 1-year study period, multiply the intersectional ADT by 365.

Mid-Block - Multiply the mid-block ADT by the section length times the length of the study period in days.

Accident Rate

Intersectional - Multiply the accident number by 1 million and divide by the intersection exposure to determine the number of accidents occurring for every million vehicles entering the intersection.

Mid-Block - Multiply the accident number by 100 million and divide this number by the mid-block exposure to determine the number of accidents occurring for every 100 million vehicle-miles traveled on the section.

EPDO Rate

Intersectional or Mid-Block - Determine this rate just as the accident rate, substituting the EPDO number for the accident number.

Step 4: If you have accident records for the location for the 2 years before the analysis year, add these records to the worksheet, determining the numbers and rates as you did for the analysis year. If the ADT has changed over the 3-year period, make sure to use the correct ADT for each year. If a location was identified as a high-accident location during an earlier year, note this in the last column of the worksheet.

Step 5: Calculate the totals of the accident numbers and EPDO numbers, and enter these figures on the worksheet. Then, calculate the 2- or 3-year average of the total number of accidents, the EPDO number, the accident rate and the EPDO rate.

Step 6: Identify all high-accident locations using the chosen criteria. If you have 2 or 3 years of accident data, use the 2- or 3-year averages to choose the high-accident locations. Those locations identified are noted by writing "yes" in the last column of the worksheet and by putting a tab on the appropriate folder of the location file.

For cities with fewer than 1,000 accidents per year, the city engineer should be able to conduct the Annual City-Wide Analysis in about 1/2 day.

Early Warning Analysis

The Annual City-Wide Analysis is an effective procedure for identifying high-accident locations on a yearly basis. Another procedure that continuously monitors where accidents are occurring is called the Early Warning Analysis.

The Early Warning Analysis looks at 3- or 6-month accident numbers to identify those locations with an unusually high short-term number of accidents. The 3- or 6-month accident numbers are reviewed each time a report is filed. The person who maintains the location file should perform the Early Warning Analysis as follows:

Step 1: As accidents are filed in the location file, fill out the Accident Location-File Log (Figure 13), which is a chronological listing of accidents at a location during the current calendar year. It is attached to the front of a location's file folder, and entries are made each time an accident report is filed. The

ACCIDENT LOCATION - FILE LOG

LOCATION 300 - 600 NORTH OAK STREET

DATE OF ACCIDENT	LOCATION	SEVERITY
1-15-74	421 NORTH OAK	PDO
2-25-74	515 NORTH OAK	2 INJURIES
3-3-74	301 NORTH OAK	PDO
5-15-74	50' NORTH of 4TH STREET	1 INJURY
7-12-74	517 NORTH OAK	PDO

Figure 13—Accident Location-File Log

log is a permanent record of the accident experience at a location, and serves as a check that no reports are missing from the folder.

Step 2: When a report is added to the log, check for high-accident locations by reviewing the most recent 3- or 6-month periods. Include the month in which the accident that you are filing occurred. For example, if you are filing an accident dated June 21, include June, May and April for the 3-month period. The 6-month period includes those 3 months and March, February and January. For accidents occurring before June, use the previous year's accident location file in addition (if Accident Location-File Logs are available for that year).

Step 3: Flag the location as a high-accident location by marking the file folder with a tab if either of the following criteria is met.

3-Month Criteria

Intersectional - Three accidents, of which at least one is an injury or fatal accident, or five property-damage-only accidents.

Mid-Block - Five mid-block accidents in a three-block section.

6-Month Criteria

Intersectional - Five accidents, of which at least one is an injury or fatal accident, or eight property-damage-only accidents.

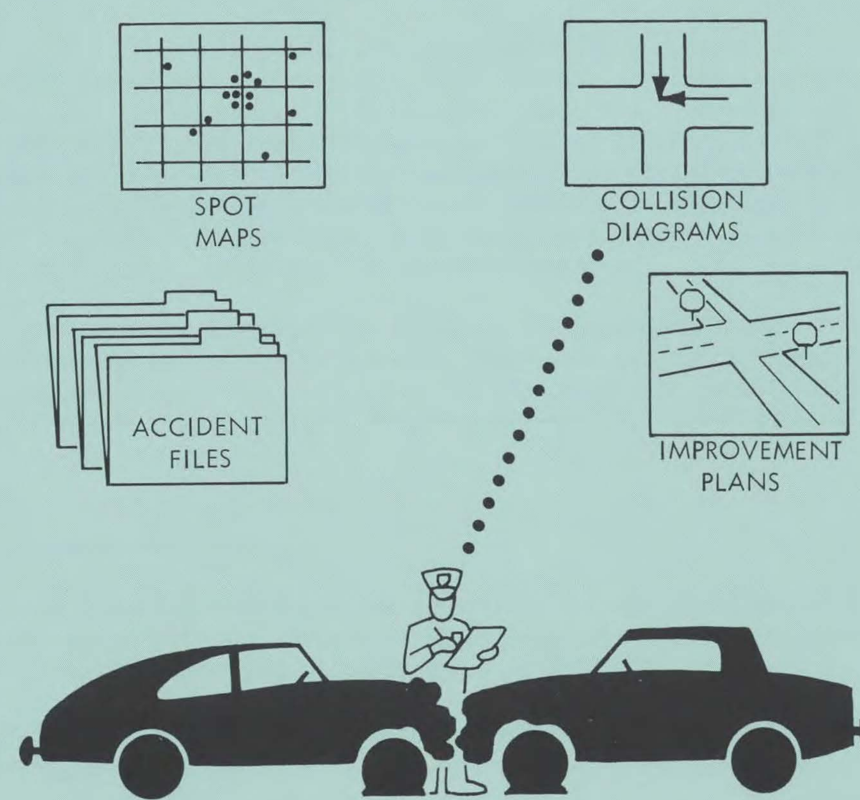
Mid-Block - Eight mid-block accidents in a three-block section.

These criteria identify locations with unusually high short-term accident numbers, and will alert you to unexpected problems with recent improvements. Also, problems arising from changes in the operations or the environment of the location will be identified.

The Early Warning Analysis is not used when the location file is first established with an entire year's accident reports. As soon as the year's reports are filed by location, the Annual City-Wide Analysis will identify the high-accident locations. Then as you add the current year's accident reports to the location file, initiate the Early Warning Analyses.

With high-accident locations identified, the job ahead is to analyze the accidents at each location to find accident patterns that can be corrected.

CHAPTER 4—ANALYZING HIGH-ACCIDENT LOCATIONS



Analyzing traffic accidents is like solving a Sherlock Holmes mystery. The accidents during the last 1 to 3 years are clues to what part of the driving environment is contributing to traffic accidents. As in a good mystery, the obvious suspect may not always be guilty, and false clues may appear. This is particularlv true with traffic accidents because they are statistically rare occurrences. As you know from computing accident rates in Chapter 3, intersections may have only two or three accidents for every million entering vehicles. For this reason, the good accident analyst is very careful to avoid concluding too much from a few accidents. Instead, he uses the pattern of accidents as a clue to why a location is a high-accident location.

Just as Sherlock Holmes uses his magnifying glass and his trustworthy assistant, Dr. Watson, to help him analyze crimes and determine his list of suspects, this chapter describes the Locational Analysis Procedure that will help you analyze high-accident locations and determine alternative accident countermeasures (improvements). Although the procedure is as complete as possible, it will not automatically produce accident countermeasures. *You* must use it as a tool to solve your own accident mystery.

This chapter describes the analysis of accident patterns at a location to determine the probable causes and general accident countermeasures. Then additional traffic data will be collected in order to determine specific countermeasures for the accidents at that location.

Locational Analysis

All high-accident locations identified by either the Annual City-Wide Analysis or the Early Warning Analysis are further analyzed using the Locational Analysis Procedure as follows:

Step 1: Record the date and the location name on the Locational Analysis Worksheet (Figure 14).

Step 2: Complete the Accident Analysis section of the worksheet. If the location was identified from the Annual City-Wide Analysis, copy Block A directly from the High-Accident Location Identification Worksheet. If the location was identified by the Early Warning

Form #1

LOCATIONAL ANALYSIS WORKSHEET

DATE APRIL 23, 1975

LOCATION Intersection of Lincoln Street and Third Street

EXISTING TRAFFIC CONTROL Two-way Stop

ACCIDENT ANALYSIS:

BLOCK A - NUMBER AND RATE SUMMARY

LOCATION	ACCIDENTS					2 and 3 Year Ave	EPDO	ADT	Exposure	Accident Rate	EPDO Rate
	Year	Fatal	Injury	PDO	Total						
	1974			5	5		5	2210	806,650	6.198	6.198
TOTALS										Avg=	Avg=

BLOCK B - INTERSECTION-RELATED ACCIDENTS

	Right Angle	Rear End	Side-Swipe Meeting	Side-Swipe Passing	Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
No. of Accidents	///				/				/		5
Percent of Total	60				20				20		100%

BLOCK C - MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking: Ped.	Pk. Car	Veh. @ Dr.	F.O.	Vehicle On St.	Train	TOTAL
No. of Accidents								
Percent of Total								100%

BLOCK D - CONDITIONS

No. of accidents

Time of day - 6:00 am - Noon / ; 6:00 pm - Midnight ____
Noon - 6:00 pm //// ; Midnight - 6:00 am ____

Light conditions - Day ~~////~~ ; Night ____

Surface conditions - Dry //// ; Wet / ; Snow or Ice ____

Weather - Cloudy ____ ; Clear //// ; Rain / ; Snow ____ ; Other ____

Other - ____

Figure 14—Locational Analysis Worksheet

Form #2

LOCATIONAL ANALYSIS WORKSHEET

BLOCK E - ACCIDENT ANALYSIS SUMMARY

☒ Collision diagram attached

Identified Patterns of Accidents — Predominate: RIGHT ANGLE Secondary: TURNING

Probable causes and General Countermeasures:

RESTRICTED SIGHT DISTANCE - 1. INSTALL 4-WAY STOP
2. REMOVE SIGHT OBSTRUCTIONS
3. RESTRICT PARKING NEAR CORNERS
4. REDUCE SPEED LIMIT ON APPROACHES

TURNING RADIUS TOO SHORT - 1. INCREASE CURB RADII @ INTERSECTION

OPERATIONAL AND PHYSICAL DATA ANALYSIS

Supporting data attached:

- ☒ On-site observation report
- ☐ Condition diagram
- ☐ Speed study
- ☐ Turning movement count
- ☐ Conflict count
- ☐ Other ____

General conclusions from supporting data: SIGHT DISTANCE RESTRICTED ON NORTHWEST CORNER BY BUSHES. TURNING MOVEMENTS DIFFICULT BECAUSE OF TOO SHORT RADII

COUNTERMEASURE SELECTION:

Specific countermeasures:

1. Remove Shrubbery and Trees from NORTHWEST CORNER
2. INCREASE CURB RADII AT ALL FOUR CORNERS
3. INCREASE PAVEMENT WIDTH NEAR INTERSECTION ON LINCOLN
4. COMBINATION OF ALL THREE ABOVE.
5.

(for each countermeasure fill out a countermeasure analysis worksheet.)

Best Countermeasure 4. COMBINATION

Average Annual Net Return $807

Benefit/Cost Ratio 5.80 Implementation Cost $2,100

Priority 3

Figure 14—Locational Analysis Worksheet (Concluded)

Analysis, complete Block A as described in the Annual City-Wide Analysis. Complete Block B if the location is an intersection, and Block C if the location is a mid-block section.

Step 3: If a pattern of accidents at the location is not clear from the worksheet, or if data are conflicting, prepare a collision diagram. Instructions for preparing collision diagrams are given later in this chapter.

Step 4: Identify the predominant accident pattern if one is evident. Other patterns are classified as secondary. Record this information in the Accident Analysis Summary block.

Step 5: Use the table in Appendix A to determine probable causes of accidents and their general countermeasures. If no predominant accident patterns are identified but a probable cause has been hypothesized, this probable cause is used to identify general countermeasures. For example, restricted sight distance at an intersection could result in an accident pattern of right-angle and pedestrian accidents with neither predominating. General countermeasures can be identified by looking for "restricted sight distance" in the "Probable Cause" column of the table. List the general countermeasures identified in the Accident Analysis Summary block.

Step 6: Plan and conduct an on-site observation of the location (see instructions, page 18) using the Accident Analysis as a guide for diagnosing existing problems. Attach the observation report to the worksheet and check the square by "on-site observation report."

Step 7: From the general countermeasures chosen and the on-site observation, determine what other data are needed to determine specific countermeasures for the location (see page 50).

Step 8: Check all specific countermeasures that have established warrants to determine if these warrants are met (see page 51). Warrants are guidelines that have been established to tell you when a countermeasure could be installed at a location. The warrants are specified minimum values for traffic accidents, traffic volumes or other location characteristics.

Step 9: Determine specific countermeasures for the location. List each specific countermeasure on the Locational Analysis Worksheet. List all possible alternative countermeasures as well as possible combinations. This list should also include estimated costs for each improvement. For many kinds of improvements, city personnel can design the improvement and estimate its cost. Some improvements, such as signalization, should be designed by competent traffic engineers. The Missouri Highway Commission offers such assistance through its "Traffic Engineering Assistance Program." This service is available for any location not on a state-maintained street and is offered at no cost to the city. Information about this program can be obtained from the District Office of the Missouri State Highway Department.

The principal aids used in the Locational Analysis are collision diagrams, the General Countermeasure Table in Appendix A, and the on-site observation. Other traffic data may also be required.

Collision Diagrams

Step 3 of the Locational Analysis procedure is preparing a collision diagram. Just as the spot map shows where accidents are occurring city wide, a collision diagram quickly shows where accidents are occurring at a high-accident location. But collision diagrams contain more details about each accident than spot maps, and if the accidents occurring at the location have patterns, they will be easy to identify on the completed collision diagram.

To prepare a collision diagram, first obtain accident reports for all accidents at the location during the preceding period of at least 1 year. If significant changes (construction, signals, islands and medians, etc.) were made in the location in recent years, do not include reports for accidents that occurred before these changes.

Sketch the location diagram (see Figure 15). This sketch need not be to scale, but should allow enough room to show the path of each vehicle involved; also note traffic control devices at the location. A standard blank diagram for intersections is in the packet of worksheets included with this manual.

Next, sketch the intended movement of each vehicle involved in each accident on the diagram. The accident type and severity are shown by the symbols, as in the legend of Figure 15.

Noninvolved vehicles or pedestrians can also be shown on collision diagrams. These vehicles or pedestrians are those contributing to an accident but not physically struck. An example of a noninvolved contributing element is an accident where a vehicle, stopped to allow a pedestrian to cross, is struck in the rear by another vehicle. The pedestrian path is shown as a noninvolved element (see Figure 16).

Write other basic characteristics of each accident on the accident symbol such as:

- Date, day of week, and time of accident;
- Weather or pavement conditions;
- Light conditions; and
- Number of injuries or fatalities.

Also note any special circumstances or driver comments, such as:

- Signal control device not working;
- Signs down or faded; and
- Any parking or turning restrictions that apply only at specific times on specific days; for example, "No Parking Monday through Friday," or "No Left Turn 4-6 p.m."

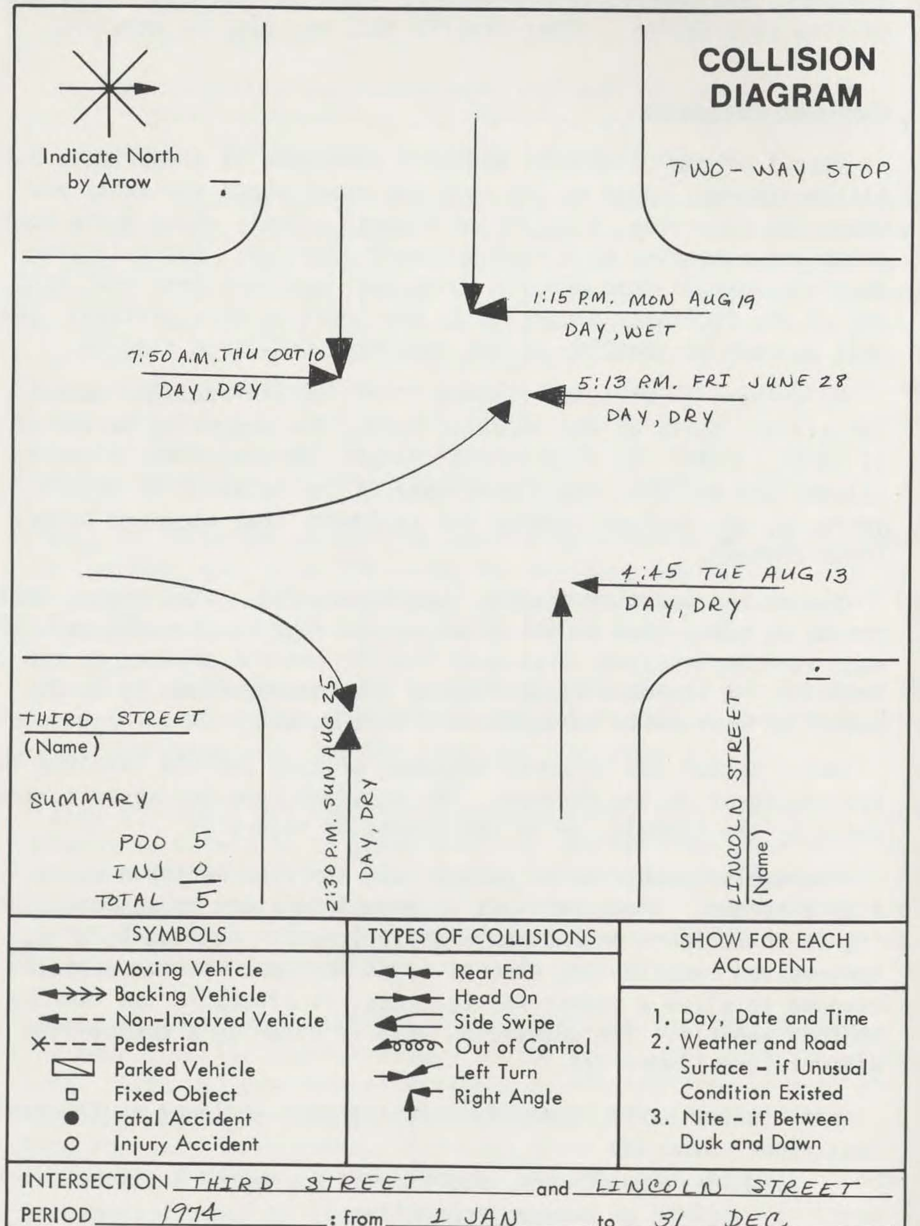


Figure 15—Sample Collision Diagram

After all accidents are sketched, determine what patterns are evident. See what kinds of accidents are occurring on each intersection approach or at certain spots in a mid-block section. Identify the time when most accidents are occurring and the weather conditions. Use the collision diagram and the accident summaries

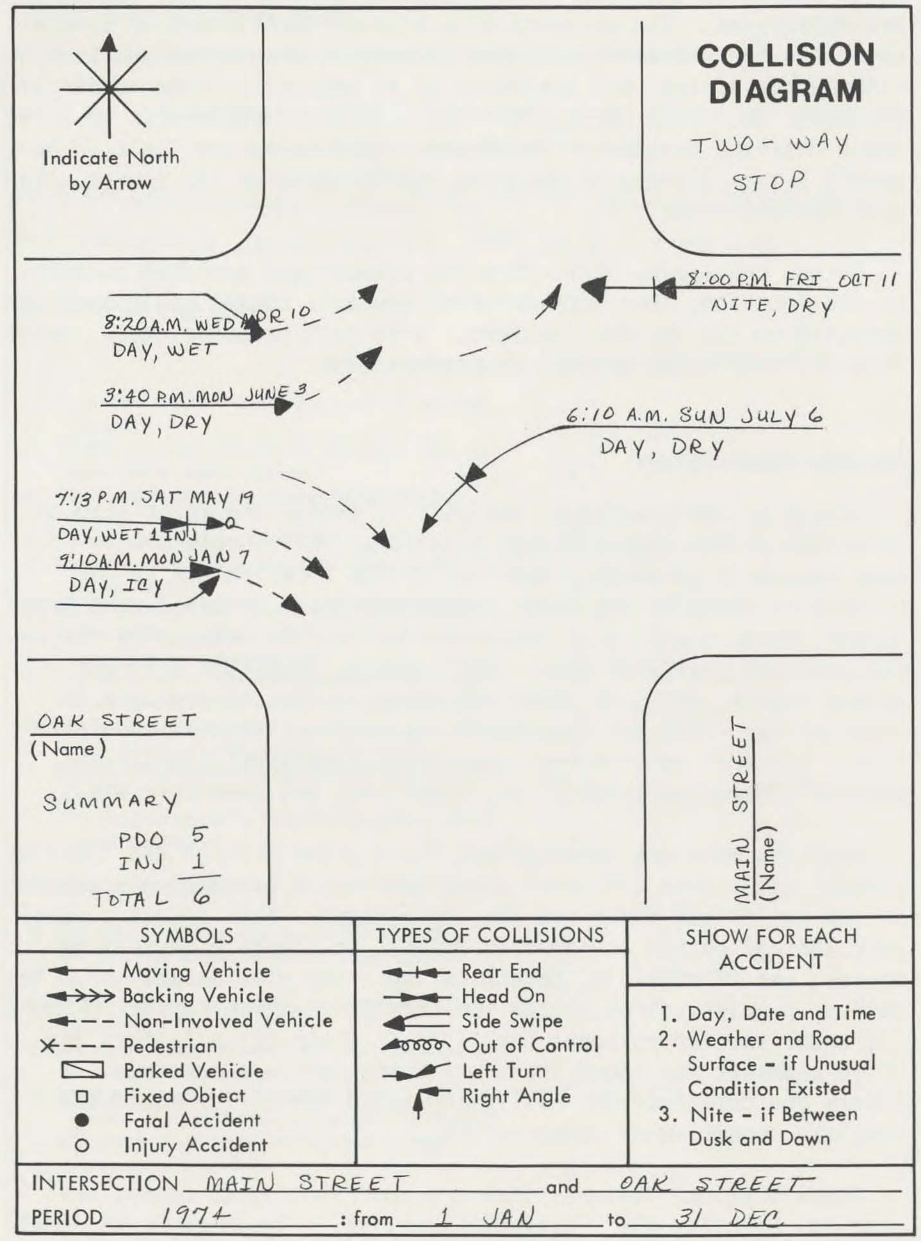


Figure 16—Noninvolved Vehicle Collision Diagram

to determine the predominant and secondary accident patterns at the location.

General Countermeasures for Accident Patterns and Their Probable Causes

In Step 5 of the Locational Analysis, general countermeasures are determined. The analysis of a high-accident location should point out the prevalent accident pattern at that location, such as high number of rear-end accidents or an unusually large number of accidents occurring during darkness. Choose improvements to solve these observed patterns. The General Countermeasure Table in Appendix A is a listing of accepted countermeasures for common urban accident patterns.

To use the table, first find the predominant accident pattern at the location, then consider what probable causes could have contributed to the accident pattern. With each probable cause, determine all reasonable general countermeasures.

On-Site Observation

Step 6 of the Locational Analysis is conducting an on-site observation of the high-accident location. This should always be done because a personal inspection of the location can be very helpful in choosing the right countermeasure. Rather than a haphazard, hasty visit, plan these observations in advance by reviewing existing available data. Collision or condition diagrams, volume counts, and spot speed and delay studies of the area in question may point out conditions that warrant special consideration. Schedule observations according to apparent significant accident characteristics (i.e., nighttime, wet pavement, etc.).

When you make the observation, first drive through the location several times from different directions--with particular attention to how the driver might see the environment. Then select several good vantage points and observe drivers to identify unusual behavior, and if possible, determine the cause of the behavior. Record your observations on the "On-Site Observation Report" (Figure 17) under the "Operational Checklist." Check off all items and write comments for those items where problems are observed. A camera and tape recorder will often prove useful for rapid and complete recording of observations.

Check physical features that are contributing to operational problems by using the "Physical Checklist." Again comments should be made for those items where problems are observed. Solicit per-

sonal insights from persons residing or working near the location and add these to your comments. Attach pictures to the back of the report if they are useful.

If additional probable causes or general countermeasures are identified during the on-site observation, add them to the Locational Analysis Worksheet.

Form #1

ON-SITE OBSERVATION REPORT

LOCATION Lincoln and Third Street CONTROL Two-way stop on Lincoln St.

DATE Wednesday April 23, 1975 TIME 2:30 - 4:00 P.M.

OPERATIONAL CHECKLIST:

	No	Yes (See 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 (See 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?	✓	

Figure 17—On-Site Observation Report

Traffic Data Collection

Other kinds of traffic data are helpful in making a complete analysis of a high-accident location. These include traffic counts, speed studies, condition diagrams, and "conflict counts." These traffic studies are briefly described below and instructions and additional references on collecting these types of data are given in Appendix B.

Form #2

	No	Yes (See Comments)
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:

Operational--"O" and Item Number
Physical--"P" and Item Number

O1, P1 Lincoln Street eastbound approach, bushes on property at northwest corner obstruct vision to the north. O3, O8, P3, all curb radii are too small. Vehicles turning onto Lincoln must enter lane of approaching traffic. P2-Lincoln Street, westbound approach has narrow pavement width with a deep drainage ditch on north side.

Generally this intersection has a definite sight obstruction in the northwest corner. Turning movements are difficult because of the small curb radii and narrow pavement width.

Figure 17—On-Site Observation Report (Concluded)

Basic 24-hr traffic volume counts are necessary to calculate accident rates. Also other counts can be very effective in analyzing a specific location, e.g., a turning movement count. These volume counts show the origin and destination of vehicle movements within an intersection. They are usually conducted for 1 or 2 hr during peak and off-peak periods of the day. In urban areas, pedestrian counts may be very helpful for high-accident location analysis. On sections of roadways, directional counts and vehicle classification counts often are used to clarify the accident experience.

Conduct speed studies if speed is a possible factor in the accident experience. The location of sight obstructions at an intersection can be used to determine the safe approach speed of vehicles on each approach to the intersection. Compare this speed with either the speed limit or the 85th percentile speed (that speed below which 85% of the sampled vehicles travel) determined from a speed study.

For some high-accident locations, a condition diagram may be helpful. Unlike the collision diagram, draw the condition diagram to scale. Depending on the size of the location, scales of 1 in. = 40 ft to 1 in. = 10 ft are used. The condition diagram will normally show the important physical characteristics of a location and traffic control devices and regulations used at the location. A sample condition diagram is shown in Appendix B.

The condition diagram is normally used in combination with the collision diagram to compare the patterns of various accidents with the physical layout. In some cases, a combined collision-condition diagram can be prepared.

Conflicts analysis is a method of observing situations in which one driver is forced to take evasive action, such as swerving or braking, to avoid a collision with another vehicle. The frequency of the different types of conflicts is thought to be an indication of the accident experience at an intersection. Although there is disagreement on the value of conflict analysis to replace accident data analysis, it can be used as a supplementary diagnostic tool at a location to point out possible improvements.

Warrants

Step 8 of the Locational Analysis involves checking countermeasure warrants. Warrants (e.g., specific minimum values to warrant installation) have been developed to prescribe the use of many countermeasures and must be considered to insure the selection of feasible countermeasures. *The Manual of Uniform Traffic Control*

Devices contains warrants for installation of signals and other traffic control devices. Warrants have also been developed for installation of other countermeasures such as flashing beacons, safety lighting, and one-way streets (these are given in Appendix C). Also, the list of references contains publications that have warrants for guardrail installation[27] and construction of a left-turn lane in a median.[7] Check countermeasures to insure that all warrants are met at the location being analyzed.

You should understand one last point about warrants. Even if the warrants for a countermeasure are satisfied, the countermeasure is not necessarily the best one to install at the location. The alternative improvements should still be compared by using the Countermeasure Analysis described in Chapter 5.

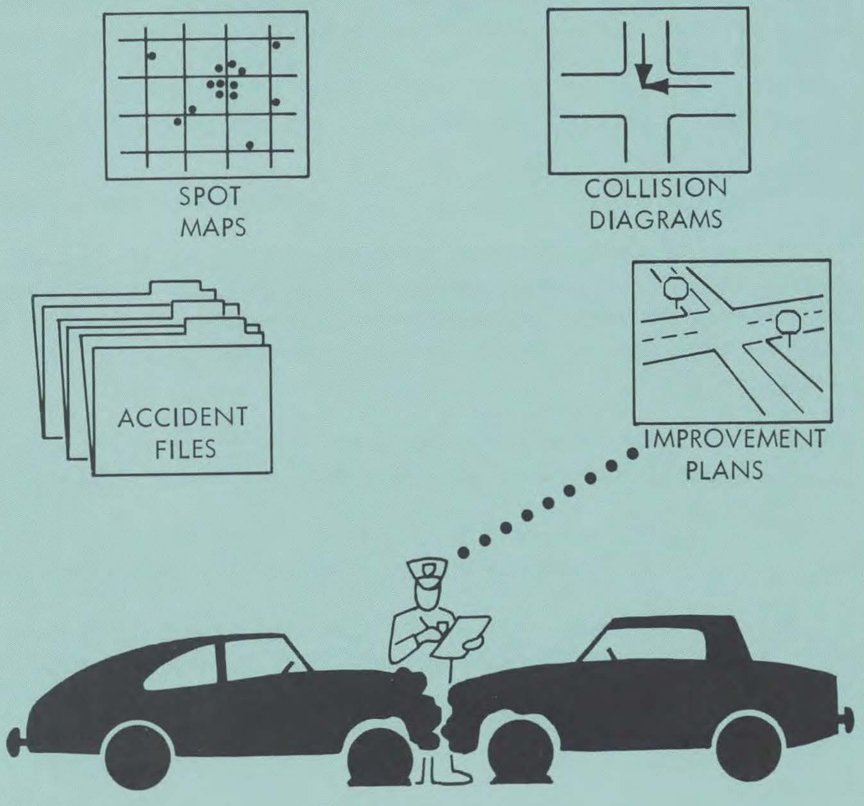
Specific Countermeasures

The last step in the Locational Analysis is to determine specific countermeasures by adapting the general countermeasures to the high-accident location being analyzed. The specific countermeasures should be warranted and feasible. Gather additional data (such as right-of-way plans) if needed to determine that a countermeasure is feasible. List all feasible countermeasures and possible combinations of countermeasures on the Locational Analysis Worksheet.

When determining if a countermeasure is feasible, estimate the cost of the countermeasure. Current cost estimates are listed in Appendix D.

If a more detailed analysis of the location is needed in order to identify specific countermeasures, professional engineering assistance is available through the "Traffic Engineering Assistance Program." Information about this program can be obtained from the District Office of the Missouri State Highway Department.

CHAPTER 5 – CORRECTING HIGH-ACCIDENT LOCATIONS



At this point you have identified specific countermeasures that will reduce the number and severity of accidents at each high-accident location. The next process involves choosing the best countermeasure at each location, and ranking the priority order of improving the high-accident locations in your city.

If funds were unlimited, you could install the countermeasure that promised to produce the greatest reduction in traffic accident numbers and severity at each high-accident location. But because funds are always limited, you must strive to obtain the greatest overall benefit from available funds.

This chapter describes the economic analysis of each specific countermeasure to determine its average annual benefits and costs. That countermeasure with the highest average annual return (benefits minus costs) is selected as the best countermeasure for the location. Then based on the average annual return, the priority order of installing the countermeasures by location is determined.

Countermeasure Analysis

The average annual net *return* is the difference between the average annual *benefits* and the average annualized *costs*. Starting with the first specific countermeasure listed on the Locational Analysis Worksheet determine the average annual net return as follows:

Step 1: At the top of the Countermeasure Analysis Worksheet (Figure 18), record the countermeasure number and description.

Step 2: Estimate the service life from Appendix E, or from past experience, and record it on the worksheet.

Step 3: Estimate ADT growth factors in order to correctly determine the benefit of the improvement after installation. If better estimates are not available, contact the Planning Division of the Missouri State Highway Department for estimates of past ADT growth.

Step 4: Complete the "Estimated Annual Accident Reduction" section of the worksheet by recording each accident type that will be reduced, the estimated percent reduction (use Appendix F) divided by 100, the average annual number of PDO or fatal and injury

COUNTERMEASURE ANALYSIS WORKSHEET — Form #1

COUNTERMEASURE NO. 4   ESTIMATED SERVICE LIFE 20 YEARS
COUNTERMEASURE DESCRIPTION Combination of CM 1, 2, AND 3
CURRENT 1975 ADT 2210   ESTIMATED 1995 ADT 3530

Constant
Increasing by 3 % annually
Increasing by 66 VPD annually

ESTIMATED ANNUAL ACCIDENT REDUCTION:

	Estimated % Reduction ÷100	×	Accidents of this Type		=	Estimated Accident Reduction	
Accident Type Right Angle	33	×	PDO 3	F&I 0	=	PDO 1	F&I 0
Accident Type Head On	50	×	PDO 1	F&I 0	=	PDO .5	F&I 0
Accident Type ____	____	×	PDO ____	F&I ____	=	PDO ____	F&I ____
Accident Type ____	____	×	PDO ____	F&I ____	=	PDO ____	F&I ____
				Total Reduction		PDO 1.5	F&I ____

AVERAGE ANNUAL BENEFITS:

1. Enter the estimated reduction of PDO Accidents	1.5
2. Enter the average cost of a PDO Accident	500
3. Multiply Line 1 by Line 2 (average annual benefit of reducing PDO Accidents)	750
4. Enter the estimated reduction of fatal and injury accidents	0
5. Enter the average cost of a fatal or injury accident	16,000
6. Multiply Line 4 by Line 5 (average annual benefit of reducing fatal and injury accidents)	0
7. Add Line 6 to Line 3 (average annual benefit from reducing accidents)	750
COMPLETE LINES 8 THROUGH 13 IF ADT WILL INCREASE DURING SERVICE LIFE OF IMPROVEMENT--IF NOT GO TO LINE 14	
8. Enter the expected ADT at the end of the service life	3530
9. Enter the present ADT	2210
10. Add Line 9 to Line 8	5740
11. Divide Line 10 by 2 (average ADT during service life)	2870
12. Divide Line 11 by Line 9 (ADT growth factor)	1.3
13. Multiply Line 7 by Line 12 (average annual benefits from reducing accidents--ADT increasing)	975
14. Enter secondary annual benefits from improvement (if known)	0
15. If ADT is constant add Line 14 to Line 7 / If ADT is increasing add Line 14 to Line 13 } Average Annual Benefits	975

Figure 18—Countermeasure Analysis Worksheet

accidents of this type. For each accident type compute the estimated accident reduction by multiplying the reduction/100 times the number of PDO or fatal and injury accidents. Then total the reduction of PDO and fatal and injury accidents.

If a combination of countermeasures is being considered at a location, the total percent reduction in accidents cannot be found by simply adding the percent reduction of each countermeasure. For example, if one countermeasure should reduce all accidents by 30% and another by 25%, the total percent reduction that could be

COUNTERMEASURE ANALYSIS WORKSHEET — Form #2

AVERAGE ANNUALIZED COST*:

1. Enter the initial cost of improvement	2100
2. Enter the capital recovery factor for service life of the improvement (see Interest Factors Table in Appendix G)	0.0802
3. Multiply Line 1 by Line 2	168
4. Enter the terminal value of improvement	0
5. Enter the sinking fund factor at the service life of the improvement (see Interest Factors Table in Appendix G)	0.0302
6. Multiply Line 4 by Line 5	0
7. Enter the constant annual cost	0
8. Subtract Line 6 from Line 3, then add Line 7 (Average Annualized Costs)	168

AVERAGE ANNUAL NET RETURN:

1. Enter the Average Annual Benefits	975
2. Enter the Average Annualized Costs	168
3. Subtract Line 2 from Line 1 (Average Annual Net Return)	807

BENEFIT/COST RATIO:

1. Enter the Average Annual Benefits	975
2. Enter the Average Annualized Costs	168
3. Divide Line 1 by Line 2 (Benefit/Cost Ratio)	5.80

* Based on 5% interest, annual cost uniform throughout service life.

Figure 18—Countermeasure Analysis Worksheet (Concluded)

expected would be 30% of all accidents plus a 25% reduction of accidents that are uncorrected by the first countermeasure or 30 + (0.70) 25 = 47.5%. When a combination of countermeasures is being used, the total percent reduction in accidents can be determined by the equation:

$$P_T = P_1 + \left(\frac{100 - P_1}{100}\right) P_2 + \left(\frac{100 - P_1}{100}\right)\left(\frac{100 - P_2}{100}\right) P_3 + \ldots.$$

where P_T = total percent reduction in accidents

P_1 = largest percent reduction in accidents of any one of the countermeasures

P_2 = second largest percent reduction in accidents of any one of the countermeasures

P_3 = third largest percent reduction in accidents of any one of the countermeasures

Step 5: Complete the "Average Annual Benefits" section of the worksheet. First enter the total reduction of PDO accidents on Line 1 and the total reduction of fatal and injury accidents on Line 4. Unless state or local estimates of the cost of accidents are available use the following cost figures: $16,000 for the average cost of a fatal or injury accident; and $500 for PDO accidents. Enter these values on Lines 2 and 5. Compute the Average Annual Benefit (for constant ADT) by performing the operations in Lines 1 to 7.

If the ADT will be increasing during the service life of the improvement, the accidents would increase also if an improvement were not made. Therefore, when ADT is increasing the benefits of making an improvement are also increasing. Determine the average annual benefits if the ADT is increasing by completing Lines 8 to 13.

If secondary annual benefits, such as reduced delay, can be quantified, enter them on Line 14. The total average annual benefit is determined on Line 15.

Step 6: To compare the costs of improvements with varying service lives, complete the "Average Annualized Cost" section. The initial cost of the improvement, the value of the improvement at the end of its service life (terminal value) if any, and any annual costs of the improvement must all be considered in determining the

average annualized costs. The costs must also be adjusted according to the future value of money. Interest Factors used can be obtained from the Interest Factors Table in Appendix G.

Step 7: When the average annual benefits and average annualized costs have been determined, the average annual net return is found by subtracting the costs from the benefits. Enter this figure on the Countermeasure Analysis Worksheet (Figure 18).

Step 8: The benefit/cost ratio is determined by dividing the average annual benefits by the average annualized costs. Determine this ratio and also enter it on the worksheet.

Compute the average annual net return for each specific countermeasure. Any improvement with a positive average annual net return or a benefit/cost ratio greater than one will return more benefit than its cost to the city. The best countermeasure is the one with the highest average annual net return.

When the best countermeasure or group of countermeasures is determined, enter the countermeasure name, its average annual net return, its benefit/cost ratio and its implementation cost on the Locational Analysis Worksheet.

Priority of Implementing Countermeasures

When the best countermeasure has been selected for each high-accident location, rank the high-accident locations to determine which location is improved first, which is improved second, and so on.

The priority of implementing the improvements is determined by the average annual net return of the improvement and the funds available for making improvements. State or federal funds may be available for some types of countermeasures. Contact the District Office of the Missouri State Highway Department to determine what funds are available.

Give first priority to the location that has the countermeasure with the highest average annual net return. Then subtract the cost of implementing this improvement from the improvement budget and record the priority on the Locational Analysis Worksheet.

Continue the ranking of improvements until remaining funds are insufficient to program the next ranking improvement.

At this point the funds that are remaining can be spent on lower cost improvements until the budget is expended. These lower cost improvements should also be ranked according to their average annual net return.

Installation of Improvements

When the project ranking is completed, design and install each improvement. Although this manual does not cover final improvement design, several references on this subject are given in the reference list.

Many minor improvements can probably be done by city personnel. Keep good records on the actual cost of making the improvements to improve future countermeasure analyses.

If several improvements are done under one contract, make an effort to keep the costs of each countermeasure separated so they can be determined after the work has been finished.

Evaluation of Improvements

After the installation of improvements, continue the analysis of traffic and accident data to evaluate the effectiveness of the installed improvements in reducing the number and severity of traffic accidents at that location. This effort is very necessary in order to increase the accuracy of future improvement selections.

The most common method of evaluating the effectiveness of improvements is the before-after study. Before-after studies compare the accident experience of a location before and after an improvement is installed.

To evaluate an improvement, the accident analyses and the improvement selection process must be well documented. Start a documentation file on each improved location with the completed copies of the Locational Analysis Worksheets.

After the improvement is installed, perform the following steps to evaluate the improvement:

Step 1: Observe operation of the location immediately after it has been improved to see if there are any serious problems that were not expected. If problems are observed, alter the improvement to take care of the problems, record the problems and changes to the improvement and put them in the documentation file.

Step 2: Note the date of completion of the countermeasure on the Accident Location-File Log so that the Early Warning Analysis will be conducted starting 3 months after the improvement was installed. If the location is flagged as a high-accident location, immediately reinstate the Locational Analysis to see what is causing the unexpected number of accidents.

Develop alterations to the installed improvement or additional improvements from this Locational Analysis of the 3- or 6-month accident experience.

Step 3: Conduct a before-after study of the location when the following conditions are met:

a. After accident data are available for a period comparable to that used for the before period.

b. ADT data are available for both periods to enable the accident numbers to be adjusted for exposure.

c. The composition of the traffic flow (the percent of truck and buses) is basically unchanged during the two periods.

d. The accident totals are corrected for existing trends. For example, an overall reduction in accidents due to the national speed limit reduction.

Step 4: Conduct the before-after study as follows:

a. Fill out the Countermeasure Evaluation Worksheet (Figure 19). The "After Accident Analysis" section is filled out in a manner similar to the Locational Analysis Worksheet, using accident data after the improvement was installed.

b. If the ADTs of the before and after periods are different, determine the ADT ratio by dividing the average after ADT by the average before ADT. Adjust all after accident numbers by dividing them by the ADT ratio.

c. Figure the percent accident reduction of all types of accidents, accident totals, and accident rates by this equation:

$$P = \frac{(N_B - N_A)100}{N_B}$$

Where P = percent accident reduction

N_B = number of before accidents

N_A = number of after accidents

If after accident numbers have been adjusted for ADT, use the adjusted numbers in figuring the percent reduction. Accident rates do not have to be adjusted since ADT is used to compute the rates.

Form #1

COUNTERMEASURE EVALUATION WORKSHEET

DATE MARCH 15, 1977

LOCATION INTERSECTION OF LINCOLN STREET AND THIRD STREET

COUNTERMEASURE COMBINATION – REMOVE BUSHES, INCREASE CURB RADII, INCREASE PAVEMENT WIDTH

AFTER ACCIDENT ANALYSIS:

BLOCK A - NUMBER AND RATE SUMMARY

LOCATION	ACCIDENTS					2 and 3 Year Ave	EPDO	ADT	Exposure	Accident Rate	EPDO Rate
	Year	Fatal	Injury	PDO	Total						
	1976			2	2		2	2650	967,250	2.06	2.06
TOTALS										Avg=	Avg=

BLOCK B - INTERSECTION-RELATED ACCIDENTS

	Right Angle	Rear End	Side-Swipe Meeting	Side-Swipe Passing	Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
No. of Accidents	1	1									2
Percent of Total	50	50									100%

BLOCK C - MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking: Ped.	Pk. Car	Veh. @ Dr.	F.O.	Vehicle On St.	Train	TOTAL
No. of Accidents								
Percent of Total								100%

BLOCK D - CONDITIONS

No. of accidents

Time of day – 6:00 am - Noon ______ 6:00 pm - Midnight ______
Noon - 6:00 pm 11 Midnight - 6:00 am ______

Light conditions – Day 11 Night ______

Surface conditions – Dry 1 Wet 1 Snow or Ice ______

Weather – Cloudy ______ Clear 1 Rain 1 Snow ______ Other ______

Other – ______

Figure 19—Countermeasure Evaluation Worksheet

Evaluation of the HAL System

As mentioned in Chapter 1, the analysis of high-accident locations to reduce accident numbers and severity cannot be accomplished without a city spending time and money. In this section

Form #2

COUNTERMEASURE EVALUATION WORKSHEET

BLOCK E - AFTER ACCIDENT ANALYSIS SUMMARY

☐ Collision diagram attached

Identified Patterns of Accidents — Predominate: NONE Secondary: ______

ADT Ratio: $\frac{\text{After ADT}}{\text{Before ADT}} = \frac{2650}{2210} = 1.20$

Adjusted After Accident Numbers:

By Types:				By Severity:	
Left turn		Skidding		Fatal	
Head on		Wet pavement	.83	Injuries	
Rear end	.83	Night		PDO	
Right angle	.83	RR crossing		Total	
Side swipe					
Fixed object				All Accidents	1.67
Lost control					

Accident Reduction: $\% \text{ Reduction} = \frac{\text{Before} - \text{After}}{\text{Before}} \times 100$

By Types:				By Severity:	
Left turn	100 %	Skidding	%	Fatal	%
Head on	100 %	Wet pavement	17 %	Injuries	%
Rear end	%	Night	%	PDO	67 %
Right angle	72 %	RR crossing	%	Total	%
Side swipe	%		%		
Fixed object	%		%		
Lost control	%		%		

EDPO Number 67 %

Accident Rate 67 %

EDPO Rate 67 %

All Accidents 67 %

Figure 19—Countermeasure Evaluation Worksheet (Concluded)

a procedure for computing the benefits of the analysis system versus the cost to a city is computed. The procedure is done as follows:

Step 1: For each year that countermeasures are evaluated using the before-after analysis, fill out a System Evaluation Worksheet (Figure 20).

The year that the analysis covers should be entered on the worksheet. Also enter the number of high-accident locations that have been corrected since the analysis system was begun.

SYSTEM EVALUATION WORKSHEET

Year 1978 TOTAL NO. OF HIGH-ACCIDENT LOCATIONS CORRECTED 12

BENEFIT FOR 7 LOCATIONS:

1	Enter the average annual number of before injury or fatal accidents	19
2	Enter the average annual number of after injury or fatal accidents	8
3	Subtract Line 2 from Line 1 (the reduction in injury or fatal accidents)	11
4	Enter the average annual number of before PDO accidents	34
5	Enter the average annual number of after PDO accidents	16
6	Subtract Line 5 from Line 4 (the reduction in PDO accidents)	18
7	Add Line 6 to Line 3 (the total accident reduction)	29
	WAS ACCIDENT REDUCTION SIGNIFICANT ACCORDING TO FIGURE 21?	(Yes) No
8	Enter the unit cost of injury and fatal accidents	16,000
9	Multiply Line 3 by Line 8 (the benefit of reducing injury and fatal accidents)	176,000
10	Enter the unit cost of PDO accidents	500
11	Multiply Line 6 by Line 10 (the benefit of reducing PDO accidents)	9,000
12	Add Line 10 to Line 13 (the total benefit)	185,000

COST:

1	Enter the total annual cost of improvements	13,600
2	Enter the annual cost to engineering department	4,300
3	Enter the annual cost to police department	1,250
4	Enter other costs	400
5	Add Lines 1, 2, 3, and 4 (total costs)	19,550

BENEFIT/COST RATIO:

1	Enter the total benefit	185,000
2	Enter the total costs	19,550
3	Divide Line 1 by Line 2 to get the benefit to cost ratio	9.46

Figure 20—System Evaluation Worksheet

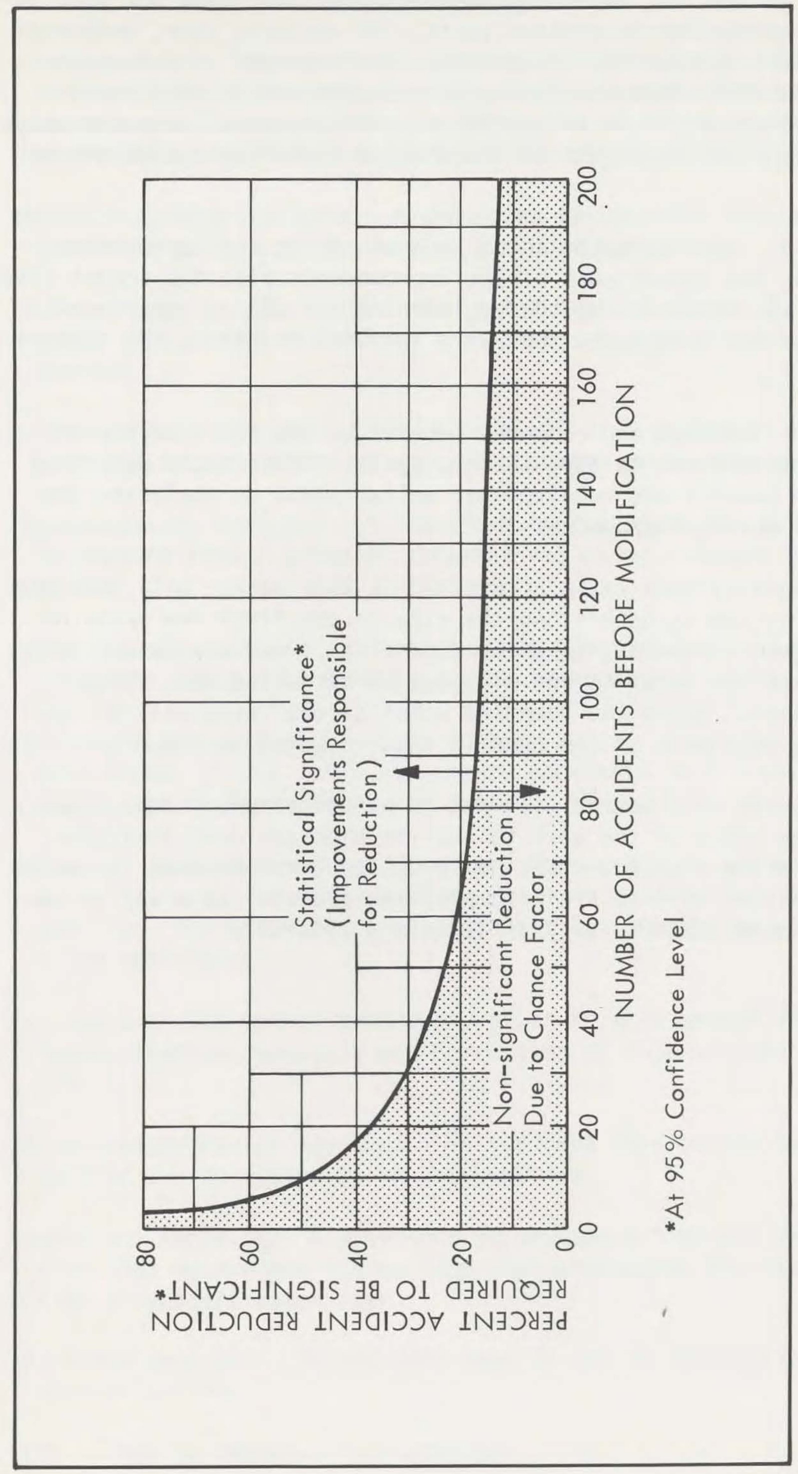


Figure 21—Curve for Determining the Statistical Significance of Accident-Reducing Techniques

Step 2: For all improved locations that have been analyzed by the Countermeasure Evaluation during the analysis year, determine the benefit by totaling the average annual number of before and after accidents from the Countermeasure Evaluation Worksheets. "After" numbers should be the ADT-adjusted numbers. Use the graph in Figure 21 to determine if there was a significant accident reduction.

Step 3: Determine the total cost of making the improvements by adding the annual cost of the improvements plus the annual cost of work and materials to the engineering and police departments and other indirect costs that were involved in making the improvements.

Step 4: Divide the computed benefit by the costs of the improvements and maintaining the HAL system. This ratio will tell how much benefit was received per dollar spent on analyzing the data and making improvements.

The benefit/cost ratio determined in this manner will indicate how the system is benefiting the city in the first few years of the program. However, benefits from older improvements are not added into the benefits and will not be accounted for. Thus, after several years the computed benefit/cost ratio will be reflecting only part of the benefit that is going to the city.

Of course this method will not be practical until 2 to 4 years after the start of the work to analyze high-accident locations. But it can be a good indication in dollar terms of what the accident analysis efforts are accomplishing and will be a way of enlisting more support for traffic safety efforts.

GLOSSARY

Accident Rate: The number of accidents occurring for a given unit of vehicle exposure, for intersections expressed as accidents per million entering vehicles, for mid-block sections expressed as accidents per 100 million vehicle miles traveled.

Annual City-Wide Analysis: A procedure to identify high-accident locations using 1 to 3 years of accident data.

Average Daily Traffic (ADT): The total traffic volume during a given time period divided by the number of days in that time period.

Countermeasure (Improvement): A physical or operational measure designed to reduce the severity and number of traffic accidents.

Countermeasure Analysis: A procedure to determine the best countermeasure from a group of alternatives using economic considerations.

Early Warning Analysis: A procedure to identify high-accident locations using 3 or 6 months of accident data.

Equivalent-Property-Damage-Only Number (EPDO): A weighted accident number giving fatal and injury accidents more importance than property-damage-only accidents.

Exposure: A measure of the frequency that vehicles are exposed to collisions, for intersections, unit is million entering vehicles, for mid-block sections, unit is 100 million vehicle miles traveled.

HAL System: The set of procedures given in this manual for the identification, analysis and correction of high-accident locations.

Intersection-Related Accident: An accident that occurs as a result of the operation of an intersection.

Locational Analysis: A procedure to analyze a high-accident location that determines appropriate countermeasures for the location's accident experience.

Mid-Block Accident: An accident that is not an intersection-related accident.

PDO: Property-damage-only accident.

STARS: Statewide Traffic Accident Records System.

Traffic Records System: The personnel, equipment, facilities, information, and procedures necessary to correlate accident data with vehicle, driver and/or highway data to identify the causes of traffic accidents and the means of preventing them.

Warrant: Minimum specified value for traffic accidents, traffic volumes or other location characteristics that establish when a countermeasure could be installed at a location.

References

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APPENDICES

APPENDIX A

General Countermeasures for Accident Patterns and Their Probable Causes

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
Right-angle collisions at unsignalized intersections	Restricted sight distance	Remove sight obstructions Restrict parking near corners Install stop signs (see MUTCD) Install warning signs (see MUTCD) Install/improve street lighting Reduce speed limit on approaches* Install signals (see MUTCD) Install yield signs (see MUTCD) Channelize intersection
	Large total intersection volume	Install signals (see MUTCD) Reroute through traffic
	High approach speed	Reduce speed limit on approaches* Install rumble strips
Right-angle collisions at signalized intersections (Continued)	Poor visibility of signals (Continued)	Install advanced warning devices (see MUTCD) Install 12-in. signal lenses (see MUTCD) Install overhead signals Install visors Install back plates

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
		Improve location of signal heads Add additional signal heads Reduce speed limit on approaches*
	Inadequate signal timing	Adjust amber phase Provide all-red clearance phases Add multi-dial controller Install signal actuation Retime signals Provide progression through a set of signalized intersections
Rear-end collisions at unsignalized intersections	Pedestrian crossing	Install/improve signing or marking of pedestrian crosswalks Relocate crosswalk
	Driver not aware of intersection	Install/improve warning signs
(Continued)	Slippery surface	Overlay pavement Provide adequate drainage Groove pavement Reduce speed limit on approaches* Provide "SLIPPERY WHEN WET" signs

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	Large numbers of turning vehicles	Create left- or right-turn lanes Prohibit turns Increase curb radii
Rear-end collisions at signalized intersections	Poor visibility of signals	Install/improve advance warning devices Install overhead signals Install 12 in. signal lenses (see MUTCD) Install visors Install back plates Relocate signals Add additional signal heads Remove obstacles Reduce speed limits on approaches*
	Inadequate signal timing	Adjust amber phase Provide progression through a set of signalized intersections
(Continued)	Pedestrian crossings	Install/improve signing or marking of pedestrian crosswalks Provide pedestrian "WALK" phase

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	Slippery surface	Overlay pavement Provide adequate drainage Groove pavement Reduce speed limit on approaches* Provide "SLIPPERY WHEN WET" signs
	Unwarranted signals	Remove signals (see MUTCD)
	Large turning volumes	Create left- or right-turn lanes Prohibit turns Increase curb radii
Pedestrian accidents at intersections	Restricted sight distance	Remove sight obstructions Install pedestrian crossings Improve/install pedestrian crossing signs Reroute pedestrian paths
	Inadequate protection for pedestrians	Add pedestrian refuge islands
	Inadequate signals	Install pedestrian signals (see MUTCD)
(Continued)	Inadequate signal phasing	Add pedestrian "WALK" phase Change timing of pedestrian phase

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	School crossing area	Use school crossing guards
Pedestrian accidents between intersections	Driver has inadequate warning of frequent mid-block crossings	Prohibit parking Install warning signs Lower speed limit* Install pedestrian barriers
	Pedestrians walking on roadway	Install sidewalks
	Long distance to nearest crosswalk	Install pedestrian crosswalk Install pedestrian actuated signals (see MUTCD)
Pedestrian accidents at driveway crossings	Sidewalk too close to traveled way	Move sidewalk laterally away from highway
Left-turn collisions at intersections (Continued)	Large volume of left turns	Provide left-turn signal phases Prohibit left turns Reroute left-turn traffic Channelize intersection Install STOP signs (see MUTCD) Create one-way streets Provide turning guidelines (if there is a dual left-turn lane)

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	Restricted sight distance	Remove obstacles Install warning signs Reduce speed limit on approaches*
Right-turn collisions at intersections	Short turning radii	Increase curb radii
Fixed-object collisions	Objects near traveled way	Remove obstacles near roadway Install barrier curbing Install breakaway feature to light poles, signposts, etc. Protect objects with guardrail
Fixed-object collisions and/or vehicles running off roadway	Slippery pavement	Overlay existing pavement Provide adequate drainage Groove existing pavement Reduce speed limit* Provide "SLIPPERY WHEN WET" signs
(Continued)	Roadway design inadequate for traffic conditions	Widen lanes Relocate islands Close curb lane

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	Poor delineation	Improve/install pavement markings Install roadside delineators Install advance warning signs (e.g., curves)
Sideswipe collisions between vehicles traveling in opposite directions or head-on collisions	Roadway design inadequate for traffic conditions	Install/improve pavement markings Channelize intersections Create one-way streets Remove constrictions such as parked vehicles Install median divider Widen lanes
Collisions between vehicles traveling in same direction such as sideswipe, turning or lane changing	Roadway design inadequate for traffic conditions	Widen lanes Channelize intersections Provide turning bays Install advance route or street signs Install/improve pavement lane lines Remove parking Reduce speed limit*
Collisions with parked cars or cars being parked (Continued)	Large parking turnovers (Continued)	Prohibit parking Change from angle to parallel parking Reroute through traffic Create one-way streets

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
		Create off-street parking Reduce speed limit*
	Roadway design inadequate for present conditions	Widen lanes Change from angle to parallel parking Prohibit parking Reroute through traffic
Collisions at driveways	Left-turning vehicles	Install median divider Install two-way left-turn lanes
	Improperly located driveway	Regulate minimum spacing of driveways Regulate minimum corner clearance Move driveway to side street Install curbing to define driveway location Consolidate adjacent driveways
(Continued)	Right-turning vehicles	Provide right-turn lanes Restrict parking near driveways Increase the width of the driveway Widen through lanes Increase curb radii

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
	Large volume of through traffic	Move driveway to side street Construct a local service road Reroute through traffic
	Large volume of driveway traffic	Signalize driveway Provide acceleration and deceleration lanes Channelize driveway
	Restricted sight distance	Remove sight obstructions Restrict parking near driveway Install/improve street lighting Reduce speed limit*
Night accidents	Poor visibility	Install/improve street lighting Install/improve delineation markings Install/improve warning signs
Wet pavement accidents	Slippery pavement	Overlay existing pavement Provide adequate drainage Groove existing pavement Reduce speed limit* Provide "SLIPPERY WHEN WET" signs

* Spot speed study should be conducted to justify speed limit reduction.

General Countermeasures for Accident Patterns and Their Probable Causes

ACCIDENT PATTERN	PROBABLE CAUSE	GENERAL COUNTERMEASURE
Collisions at railroad crossings	Restricted sight distance	Remove sight obstructions Reduce grades Install train actuated signals (see MUTCD) Install stop signs (see MUTCD) Install gates (see MUTCD) Install advance warning signs (see MUTCD)

APPENDIX B

Collection of Traffic Data

Conducting Turning Volume Counts

Conducting Spot Speed Studies

Preparing Condition Diagrams

Determining Safe Approach Speed at Uncontrolled Intersections

Preparing a Traffic Conflict Survey

Additional References on Collection of Traffic Data

Conducting Turning Volume Counts

A. What to Count

1. Unless otherwise directed, only vehicles entering the intersection are counted.

2. Each vehicle is tabulated:

a. According to the direction from which it enters the intersection.

b. Then as to whether it goes right, left or straight.

3. U-turns are counted as left turns.

4. Vehicles that should be counted are:

a. Cars, including motorcycles;

b. Trucks--light and heavy;

c. Buses; and

d. In some cases, bicycles or pedestrians.

As a general rule, large trucks and buses are classified as commercial vehicles while cars, small trucks, motorcycles and motor scooters are classified as passenger vehicles. Bicycles and pedestrians are not counted unless specifically asked for.

5. Be sure to include:

a. North point;

b. Movements counted (total); and

c. Street names and route numbers.

B. Tally Sheet

Vehicle turning movement counts at intersections can be recorded manually by using the Traffic Count Field Sheet (Figure B-1).

The tally sheet has four squares with room for recording vehicles entering the intersection from at least four directions.

Make sure to line the sheets up with actual direction of traffic flow. Then indicate north.

These sheets can be set up for whatever time period is desired, i.e., 5, 15, 30 or 60 min periods.

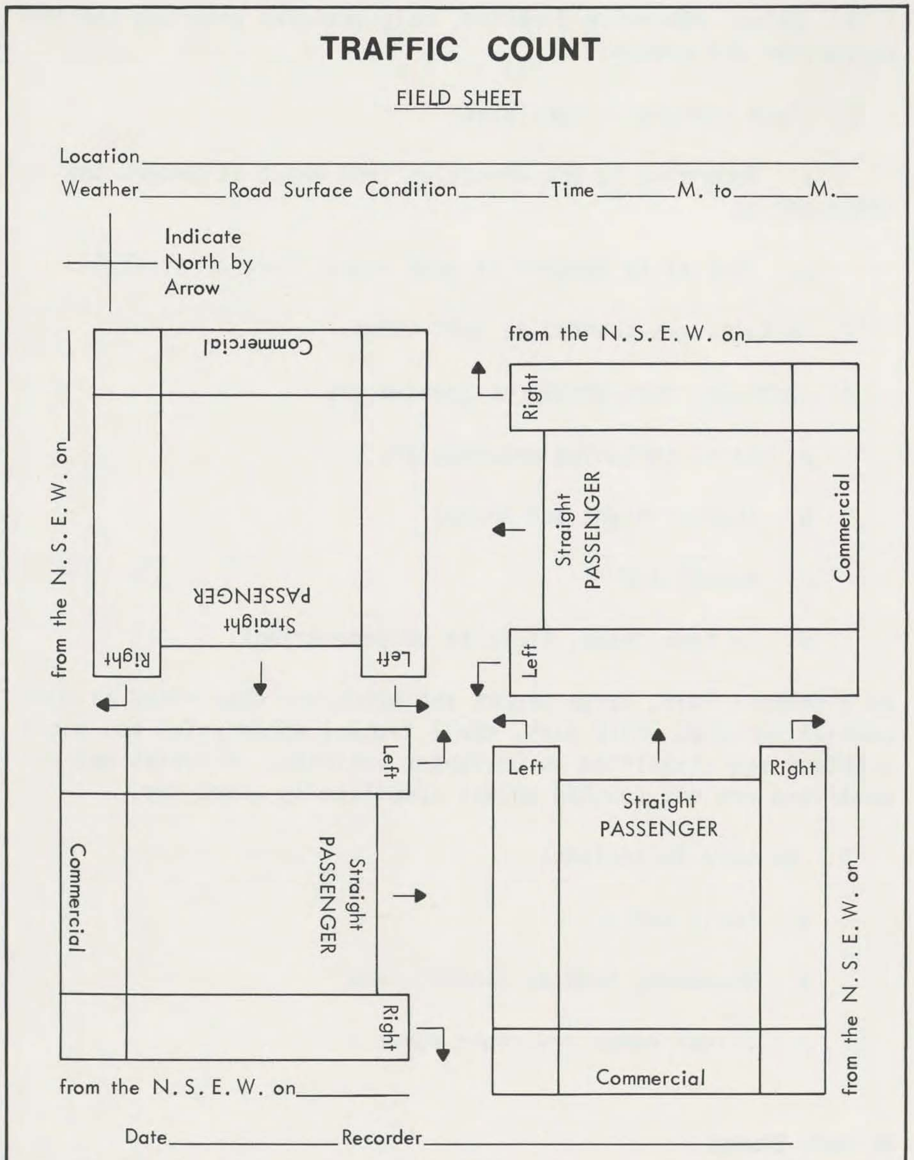


Figure B1—Traffic Count Field Sheet

Usually a new sheet is used at least every hour. This depends on traffic volume and individual preference.

To record the vehicle movements use the tally system of four vertical marks with a fifth mark diagonally through the four (i.e., 卌).

Also record weather conditions at beginning and end, making sure to note the duration of any changes.

C. Suggested Equipment

1. A watch;
2. Several pencils;
3. Eraser;

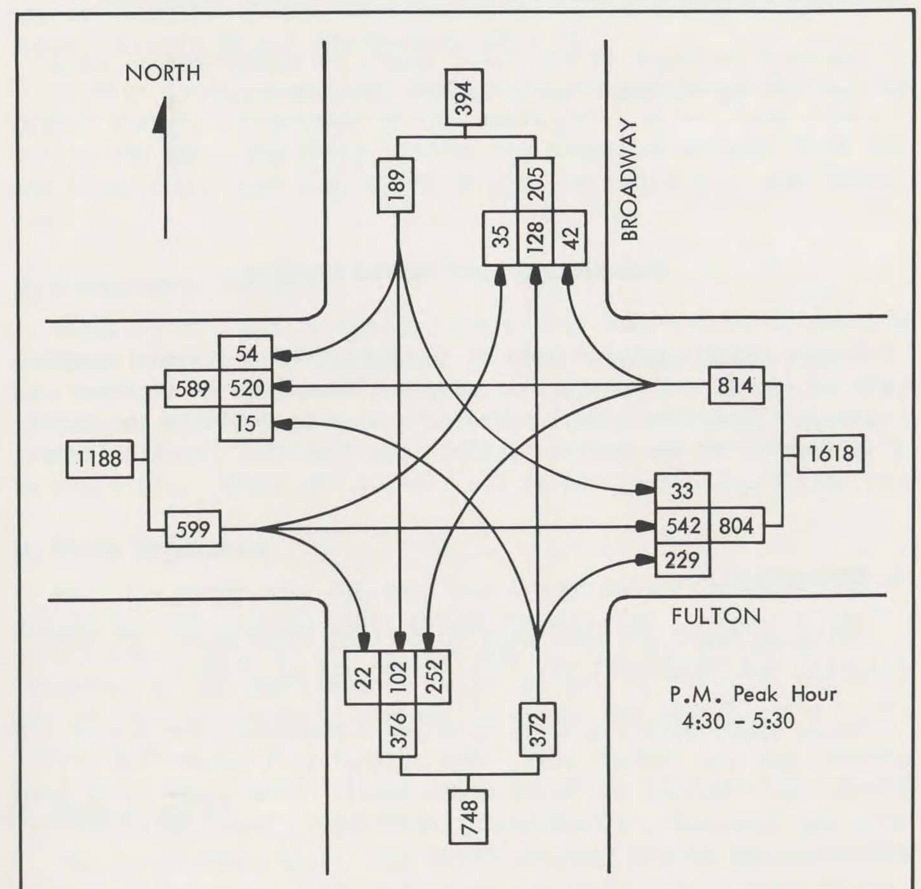


Figure B2—Turning Movement Count Summary

4. Pencil sharpener; and

5. Accumulating register (optional).

When two persons are conducting a volume count at a simple four-way intersection, they should stand at diagonal corners. Each observer should count vehicles entering two approaches. Heavy traffic might, however, call for an observer for each approach.

Hand-operated accumulating registers can be used to ease the tallying process. These registers are available in configurations representing intersection turning movements. Running totals are recorded at the desired sampling intervals.

When using the registers, one observer can usually record all movements at an intersection. Heavy traffic and the counting of pedestrian movements could necessitate additional observers.

The data recorded in the field should be summarized as shown in the Turning Movement Count Summary (Figure B-2).

Conducting Spot Speed Studies

A spot speed study is made by measuring the individual speeds of a sample of the vehicles passing a given point on a street or highway. These individual speeds are used to estimate the speed distribution of the entire traffic stream at that location under the conditions prevailing at the time of the study.

A. Equipment

Although there are many ways to collect speed data, the most reliable and convenient way is with the use of radar.

Radar speed meters usually have two components, the transmitter-antenna and the control unit. The control unit powers the transmitter and displays the speed measurement. Some radar units have only one component, a hand-held transmitter. Speed measurements are displayed at the rear of the unit.

Radar meters operate on the fundamental principle that a radio wave reflected from a moving target has its frequency changed in

proportion to the speed of the target (Doeppler Effect). The meter evaluates the difference between transmitted and received frequencies and converts the result into miles per hour.

With radar meters which have two components, the transmitter-antenna is positioned at the edge of the roadway at about a 15 degree angle with the centerline of the roadway and about 3 ft above the roadway surface. In this position the meter will indicate speeds for vehicles traveling in either direction in the adjacent two to three lanes.

B. Selection of Study Location and Time

The site chosen for making speed measurements should be on a mid-block section away from the influence of stop signs, signals, etc. The site should have a place near the roadway where the vehicle with the radar equipment can be concealed or made inconspicuous to the approaching driver. The person making the speed measurements should be able to see approaching vehicles.

Usually speed studies are conducted during off-peak hours. One method that is recommended is to sample for 1 hr at three times during the day. The three studies are conducted between 9:00 a.m. and 12:00 a.m., 3:00 p.m. and 6:00 p.m., and 8:00 p.m. and 10:00 p.m.

C. Selection of Sample

Normally at least 50 speeds, preferably 100, should be measured during a study. Only the speeds of free-flowing vehicles should be recorded. Free-flowing vehicles are those whose speed is not influenced by other vehicles; therefore, only vehicles that are traveling alone or are at the front of a group of vehicles should be measured.

D. Study Procedure

When the radar unit has been positioned and calibrated, the speeds of free-flowing vehicles can be recorded. Speeds of both directions of traffic can be recorded or only one direction. The recording of the measurements should be done by tallying the number of vehicles (usually divided into cars and trucks) in a 1 to 2 mph range.

E. Data Analysis

The speed measurements are analyzed to determine the characteristics of the speed distribution at the study site. Some of the most frequently used speed distribution characteristics are the mean speed, the 85th percentile speed, and the pace.

The mean speed is the average speed of all observed vehicles. It can be found by multiplying the mean speed of each group by the number of observations in that group, summing the products, and dividing by the total number of observations.

The 85th percentile speed is the speed below which 85% of the observed vehicles travel. This speed can be found by multiplying 0.15 times the number of observed vehicles and counting down from the highest speed vehicle, this number of vehicles.

The pace is the 10 mph range in speeds in which the highest number of observations were recorded.

Preparing Condition Diagrams

A condition diagram is a *scaled* drawing of the important physical conditions of a hazardous intersection or section of roadway. It is used to relate the accident patterns on a collision diagram to the roadway and operational elements at the hazardous location.

Pick a scale you wish to use; 1 in. = 30 ft or 1 in. = 20 ft, are most commonly used, see Figure B-3.

Judge how detailed the diagram needs to be. Minor changes such as changing the control device may only warrant a superficial look. Major changes such as median dividers and channelizing islands require the most extensive diagram possible.

The following items should be included on the condition diagram:

1. Street names;

2. Functional classification of streets (major, collector, local);

3. Intersection angle (to scale);

4. Width of all streets;

5. Parking conditions, whether marked or unmarked;

6. Grades on all approaches;

7. Corner radii (to scale);

8. Sidewalk locations (to scale);

9. Pavement markings including pedestrian crosswalks and stoplines;

10. Traffic regulations;

11. Traffic control devices;

12. Speed limits on all approaches;

13. Location of all view obstructions (to scale, with height noted);

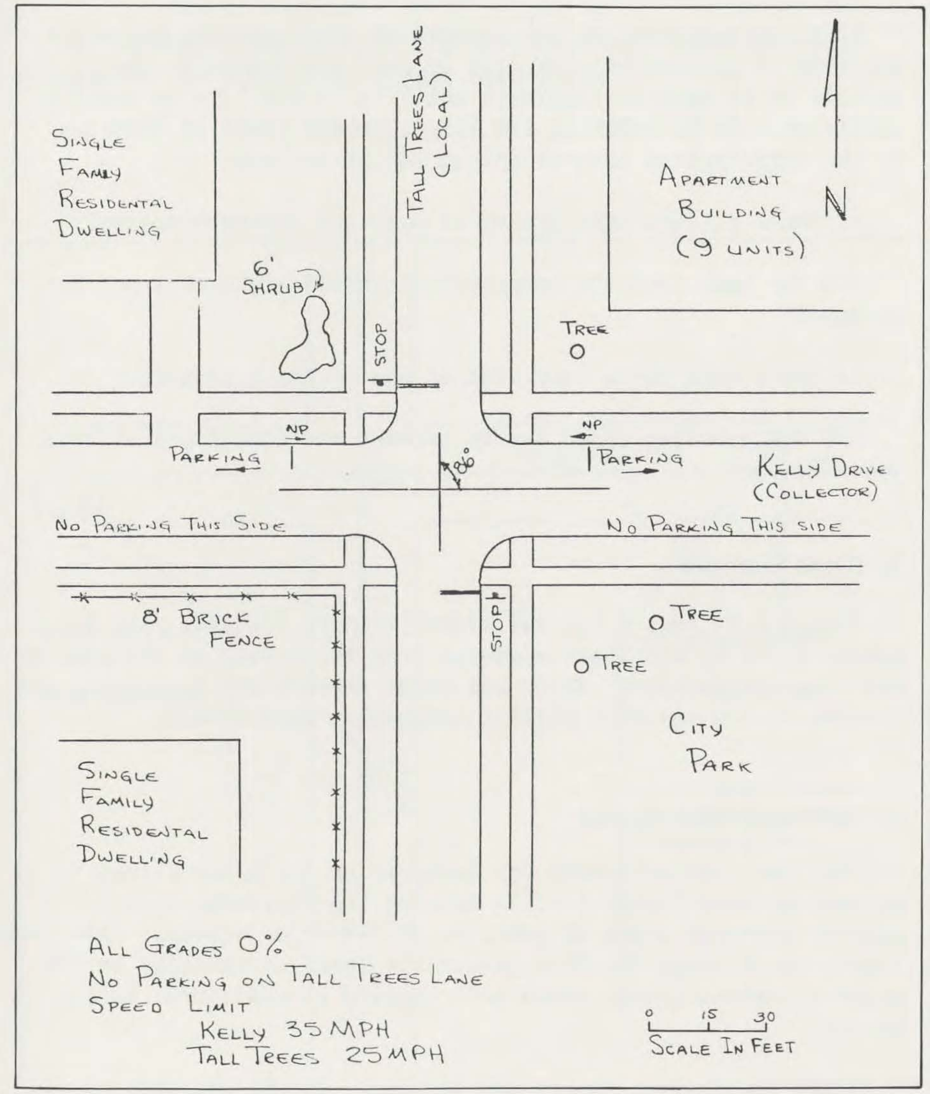


Figure B3—Intersection Condition Diagram

14. Fixed objects, such as fire plugs and trees over 12 in. in diameter;

15. Driveway locations (to scale); and

16. Road surface irregularities.

Determining Safe Approach Speed at Uncontrolled Intersections

Sight obstructions on the corners of intersections may block the view of approaching vehicles so they are unable to see a vehicle on an opposing approach until it is too late to avoid a collision. By determining the safe approach speed of vehicles at the intersection several things can be decided:

Is there a sight obstruction at existing approach speeds?

How far back from the intersection should sight obstructions be moved?

Is there need for a stop sign on one of the approaches?

Are the existing speed limits correct for conditions at this intersection?

A. Sight Triangle

Figure B-4 shows a typical sight triangle diagram. The distances a, b, c, and d are measured from the driver to the edge of the view obstruction. Major and minor streets are designated according to the relative traffic volumes on each street.

B. Safe Approach Speed

The safe approach speed for vehicles on the minor street is determined from Figure B-5, by knowing the distances a, b, c, d and the approach speed of vehicles on the major street. This speed should be at least the 85th percentile speed of vehicles on the major street--a higher speed will provide an additional safety factor.

After the four distances and the major street approach speed are known the coordinates (a,b) and (c,d) are plotted on the chart.

Then a line is drawn from the major street approach speed through each of the plotted points to the minor street approach speed. The value of the minor street safe approach speed is the point where the line intersects the bottom line of the graph. The minimum value is the minor street safe approach speed.

In Figure B-5, an example is shown where a = 35 ft, b = 50 ft, c = 40 ft, d = 30 ft and the major street approach speed equals 33 mph. The values determined for the minor street approach speeds are 16 mph and 12 mph. Thus, 12 mph is the minor street safe approach speed.

At four-way intersections the safe approach speed should be determined for both minor street approaches.

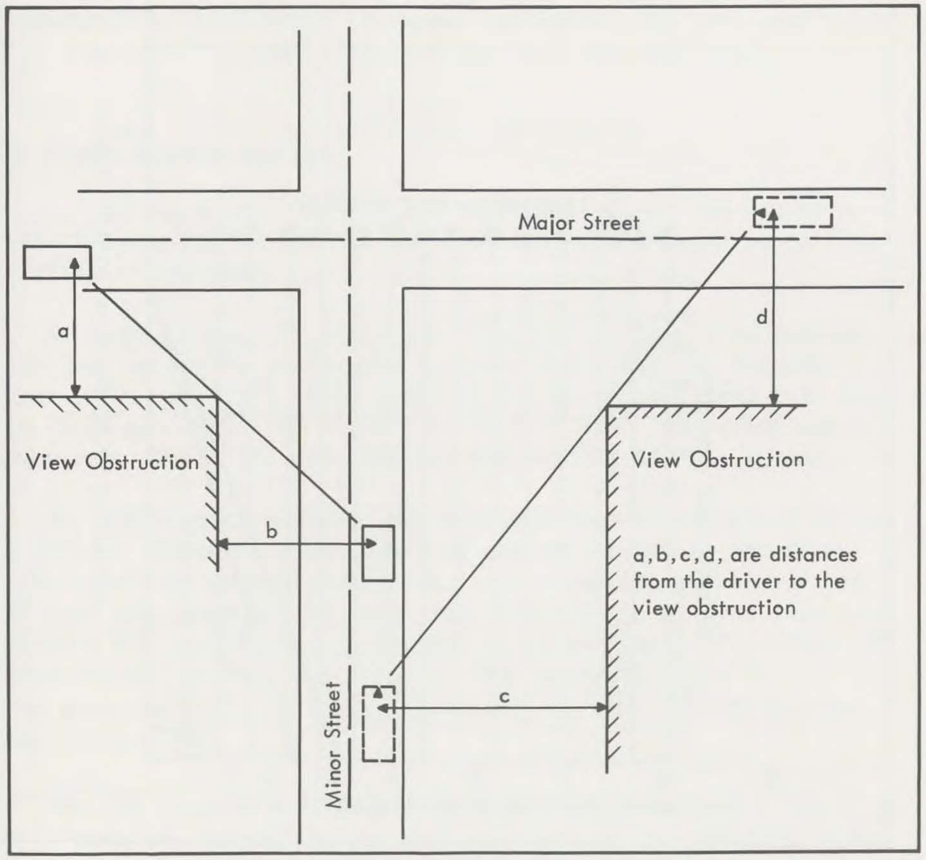


Figure B4—Sight Triangle Diagram

C. Countermeasures

Once the safe approach speed of vehicles has been determined, the countermeasures that can either reduce existing approach speeds or increase the sight distance available must be determined. Some general countermeasures are:

1. Remove sight obstructions near the corner of the intersection;

2. Install a stop sign on one of the approaches; and

3. Reduce the speed limit on one of the approaches.

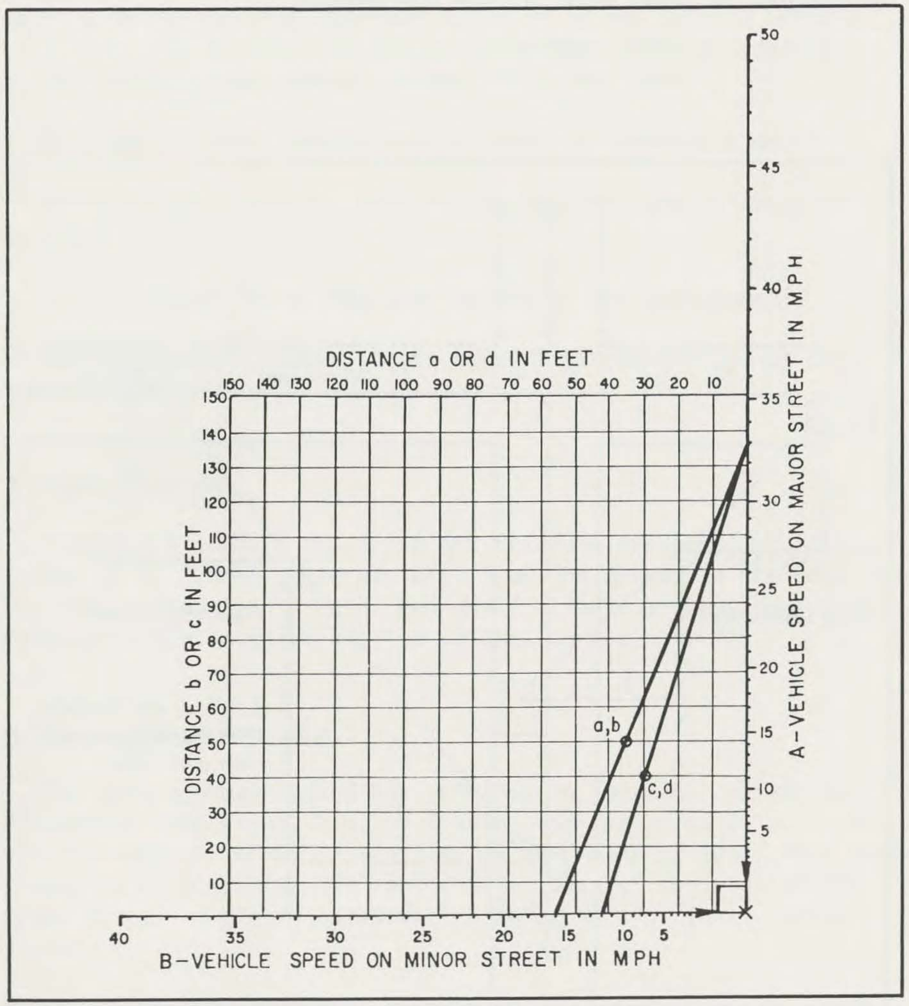


Figure B5—Safe Approach Speed Chart

Preparing a Traffic Conflict Survey

A. Definition

A traffic conflict occurs when a driver takes *evasive* action by either braking hard or weaving into a neighboring traffic lane in order to avoid another vehicle.

There are several types of conflicts that might be included in a conflict survey and it is necessary to decide which ones are going to be counted. An example of conflicts will be given to make it possible to determine to what extent an all-out conflict survey would be beneficial.* Also a general knowledae of the conflict types will be useful when conducting an on-site observation of a location.

Figures B-6 through B-9 give examples of four major types of intersection conflicts: (1) weave conflicts; (2) turn conflicts; (3) cross-traffic conflicts; and (4) rear-end conflicts.

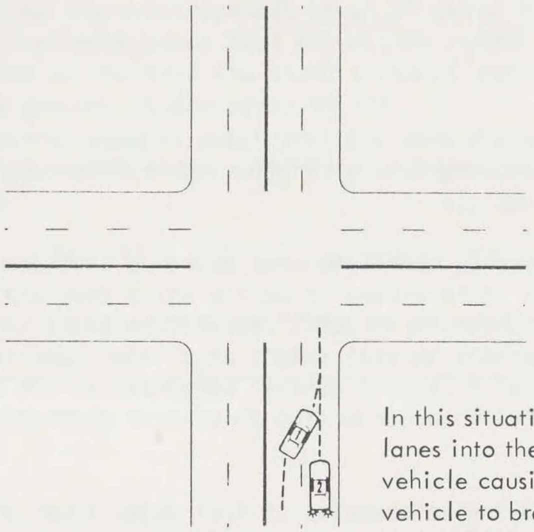
B. Traffic Conflict Survey

1. *Survey team*: Usually the team consists of two men in a vehicle; one man to collect conflict data and one man to collect traffic volume data.

2. *Survey day*: At least one 10-hr period should be sampled. The days generally chosen are Tuesday, Wednesday, or Thursday. Each survey day is a 10-hr counting day which goes from 7:30 a.m. to 12:00 noon and from 12:45 p.m. to 6:15 p.m. Variation may be necessary to include peak morning and evening traffic volume.

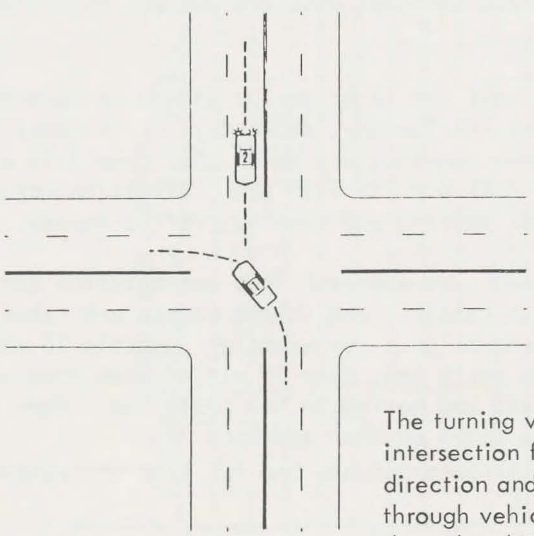
3. *Sampling procedure*: Two approach legs are observed during a survey. Fifteen minute conflict and volume counts are taken alternately on each approach leg. For example: exactly 15 min of data are taken on the north leg, then 15 min of free time are allowed for recording data and moving to the south leg. Then 15 more minutes of data are taken on that approach leg.
The team continually alternates between the two legs throughout the counting day.

* The *GMR Traffic Conflicts Technique Procedures Manual* (by S. R. Perkins, General Motors Research Publication GMR-895) gives an extensive explanation of each type of conflict and examples of detailed tabulation procedures.



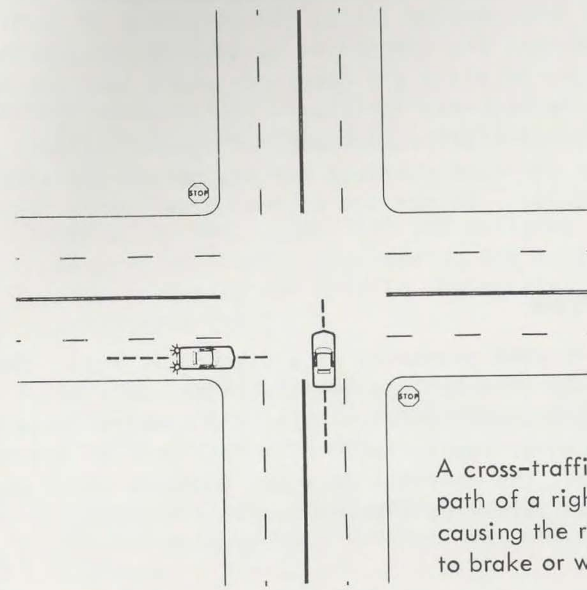
In this situation a vehicle changes lanes into the path of another vehicle causing the offended vehicle to brake or weave to avoid an impending collision.

Figure B6 — Weave Conflict



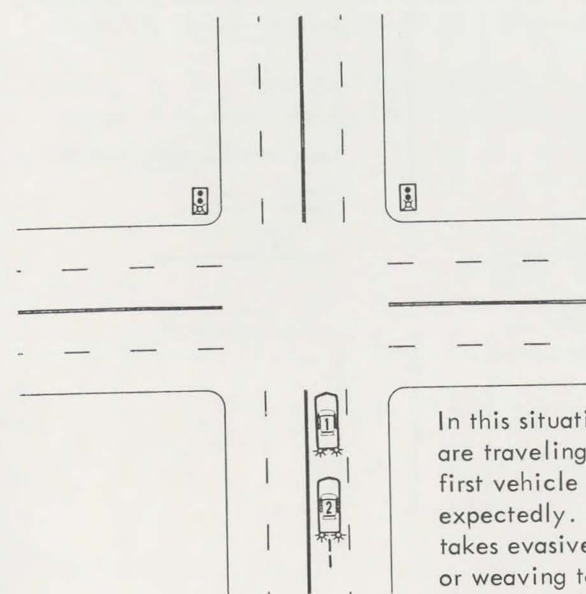
The turning vehicle approaches the intersection from the opposite direction and turns in front of a through vehicle causing the through vehicle to brake or weave.

Figure B7 — Left-Turn Conflict



A cross-traffic vehicle crosses the path of a right-of-way vehicle causing the right-of-way vehicle to brake or weave.

Figure B8 — Cross-Traffic Conflict



In this situation, two vehicles are traveling as a pair and the first vehicle stops or slows unexpectedly. The second vehicle takes evasive action, braking or weaving to avoid impending rear-end collision.

Figure B9 — Rear-End Conflict

4. *Observation position*: The vehicle should be parked 100-300 ft back from the intersection facing the direction of traffic movement. Since conflicts are identified by braking and weaving actions it is necessary to place the observers where they can see the brake lights of the observed vehicles. The position should not interfere with normal traffic movement. A special effort should be made to use the same position for any before and after studies (see Figure B-10). Do not use police surveillance vehicles.

C. Conflict Data Analysis

A conflict study is used primarily as a diagnostic tool. The conflict data should be used to supplement accident data for a location. Look for prevalent conflict types and compare these with the accident patterns identified. If only 1 year of accident data has been analyzed, the conflict data may indicate other physical or operational deficiencies that could cause accidents.

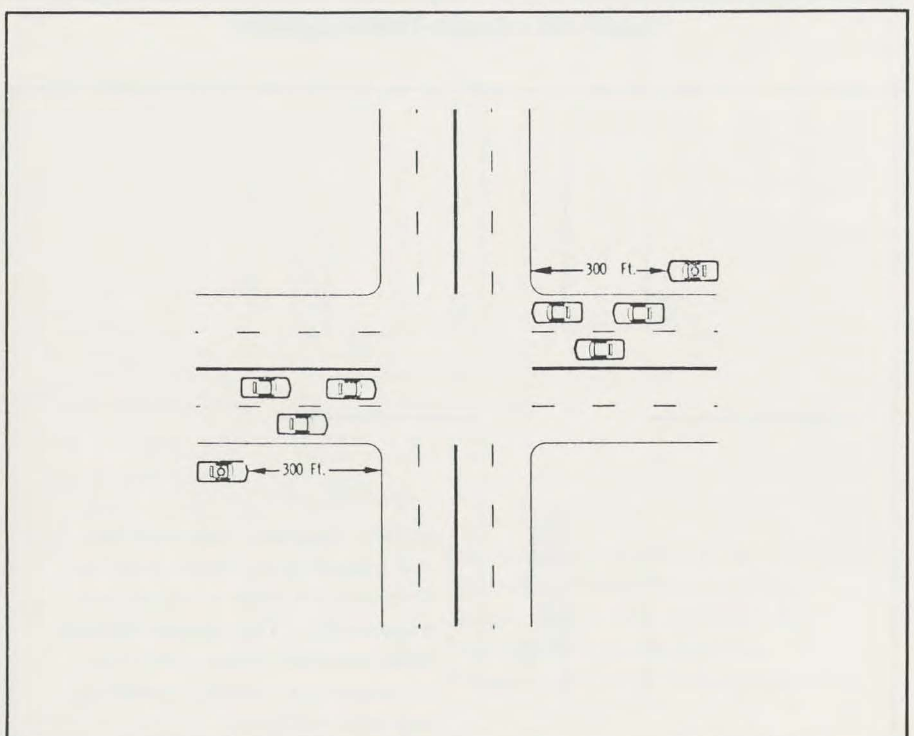


Figure B10—Brake-Light Criteria Observation

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APPENDIX C

Warrants for Flashing Beacons, Safety Lighting and One-Way Streets

Warrants for Flashing Beacons[1]

Flashing beacons should be considered to supplement existing two- or four-way stop sign control at four-way intersections on high-speed roads if four or more crossing (right angle) plus left-turn accidents occur in a year or six or more crossing plus left-turn accidents occur in 2 years.

Where four-way stop signs are warranted all-red flashing beacons should be considered also: (1) where approach speeds are high; (2) where visibility of the stop sign is limited; or (3) where the intersection is hidden or unexpected.

When flashing beacons are installed with two-way stop control, red flashing beacons are used on approaches required to stop and yellow flashing beacons are used on the approaches that are not required to stop.

Warrants for Safety Lighting[1]

The purpose of highway lighting is to safeguard and facilitate both vehicular and pedestrian traffic at night by illuminating certain permanent features at locations which require additional care and alertness. With illumination, these features will be more readily comprehended and compensated for by the motorist.

For isolated lighting at a spot location, lighting is warranted when four or more night accidents susceptible to correction by safety lighting have occurred in 1 year, or six night accidents of this type have occurred in 2 years.

The types of accidents that are most susceptible to correction by night lighting include: (1) single-vehicle accidents (especially those where a driver proceeded straight ahead at a t-intersection on the dead-ended leg); and (2) crossing (right-angle) accidents at four-way intersections.

1/ Tamburri, T. N., C. J. Hammer, J. C. Glennon, and A. Lew, "Evaluation of Minor Improvements," Highway Research Record No. 257, Highway Research Board, Washington, D.C. (1968).

General Warrants for One-Way Streets[2]

A. General Requirements

Two-way streets should be made one-way only when:

1. A demonstrated traffic problem exists that can be relieved by one-way operation.

2. One-way street designation is more desirable than other possible alternate methods of solving the problem.

3. Parallel and adjacent streets of suitable capacity, preferably within 600 ft, are available.

4. The parallel and adjacent streets are continuous in that they carry the traffic through and beyond congested areas.

5. Suitable transition roadways can be provided at the extremities of the one-way section.

6. Two-way public transit operation is not required on the street.

7. The proposed one-way streets are compatible with the overall master street plan.

8. Thorough study shows that the advantages of the one-way street far outweigh the disadvantages.

B. Increased Capacity

One-way streets may be warranted if the traffic service would be increased substantially by:

1. Reduction in time losses at intersections due to vehicle turning-movement conflicts and pedestrian-vehicle conflicts.

2. Lane-width adjustments that permit greater capacity in the existing number of lanes, or an increase in the number of lanes.

2/ Baerwald, John E., ed., *Traffic Engineering Handbook*, Third Edition, Institute of Traffic Engineers, Washington, D.C. (1965).

C. Increased Safety

One-way operation may be warranted if the safety of pedestrian and vehicular traffic would be increased substantially by:

1. Reduction in vehicle-pedestrian conflicts at intersections.

2. Preventing pedestrians from being trapped between two opposing streams of traffic.

3. Better vehicular grouping and speed control due to more effective spacing of traffic signals.

4. Reduction in the complexity of the field of driver vision on approaches to intersections.

D. Improved Operation

One-way streets may be warranted if operating characteristics would be improved substantially by:

1. Reduction in travel time.

2. Permitting a predominant turning movement from more than one lane at a greater number of intersections than would be possible with two-way operation.

3. Redistribution of traffic thereby relieving congestion on adjacent streets.

E. Improved Economy

One-way streets may be warranted if definite economic opportunities would be made available by:

1. Providing unused capacity margins that will satisfy traffic requirements for a substantial period of time, thus obviating the immediate need for large capital expenditures.

2. Permitting stage development in the execution of a master plan.

3. Providing greater flexibility to meet changing traffic patterns almost immediately and at negligible cost.

4. Saving sidewalk or boulevard width, trees, and other valuable frontage assets which would be sacrificed in the widening of two-way streets to provide traffic capacity comparable to a pair of one-way streets.

APPENDIX D

Estimated Countermeasure Costs

Estimated Countermeasure Costs

The costs (1975) of construction items were estimated using the following sources:

Missouri Highway Department (1973);
Iowa Highway Commission (1973);
California Division of Highways (1974);
Massachusetts Department of Public Works (1969);
City of Kansas City, Missouri (1975); and
City of Overland Park, Kansas (1975).

Costs of each item were adjusted upward to allow for inflation, depending on the date of the cost data. These costs, however, are only estimates. Final improvement costs will depend on the actual construction costs in that particular part of the state.

Unless noted, the following unit costs are for installation only. Overhead and administrative costs are not included. Thirty to 35% of the cost of the project should be added to an estimate to account for these costs.

Roadway grading and paving (widening)	$ 1.50	S.F.
Roadway grading and paving (reconstruction)	2.00	S.F.
Median construction* (concrete)	2.00	S.F.
Curb and gutter (barrier and mountable)	7.00	L.F.
Barrier curbing	2.00	L.F.
Curb removal	1.50	L.F.
Driveway closure	8.00	S.Y.
Driveway construction	18.00	S.Y.
Island construction*	2.00	S.F.
Sidewalk removal	3.50	S.Y.
Sidewalk construction	1.50	S.F.
Sodding	1.50	S.Y.
Asphalt overlay (1/2 in.)	2.00	S.Y.
Pavement striping (4 in. white)	0.25	L.F.
Pavement striping (4 in. yellow)	0.25	L.F.
Pavement marking (stop bars)	0.25	S.F.
Complete lighting unit	1,000.00	EA
Curb inlet	200.00	EA
Steel breakaway sign posts	11.00	L.F.
Wood sign post	4.00	L.F.

* Does not include cost of curbing.

Sign (installed--stop, yield, warning)	90.00 EA
Delineators (installed sign and post)	15.00 EA
Remove and reset roadside sign	50.00 EA
10-ft signal post	225.00 EA
Mast arm post	1,200.00 to 2,500.00 EA
Fixed-time controller	4,000.00 EA
Actuated controller	2,000.00/phase
Multi-dial controller	2,000.00 to 14,000.00 EA
Junction box	300.00 EA
Detector, loop inductive	10.00 to 15.00 L.F.
Detector, magnetic	400.00 EA
Detector, pedestrian pushbutton	100.00 EA
Conduit	7.00 to 15.00 L.F.

The following items include material costs only:

Plastic signal head (8-in. lenses)	$125.00 EA
Plastic signal head (12-in. lenses)	180.00 EA
Plastic pedestrian head (9 in.)	145.00 EA
Plastic pedestrian head (12 in.)	230.00 EA
Optically programmed signal head	750.00 EA
Plastic backplate (8 in.)	40.00 EA

APPENDIX E

Estimates of Improvement Service Life

Estimates of Improvement Service Life

Improvement	Service Life
Signals	15 years
Safety Lighting	15 years
Median Barriers	15 years
Flashing Beacons	10 years
Guardrail	10 years
Pavement Grooving	10 years
Signing (major)	10 years
Signing (minor)	5 years
Raised Pavement Markers	5 years
Guide Markers	5 years
Painted Stripes	2 years

APPENDIX F

Estimated Accident Reduction

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent) All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
PAVEMENT MARKINGS														
General Pavement Markings						10	20	10			10	10		
Double Yellow Center Lines	5													
Right Edge Lines	2												25	
Reflectorized Raised Pavement Markers	5													
No Passing Stripes	65													
PAVEMENT TREATMENTS														
Deslicking[a/]	20	15												50

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent) All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
Resurfacing[a/]	42	46												
SIGNS														
Upgrade Signs				20	10						10	10		
Overhead Lane Signs					10		20							
Overhead Warning Signs					20	20		20	20					
Four-Way Stop Signs[c/]	70	≅67												
Special Curve Warning Signs	75													
Minor Leg Stop Control	48[b/] ≅38[a/]	71[b/] ≅18[a/]												

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent) All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
Yield Sign	≅59[b/] ≅46[a/]	80[b/]												
Directional or Warning Signs at Intersections	29[b/] 41[a/]	≅59[b/] ≅47[a/]	≅26[a/]											
Warning Signs and Delineators at Intersections	20[a/]	≅27[a/]												
Warning Signs on Sections	14[b/] ≅20[a/]	≅14[b/] ≅26[a/]												
REGULATIONS														
Eliminate Parking	32[a/]	3[a/]												
Change Two-Way Operation to One-Way	25													
Prohibit Turns	40[a/]	39[a/]												

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent)												
	All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
CHANNELIZATION														
Install Median Barriers		≅61 a/												
Add Painted/Raised Medians	12 a/													
Add Left-Turn Lane w/o Signals	≅19 6 a/	≅80 ≅54 a/												
Turn Bay					20									
New Left Channelization at Signalized Intersection w/ or w/o Left-Turn Phase	w/o 15 w 36													
New Left-Turn Channelization at Unsignalized Intersection w/curbs-painted	Curb 70 Paint 15													
Install Two-Way Left-Turn Lanes	35													

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be <8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent)												
	All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
ACCESS CONTROL														
Close Median Opening				100	50	100	50	100						
Relocate Drives				20	20	10	10	10	10					
SIGNALIZATION														
Install Warning Signals		≅73 a/												
Flashing Beacons (Red-Yellow)	50													
Flashing Beacons (All Red)	75													
Flashing Beacons at RR Xing	80													

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent): All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
Advance Warning Flashers	30													
Improve Signals	31 2[a]	≅35												
Add Pedestrian Signals	13 3[a]	56 42												
Add Left-Turn Lane and Signal	27[a]	1[a]												
Add Left-Turn Signal w/o Turning Lane	39[a]	57[a]												
Add Turn Lane, Signal and Illumination	46[a]	76[a]												
Improve Timing					10	10		10	10		10			
12-in. Lens					10									

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent): All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
Improve Signals to Correspond to Manual on Uniform Traffic Control Devices					20	20	10	20	20			20		
Add Left-Turn Lane w/o Signal Turn Phase	≅19 6[a]	≅80 ≅54[a]	≅18[a]											
Modify Signals	27													
Actuate					10	10	20	10	20					
Optically Programmed Signals				20	10	10		10						
Pedestrian Phase											60			
Remove Signal					90									
Add Signal					-1/ 2000 vpd	80								

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent) All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
LIGHTING														
Add Lighting												50		
At Intersection — New / Upgrading												75 / 50		
At RR Crossing												60		
At Bridge Approach												50		
At Underpass												10		
MISCELLANEOUS														
Relocate Fixed Object										60				

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be <8,000 ADT.

Estimated Accident Reduction Table

Improvement	Accident Reduction (Percent) All	Fatal Injury	PDO	Head On	Rear End	Right Angle	Side Swipe	Left Turn	Rt. Turn	Fixed Obj.	Ped.	Night	Ran Off Road	Wet Pvmt.
Curtail Turning Movement	40 b/	39 b/												
Realignment	50													
Superelevation	50													
Reconstruct	25													
≅Rough Estimate														

a/ On two or more lanes.
b/ Two lanes.
c/ Minor street must be 35% or more of total intersection volumes; total intersection volume must be < 8,000 ADT.

APPENDIX G

Interest Factors Table

Interest Factors Table
(5% Compound Interest Factors)

Service Life of Improvement (Years)	Present Worth Factor*	Capital Recovery Factor	Sinking Fund Factor
1	0.952381	1.050000	1.000000
2	1.859410	0.537805	0.487805
3	2.723248	0.367209	0.317209
4	3.545951	0.282012	0.232012
5	4.329477	0.230975	0.180975
6	5.075692	0.197017	0.147017
7	5.786373	0.172820	0.122820
8	6.463213	0.154722	0.104722
9	7.107822	0.140690	0.090690
10	7.721735	0.129505	0.079505
11	8.306414	0.120389	0.070389
12	8.863252	0.112825	0.062825
13	9.393573	0.106456	0.056456
14	9.898641	0.101024	0.051024
15	10.379658	0.096342	0.046342
16	10.837770	0.092270	0.042270
17	11.274066	0.088699	0.038699
18	11.689587	0.085546	0.035546
19	12.085321	0.082745	0.032745
20	12.462210	0.080243	0.030243
21	12.821153	0.077996	0.027996
22	13.163003	0.075971	0.025971
23	13.488574	0.074137	0.024137
24	13.798642	0.072471	0.022471
25	14.093945	0.070952	0.020952
26	14.375185	0.069564	0.019564
27	14.643034	0.068292	0.018292
28	14.898127	0.067123	0.017123
29	15.141074	0.066046	0.016046
30	15.372451	0.065051	0.015051

Interest Factors Table (Concluded)

Service Life of Improvement (Years)	Present Worth Factor*	Capital Recovery Factor	Sinking Fund Factor
31	15.592811	0.064132	0.014132
32	15.802677	0.063280	0.013280
33	16.002549	0.062490	0.012490
34	16.192904	0.061755	0.011755
35	16.374194	0.061072	0.011072
36	16.546852	0.060434	0.010434
37	16.711287	0.059840	0.009840
38	16.867893	0.059284	0.009284
39	17.017041	0.058765	0.008765
40	17.159086	0.058278	0.008278
45	17.774070	0.056262	0.006262
50	18.255925	0.054777	0.004777
55	18.633472	0.053667	0.003667
60	18.929290	0.052828	0.002828
65	19.161070	0.052189	0.002189
70	19.342677	0.051699	0.001699
75	19.484970	0.051322	0.001322
80	19.596460	0.051030	0.001030
90	19.752262	0.050627	0.000627
100	19.847910	0.050383	0.000383

* For a uniform series of payments.

HAL System Forms

Originals of forms used in the HAL System are included in this envelope. The forms included are:

Page

1. Traffic Accident Summary
2. High-Accident Location Identification Worksheet
3. Accident Location-File Log
4. Locational Analysis Worksheet, Form No. 1
5. Locational Analysis Worksheet, Form No. 2
6. Collision Diagram
7. On-Site Observation Report, Form No. 1
8. On-Site Observation Report, Form No. 2
9. Countermeasure Analysis Worksheet, Form No. 1
10. Countermeasure Analysis Worksheet, Form No. 2
11. Countermeasure Evaluation Worksheet, Form No. 1
12. Countermeasure Evaluation Worksheet, Form No. 2
13. System Evaluation Worksheet

Form #1

COUNTERMEASURE EVALUATION WORKSHEET

DATE ______________

LOCATION ____

COUNTERMEASURE ____

AFTER ACCIDENT ANALYSIS:

BLOCK A - NUMBER AND RATE SUMMARY

LOCATION	ACCIDENTS					2 and 3 Year Ave	EPDO	ADT	Exposure	Accident Rate	EPDO Rate
	Year	Fatal	Injury	PDO	Total						
TOTALS										Avg=	Avg=

BLOCK B - INTERSECTION-RELATED ACCIDENTS

	Right Angle	Rear End	Side-Swipe		Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
			Meeting	Passing							
No. of Accidents											
Percent of Total											100%

BLOCK C - MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking					Train	TOTAL
		Ped.	Pk. Car	Veh. @ Dr.	F.O.	Vehicle On St.		
No. of Accidents								
Percent of Total								100%

BLOCK D - CONDITIONS

No. of accidents

Time of day - 6:00 am - Noon ________ 6:00 pm - Midnight ________
Noon - 6:00 pm ________ Midnight - 6:00 am ________

Light conditions - Day ________ Night ________

Surface conditions - Dry ______ Wet ______ Snow or Ice ______

Weather - Cloudy _____ Clear _____ Rain _____ Snow _____ Other _____

Other - ____

____

Form #2

COUNTERMEASURE EVALUATION WORKSHEET
BLOCK E - AFTER ACCIDENT ANALYSIS SUMMARY

☐ Collision diagram attached

Identified Patterns of Accidents   Predominate: ________ Secondary: ________

ADT Ratio: $\frac{\text{After ADT}}{\text{Before ADT}}$ = ______ =

Adjusted After Accident Numbers:

By Types:				By Severity:	
Left turn	____	Skidding	____	Fatal	____
Head on	____	Wet pavement	____	Injuries	____
Rear end	____	Night	____	PDO	____
Right angle	____	RR crossing	____	Total	____
Side swipe	____	____________			
Fixed object	____	____________		All Accidents	
Lost control	____	____________		________	

Accident Reduction: % Reduction = $\frac{\text{Before - After}}{\text{Before}}$ X 100

By Types:				By Severity:	
Left turn	____%	Skidding	____%	Fatal	____%
Head on	____%	Wet pavement	____%	Injuries	____%
Rear end	____%	Night	____%	PDO	____%
Right angle	____%	RR crossing	____%	Total	____%
Side swipe	____%	____________	%		
Fixed object	____%	____________	%		
Lost control	____%	____________	%		

EDPO Number ______%

Accident Rate ______%

EDPO Rate ______%

All Accidents ______%

SYSTEM EVALUATION WORKSHEET

Year_____ TOTAL NO. OF HIGH-ACCIDENT LOCATIONS CORRECTED_____

BENEFIT FOR_____ LOCATIONS:

1	Enter the average annual number of before injury or fatal accidents	_____
2	Enter the average annual number of after injury or fatal accidents	_____
3	Subtract Line 2 from Line 1 (the reduction in injury or fatal accidents)	_____
4	Enter the average annual number of before PDO accidents	_____
5	Enter the average annual number of after PDO accidents	_____
6	Subtract Line 5 from Line 4 (the reduction in PDO accidents)	_____
7	Add Line 6 to Line 3 (the total accident reduction)	_____
	WAS ACCIDENT REDUCTION SIGNIFICANT ACCORDING TO FIGURE 21?	Yes No
8	Enter the unit cost of injury and fatal accidents	_____
9	Multiply Line 3 by Line 8 (the benefit of reducing injury and fatal accidents)	_____
10	Enter the unit cost of PDO accidents	_____
11	Multiply Line 6 by Line 10 (the benefit of reducing PDO accidents)	_____
12	Add Line 10 to Line 13 (the total benefit)	_____

COST:

1	Enter the total annual cost of improvements	_____
2	Enter the annual cost to engineering department	_____
3	Enter the annual cost to police department	_____
4	Enter other costs	_____
5	Add Lines 1, 2, 3, and 4 (total costs)	_____

BENEFIT/COST RATIO:

1	Enter the total benefit	_____
2	Enter the total costs	_____
3	Divide Line 1 by Line 2 to get the benefit to cost ratio	_____

TRAFFIC ACCIDENT SUMMARY

DATE ____________

ANNUAL ☐
MONTHLY ☐

INTERSECTION - RELATED ACCIDENTS

MAJOR STREET INTERSECTIONS

	Right Angle	Rear End	Side-Swipe		Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
			Meeting	Passing							
MAJOR-MAJOR 2-Way Stop											
4-Way Stop											
Signal											
Officer											
MAJOR-MINOR From 2-Way Stop											
On Major St.											
On Minor St.											
Officer											
SUBTOTAL											

MINOR STREET INTERSECTIONS

	Right Angle	Rear End	Side-Swipe		Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
			Meeting	Passing							
No Control											
Yield Sign											
2-Way Stop											
4-Way Stop											
SUBTOTAL											
TOTAL INTERSECTION-RELATED ACCIDENTS											

MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking					Train	TOTAL
		Ped.	Pk. Car	Veh. @ Dr.	F.O.	Vehicle On St.		
Major St.								
Minor St.								
Alleys								

HIGH - ACCIDENT - LOCATION IDENTIFICATION WORKSHEET

INTERSECTION ☐ MID-BLOCK SECTION ☐

LOCATION	ACCIDENTS					2 and 3 Year Ave.	EPDO No.	ADT	Exposure	Accident Rate	EPDO Rate	Identified as a High-Accident Location
	Year	Fatal	Injury	PDO	Total							
TOTALS										Ave=	Ave=	
TOTALS										Ave=	Ave=	
TOTALS										Ave=	Ave=	
TOTALS										Ave=	Ave=	
TOTALS										Ave=	Ave=	
TOTALS										Ave=	Ave=	

EPDO Number = 6 (fatal + injury) + PDO

Intersections:

ADT = sum of one-way counts of all streets entering the intersection

Exposure = ADT x 365

$$\text{Accident Rate} = \frac{(\text{number of accidents})(\text{million})}{\text{exposure}}$$

$$\text{EPDO Rate} = \frac{(\text{EPDO number})(\text{million})}{\text{exposure}}$$

Mid-block sections:

ADT = average two-way count of the street

Exposure = (ADT) (section length) (365)

$$\text{Accident Rate} = \frac{(\text{number of accidents})(100\text{ million})}{\text{exposure}}$$

$$\text{EPDO Rate} = \frac{(\text{EPDO number})(100\text{ million})}{\text{exposure}}$$

ACCIDENT LOCATION - FILE LOG

LOCATION ____________________

DATE OF ACCIDENT	LOCATION	SEVERITY

Form #1

LOCATIONAL ANALYSIS WORKSHEET

DATE ____________

LOCATION ____

EXISTING TRAFFIC CONTROL ____

ACCIDENT ANALYSIS:

BLOCK A - NUMBER AND RATE SUMMARY

LOCATION	ACCIDENTS					2 and 3 Year Ave	EPDO	ADT	Exposure	Accident Rate	EPDO Rate
	Year	Fatal	Injury	PDO	Total						
TOTALS										Avg=	Avg=

BLOCK B - INTERSECTION-RELATED ACCIDENTS

	Right Angle	Rear End	Side-Swipe		Head On	Ped.	Fixed Object	Right Turn	Left Turn	Other	TOTAL
			Meeting	Passing							
No. of Accidents											
Percent of Total											100%

BLOCK C - MID BLOCK ACCIDENTS

	Non-Coll.	Vehicle Striking					Train	TOTAL
		Ped.	Pk. Car	Veh. @ Dr.	F.O.	Vehicle On St.		
No. of Accidents								
Percent of Total								100%

BLOCK D - CONDITIONS

No. of accidents

Time of day - 6:00 am - Noon ________ 6:00 pm - Midnight ________
Noon - 6:00 pm ________ Midnight - 6:00 am ________

Light conditions - Day ________ Night ________

Surface conditions - Dry ______ Wet ______ Snow or Ice ______

Weather - Cloudy ____ Clear ____ Rain ____ Snow ____ Other ____

Other - ____

____

LOCATIONAL ANALYSIS WORKSHEET

BLOCK E - ACCIDENT ANALYSIS SUMMARY

☐ Collision diagram attached

Identified Patterns of Accidents Predominate: ______________ Secondary: ______________

Probable causes and General Countermeasures: ______________________________

____

____

____

____

____

____

OPERATIONAL AND PHYSICAL DATA ANALYSIS

Supporting data attached:

☐ On-site observation report
☐ Condition diagram
☐ Speed study
☐ Turning movement count
☐ Conflict count
☐ Other ______________________________

General conclusions from supporting data: ______________________________

____

____

____

____

____

____

COUNTERMEASURE SELECTION:

Specific countermeasures:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

(for each countermeasure fill out a countermeasure analysis worksheet.)

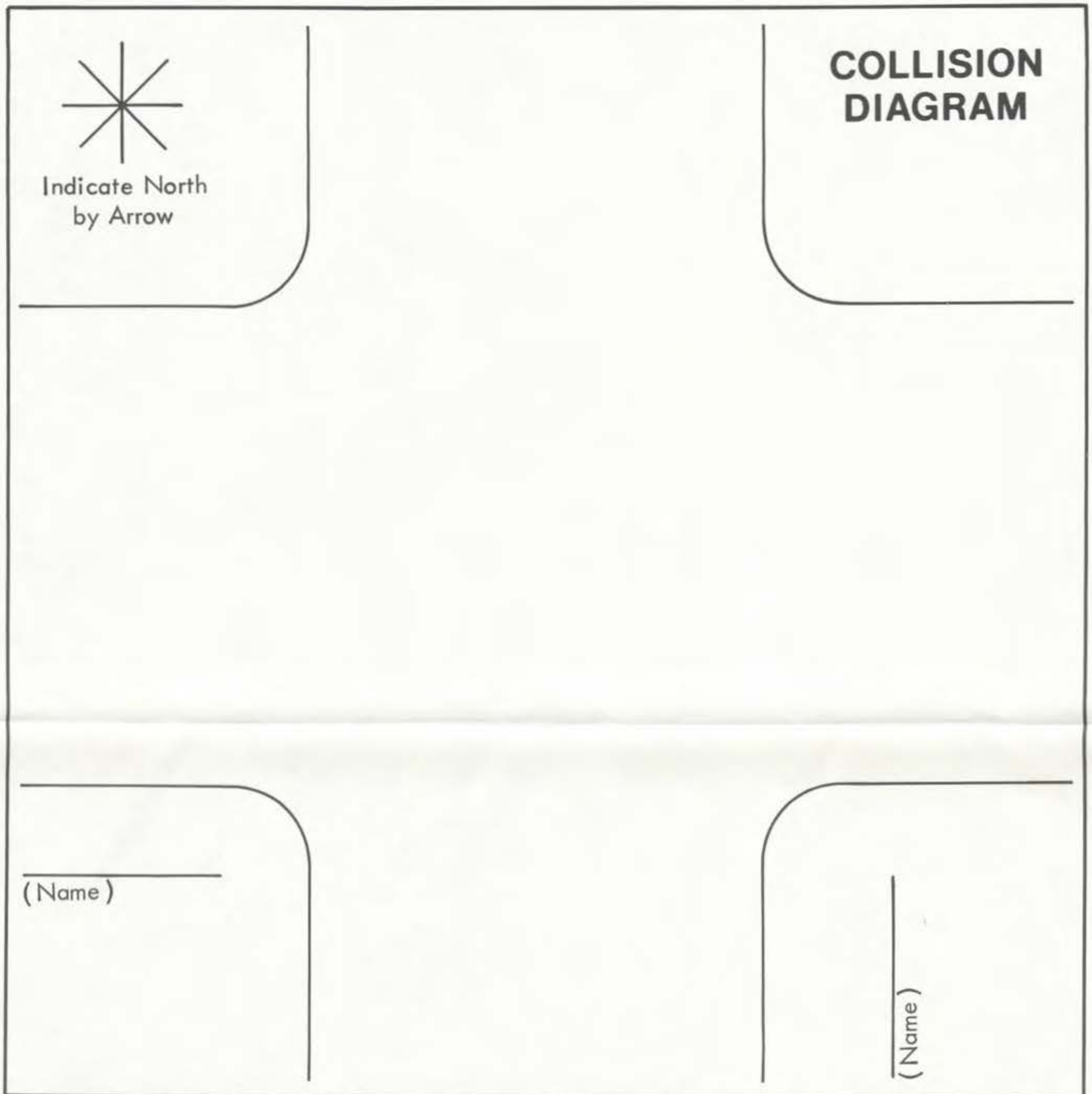
Best Countermeasure ______________________________

Average Annual Net Return ______________________________

Benefit/Cost Ratio ______________ Implementation Cost ______________

Priority ______________

COLLISION DIAGRAM



SYMBOLS	TYPES OF COLLISIONS	SHOW FOR EACH ACCIDENT
Moving Vehicle	Rear End	1. Day, Date and Time
Backing Vehicle	Head On	2. Weather and Road Surface - if Unusual Condition Existed
Non-Involved Vehicle	Side Swipe	3. Nite - if Between Dusk and Dawn
Pedestrian	Out of Control	
Parked Vehicle	Left Turn	
Fixed Object	Right Angle	
Fatal Accident		
Injury Accident		

INTERSECTION ______________________ and ______________________

PERIOD ______________: from ______________ to ______________

Form #1

ON-SITE OBSERVATION REPORT

LOCATION ______________________ CONTROL ______________________

DATE ______________________ TIME ______________________

OPERATIONAL CHECKLIST:

	No	Yes (See 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 (See 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?	___	___

Form #2

ON-SITE OBSERVATION REPORT

	No	Yes (See Comments)
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:

Operational--"O" and Item Number
Physical--"P" and Item Number

Form #1

COUNTERMEASURE ANALYSIS WORKSHEET

COUNTERMEASURE NO.________ ESTIMATED SERVICE LIFE ______YEARS
COUNTERMEASURE DESCRIPTION ______________________________
CURRENT 19__ ADT __________ ESTIMATED 19__ ADT ____________

Constant
Increasing by ______% annually
Increasing by ______VPD annually

ESTIMATED ANNUAL ACCIDENT REDUCTION:

	Estimated % Reduction ÷100	×	Accidents of this Type	=	Estimated Accident Reduction
Accident Type ________	______	×	PDO ______ F&I ______	=	PDO ______ F&I ______
Accident Type ________	______	×	PDO ______ F&I ______	=	PDO ______ F&I ______
Accident Type ________	______	×	PDO ______ F&I ______	=	PDO ______ F&I ______
Accident Type ________	______	×	PDO ______ F&I ______	=	PDO ______ F&I ______
			Total Reduction		PDO ______ F&I ______

AVERAGE ANNUAL BENEFITS:

1. Enter the estimated reduction of PDO Accidents ________
2. Enter the average cost of a PDO Accident ________
3. Multiply Line 1 by Line 2 (average annual benefit of reducing PDO Accidents) ________
4. Enter the estimated reduction of fatal and injury accidents ________
5. Enter the average cost of a fatal or injury accident ________
6. Multiply Line 4 by Line 5 (average annual benefit of reducing fatal and injury accidents) ________
7. Add Line 6 to Line 3 (average annual benefit from reducing accidents) ________

COMPLETE LINES 8 THROUGH 13 IF ADT WILL INCREASE DURING SERVICE LIFE OF IMPROVEMENT--IF NOT GO TO LINE 14

8. Enter the expected ADT at the end of the service life ________
9. Enter the present ADT ________
10. Add Line 9 to Line 8 ________
11. Divide Line 10 by 2 (average ADT during service life) ________
12. Divide Line 11 by Line 9 (ADT growth factor) ________
13. Multiply Line 7 by Line 12 (average annual benefits from reaucing accidents--ADT increasing) ________
14. Enter secondary annual benefits from improvement (if known) ________
15. If ADT is constant add Line 14 to Line 7 } Average Annual
    If ADT is increasing add Line 14 to Line 13 } Benefits ________

Form #2

COUNTERMEASURE ANALYSIS WORKSHEET

AVERAGE ANNUALIZED COST*:

1. Enter the initial cost of improvement ____________
2. Enter the capital recovery factor for service life of the improvement (see Interest Factors Table in Appendix G) ____________
3. Multiply Line 1 by Line 2 ____________
4. Enter the terminal value of improvement ____________
5. Enter the sinking fund factor at the service life of the improvement (see Interest Factors Table in Appendix G) ____________
6. Multiply Line 4 by Line 5 ____________
7. Enter the constant annual cost ____________
8. Subtract Line 6 from Line 3, then add Line 7 (Average Annualized Costs) ____________

AVERAGE ANNUAL NET RETURN:

1. Enter the Average Annual Benefits ____________
2. Enter the Average Annualized Costs ____________
3. Subtract Line 2 from Line 1 (Average Annual Net Return) ____________

BENEFIT/COST RATIO:

1. Enter the Average Annual Benefits ____________
2. Enter the Average Annualized Costs ____________
3. Divide Line 1 by Line 2 (Benefit/Cost Ratio) ____________

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* Based on 5% interest, annual cost uniform throughout service life.