Report No. FHWA-TO-80-2

PLANNING AND FIELD DATA COLLECTION

December 1982

VOLUME III IN A SERIES ON POSITIVE GUIDANCE

POSITIVE GUIDANCE

U.S. Department of Transportation
Federal Highway Administration
Office of Traffic Operations

NOTICE

Technical Report Documentation Page

1. Report No. FHWA-TO-80-2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Planning and Field Data Collection		5. Report Date December 1982
		6. Performing Organization Code
7. Author(s) Robert S. Hostetter and Harold Lunenfeld		8. Performing Organization Report No.
9. Performing Organization Name and Address Institute for Research, 257 South Pugh Street, State College, PA 16801		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U. S. Department of Transportation, Federal Highway Administration, HTO-31, Office of Traffic Operations, Washington, D.C. 20590		13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code
15. Supplementary Notes FHWA Contract Manager - Harold Lunenfeld (HTO-31)		

16. Abstract

Planning and Field Data Collection is the third volume in the Positive Guidance Series. Its purpose is to augment and supplement Volume I (2nd Edition of the Users' Guide to Positive Guidance) and Volume II - Evaluation. This Volume consists of two parts. Part 1 provides a detailed description of the Planning and Field Data Collection Phase of a Positive Guidance project. It describes the various activities needed to develop a data base for the Engineering and Human Factors procedure. Part 2 presents information on measurement techniques, procedures, and equipment for collecting performance data in the field. Guidelines are provided for traffic volume and counts; speed; erratic maneuvers; traffic conflicts; intersection delay; and travel time.

17. Key Words Planning, Field Data Collection, Positive Guidance, Historic Data Review, Site Survey and Operations Review, Erratic Maneuvers, Traffic Conflicts, Traffic Volume, Speed, Delay, Travel Time.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 226	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SERIES FORWORD

The volumes that comprise this series on Positive Guidance define a procedural approach to improving operations and safety at hazardous highway locations. The procedure incorporates and integrates the applied sciences of traffic engineering and engineering psychology.

The Positive Guidance concept was developed in 1973 when, as a result of two narrow bridge accidents in Texas and New Mexico, congressional hearings were conducted on the solution to the narrow bridge problem. It became apparent that because of the great cost, achieving safety at hazardous locations strictly through reconstruction is an undesirable and probably unattainable goal. Then Federal Highway Administrator, Norbert T. Tiemann, recommended that if we could not physically protect motorists at all hazardous locations, "we must given them enough information so that they can protect themselves." The development of that information system concept is what Positive Guidance is all about.

The booklet "Positive Guidance in Traffic Control," published in 1975, was basically a philosophic treatise on the principles involved in the concept and the rudiments of a systematic procedure for application. From the beginning of the project development cycle, it was planned to develop a handbook or users' guide and to conduct training of State employees in the use of the procedure.

In 1977, the **Users' Guide to Positive Guidance** was published and training was begun. Feedback and suggestions on improving the concept and the process were noted. Through the interest of the Senate Appropriations Committee, demonstration projects were funded. Engineers assigned to these projects at the State level began using the process, and more feedback and suggestions were recorded. Discussions of project planning, data collection, and project evaluation needed to be strengthened considerably. There was also too much redundancy in the human factors portion of the process, and the process itself needed to be streamlined. A second edition seemed appropriate. Volumes I, II, and III of this series comprise the Second Edition.

Publication of this series on Positive Guidance is the culmination of a 9-year program of concept and procedure development, training, and demonstration. We belive the program has produced a significant step forward in the development of engineering tools designed to improve traffic operations and safety at hazardous locations.

R. A. Barnhart
Federal Highway Administrator

SERIES PREFACE

Positive Guidance is an engineering tool to enhance the safety and operational efficiency of hazardous locations. The underlying concept joins the highway engineering and human factors technologies to produce an information system matched to the characteristics of the location and the attributes of drivers. Positive Guidance is designed to provide high-payoff, short-range solutions to safety and operational problems at relatively low cost. It is based on the premise that a driver can be given sufficient information to avoid accidents at hazardous locations.

The Positive Guidance approach is a systematic process consisting of three interrelated phases: Planning and Field Data Collection; The Engineering and Human Factors Procedure; and Evaluation. The Planning and Field Data Collection phase generates a data base for use in developing Positive Guidance improvements. The Engineering and Human Factors Procedure generates the improvements. Finally, the Evaluation phase assesses the effectiveness of the improvements.

Each phase of the process is documented in a separate volume. Volume I consists of two parts. Part 1 describes the concept and gives an overview of the entire Positive Guidance process. Part 2 describes in detail the heart of the process, the Engineering and Human Factors Procedure. Volumes II and III describe the supportive phases of the process--Volume II - Evaluation and Volume III - Planning and Field Data Collection. Published under separate cover and not a part of this series are the results of the various demonstration projects.

The documentation contained in this series should be useful to engineers and technicians responsible for improving operations and safety, researchers interested in the interaction between highway engineering and human factors, and educators involved in teaching highway engineering, safety and human factors.

Gerson J. Alexander
Chief, Traffic Performance Branch

TABLE OF CONTENTS

PART 2. GUIDELINES FOR PERFORMANCE DATA COLLECTION IN THE FIELD

EXECUTIVE SUMMARY

This volume is divided into two parts. The first part presents a detailed description of the Planning and Field Data Collection phase of a Positive Guidance project. Part 2 contains guidelines for collecting performance data in the field.

The Planning and Field Data Collection phase is structured to provide a data base for the application of the Engineering and Human Factors Procedure. See Volume I* for a detailed description of that phase. The extent to which each of the following activities is required depends on the nature of the problem, the complexity of the location, and the availability and quality of existing data.

- <u>Historical Data Review</u> -- The Planning and Field Data Collection phase begins with a review of existing data. The purposes of this review are to: (1) Verify the location's problem status; (2) provide insights into its characteristics; (3) indicate what observations are necessary during the Site Survey and Operations Review, and; (4) determine the data to be collected during the data collection activities. Primary data sources include engineering information, accidents, traffic operations studies, complaints, supplemental information, and photologs. The output of the Historical Data Review provides a file for use throughout the project.

- <u>Site Survey and Operations Review</u> -- The Site Survey and the Operations Review are the first data collection activities at the site. A drive-through Site Survey is conducted to experience the problems an unfamiliar motorist might encounter and to perform an expectancy violations review. The Operations Review provides the means to observe how drivers maneuver through the site. If a photolog of the site does not exist, a film, video tape, or a set of 35 mm slides of at least one drive-through of the site should be taken.

---

*Report FHWA-TO-81-1. <u>A Users' Guide to Positive Guidance</u> (2nd Edition) December 1981.

- Data Collection Plan -- Data collection requirements vary from project to project. All projects require a Site Survey and Operations Review. Additional performance data may be needed for diagnostic purposes, depending on data gaps identified by the Historical Data Review. Effectiveness data will also be required when an evaluation is performed. A Data Collection Plan should be generated prior to going into the field. The following elements are included in a typical Data Collection Plan: selection of candidate measures; operational definitions; selection of equipment and procedures; and data collection requirements (sampling, observer and equipment locations, data collection forms, and condition limits).

- Field Verification -- Data collection efforts vary with the nature of the site, the magnitude of the problems, the kinds and quantity of data, whether or not an evaluation is being conducted, and environmental and traffic characteristics. Thus, both the plan and the field efforts are tailored for each project. Factors to consider prior to collecting field data include equipment calibration, pilot testing, and assuring the data quality and the unobtrusiveness of the data collection team. Part 2 describes factors to consider when collecting field data.

- Site File -- This activity collates the information from the Historical Data Review and Field Data Collection activities. A convenient method for ordering the information is to establish a Site File. The information in the file describes the problem location in terms of its physical, environmental, and operational characteristics.

In Part 2, information is presented on measurement techniques, procedures, and equipment for collecting performance data in the field. Guidelines are provided for collecting and reducing the following types of data:

- Erratic Maneuvers
- Traffic Conflicts
- Speed
- Traffic Volume/Counts
- Intersection Delay
- Traveltime and Delay

PART 1

THE PLANNING AND FIELD DATA COLLECTION PHASE

INTRODUCTION

Scope

The Positive Guidance Process consists of three phases, Planning and Field Data Collection; The Engineering and Human Factors Procedure; and Evaluation. Planning and Field Data Collection, documented in this volume (Volume III--Report FHWA-TO-80-2), is designed to develop a data base for the application of the Engineering and Human Factors Procedure (documented in Volume I--Report FHWA-TO-81-1) and to provide "Before" data for The Evaluation (documented in Volume II--Report FHWA-TO-80-1). The purpose of Volume III is to serve as a supplement to Volumes I and II.

Part 1 of this volume is designed as a general guide for the conduct of planning activities leading to the development of a traffic-related field data collection plan. Figure 1-1 shows the relationship of the Planning and Field Data Collection phase to the Positive Guidance Process.

The phase begins with the diagnosis of problems at a site (Historical Data Review and Site Survey and Operations Review). It proceeds through the development of a Data Collection Plan including Pre-Data Collection activities. It ends with the collection of traffic and system performance data for the purpose of problem verification, improvement development, and improvement evaluation; and with the structuring of a Site File for use throughout the project.

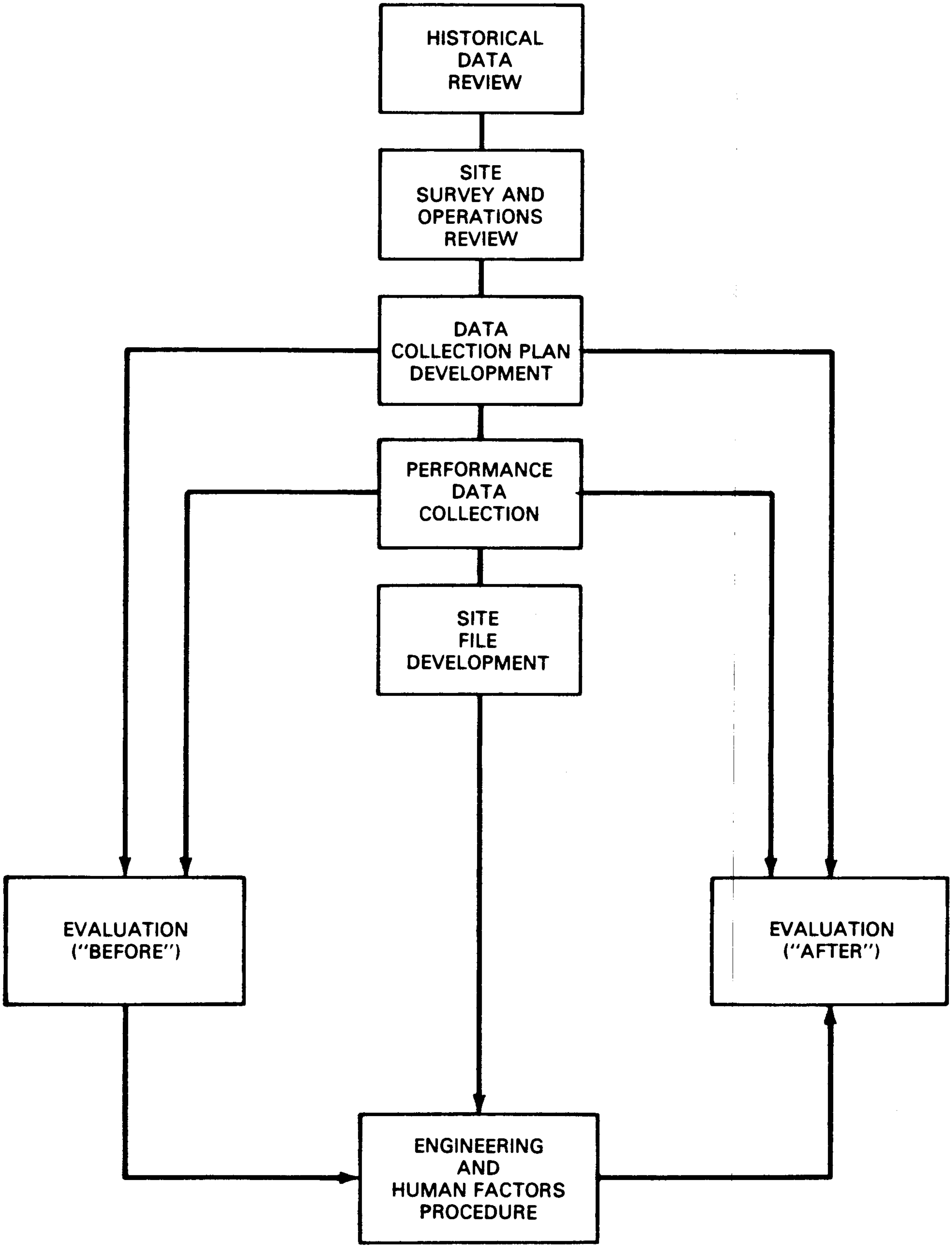


Figure 1-1. The Planning and Field Data Collection Phase in Relation to the Positive Guidance Process

Approach

The Positive Guidance approach to problem diagnosis and improvement evaluation emphasizes the use of a range of measures including accident records and system and traffic performance measures of effectiveness (MOE's). The rationale underlying this emphasis is that improvements in driver and traffic performance yield increased traffic operational efficiency and attendant decreases in accident frequency and severity.

Accident Histories

Accident histories are an important source of data for Positive Guidance. However, accident histories are not the sole input to problem diagnosis and improvement evaluation because: the reported number of any particular type of accident is often not large enough for adequate analysis; accident records may be incomplete; accident causes and locations may be difficult to pinpoint; and accident histories require a long time frame. Further, the absence of a large number of accidents often typifies low volume sites, even when there are known operational problems and/or a high accident potential.

System Performance

Traditional traffic engineering system performance measures such as throughput, travel time, delay, etc., have applicability, particularly in high-volume situations. These measures may also have limitations on their usefulness since they often lack sensitivity to changes in the information system. However, modifications at, for example, interchanges can be expected to be reflected in system performance measures such as throughput.

Traffic Performance

Because of the need for sensitive, reliable, and valid measures with which to diagnose problems and evaluate improvements on many types of problem sites, traffic performance measures of effectiveness (MOE's) are also used in Positive Guidance Projects. Traffic performance MOE's, including "near accidents" (surrogates), are among the most useful. Spot speed, lateral placement, headway, acceleration and deceleration profiles are widely employed. They are reliable, valid, and possess the sensitivity to reflect changes; even relatively minor ones. Accident surrogate measures, while not as common, are also useful. They are subdivided into erratic maneuvers (single vehicle involvement) and traffic conflicts (multiple vehicle involvement).

Summary

In summary, measures involving system and traffic performance MOE's including "near accidents" are stressed in the application of the Positive Guidance Procedure and in this volume. Part 1 focuses on the use of accident and other historical data to aid in the development of a plan to collect performance data. Part 2 discusses factors associated with collecting these MOE's in the field.

HISTORICAL DATA REVIEW

Overview

The Planning and Field Data Collection phase* begins with a review of all existing data pertaining to the site. Historical data are used to plan data collection; to provide insights into problem identification; and to verify the existence of known problems. In performing the Historical Data Review, project personnel should assemble pertinent historical data for analysis and review at the beginning of the project. These data will be used throughout the project and form the initial data input for the Site File.

Three classes of historical data are usually available: (1) Engineering data, including construction plans and specifications, signing plans, photologs, etc.; (2) problem data, including accident reports, accident studies, user complaints, etc.; and, (3) traffic operations data, including speed studies, traffic volume, vehicle mix, etc. The availability and quality of historical data often dictates the effort required during the field data collection activities. That is, where historical data are adequate for precise definitions of the problems at the site, the performance data collection effort need only include measures used for improvement evaluation. However, where historical data are inadequate, the "Before" data collection effort must include both diagnostic and evaluative measures.

---

*Although this volume is structured for Positive Guidance projects, the material is applicable for all projects involving spot and short segment improvements. Users should tailor the review activities to the needs of their specific project.

A primary goal of the Historical Data Review is to develop a suitable data collection plan designed to minimize actual field time and to ensure an efficient approach to data collection, i.e., the use of appropriate measures, measurement procedures, and schedules. Further, information from the review will aid in identifying what observations should be made during the Site Survey and Operations Review.

The Historical Review should generate the following outputs:

- Geometric Information
- Traffic Control Device Inventory
- Site/Condition Diagram
- Collision Diagrams or Plots
- Accident Summaries and Rates
- User Complaint Summaries
- Traffic Data Summaries
- List of "Things to Look For and At"

Engineering Data Review

Geometric Information

Important data sources to assemble and/or develop include construction plans, topographic maps, transportation planning maps, design specifications, and aerial photographs. They will provide necessary geometric information such as grades, degrees of curvature, lane-width, etc. In the planning stage, geometric data are useful as an aid in interpreting accident data, and in identifying potential problem sections which should be given attention during pre-data collection site visits. Geometric information is also useful in identifying MOE's and, at later stages in the project, interpreting driver/traffic performance data.

Traffic Control Device Inventory

Another necessary engineering data source is the location's signing/marking plan, including signal location and timing. This information, along with geometric data, will help to make an assessment of potential driver information problems. Particular attention should be given to identifying what changes, if any, have been made to the traffic control devices at the site. Since field changes are sometimes made but are not documented on the signing/marking plan, the inventory should always be checked during the site survey. Further, the dates of such modifications should be considered when accident data are analyzed, otherwise the data may be misinterpreted, thereby leading to erroneous problem diagnosis and irrelevant field data collection.

Site Diagram/Condition Diagram

In the Positive Guidance Procedure, an accurate plan view of the site (site diagram) is used to develop a Condition Diagram. Figure 1-2 shows a typical Condition Diagram. It is constructed by plotting traffic control devices and geometric features, and may include other important aspects of the site such as roadside hazards, guardrails, trees, culverts, etc., on the diagram. The Condition Diagram is used in the planning phase (e.g., to show accident locations) and throughout the Engineering and Human Factors Procedure (e.g., hazard profile development, information handling zone location, trace analysis plotting, expectancy identification, etc.).

The Site Diagram is used to show locations of observers and/or data collection equipment (see Figure 1-3), and to show where "Before" measures are made. This assures the data collection set-up can be duplicated in the "After" phase of an evaluation. Both Site and Condition Diagrams should be to scale, and should encompass areas upstream and downstream of the specific problem location.

Photologs

Photologs provide a "drivers-eye" view of the location and can be used to note the location of traffic control devices and identify or verify potential problem sections and hazards determined from other engineering data sources. They enable project personnel to "view" the site at their leisure and often serve as a site familiarization tool.

Problem Data Review

Accident Data

Accident data are among the most important aids to problem diagnosis in that they indicate a failure related to the driver, roadway, and/or environment. Since accidents are indicators of problems, accident data should be reviewed carefully and completely to identify characteristics and trends that could lead to an identification of the source of the problem. Accident data can also provide useful inputs to the planning of field data collection activities.

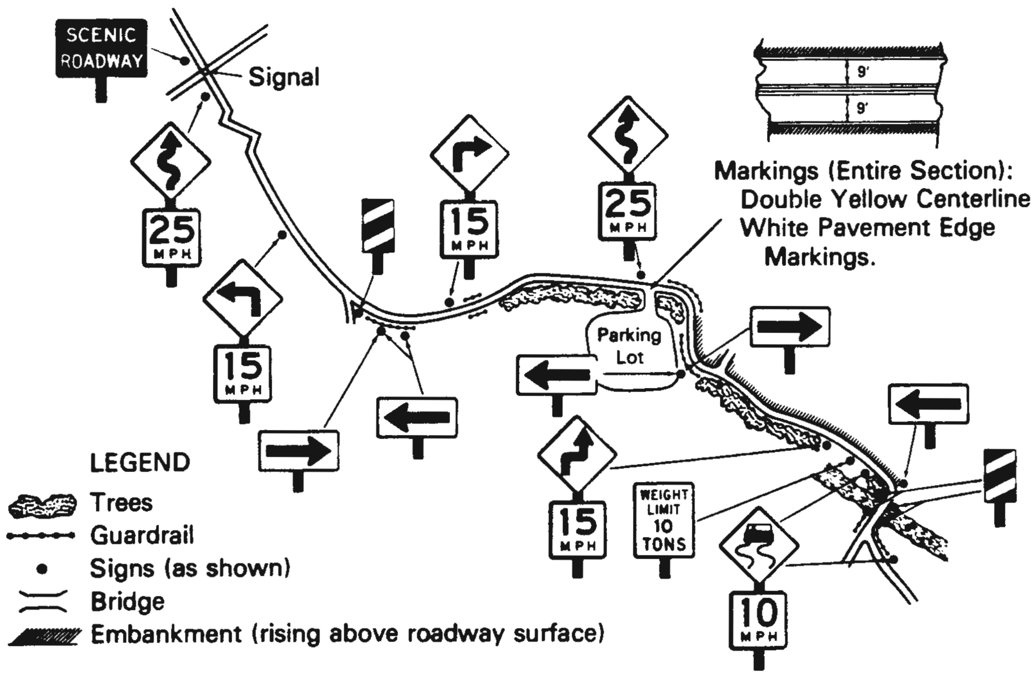


Figure 1-2.
Condition Diagram

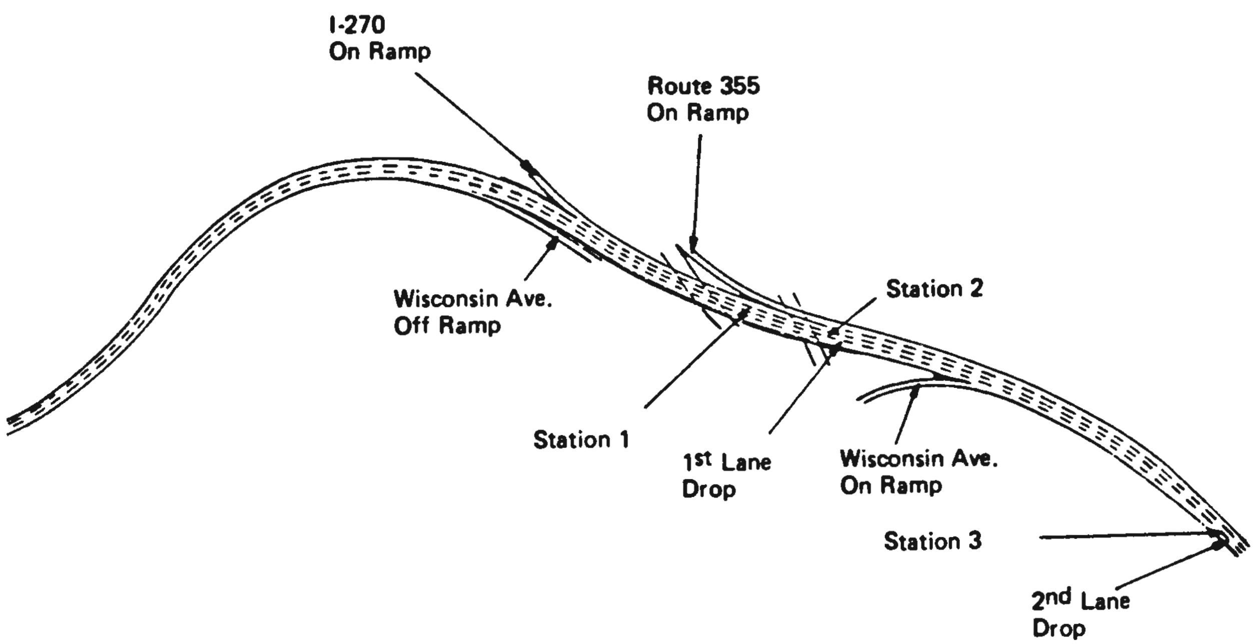


Figure 1-3.
Observation and Data Collection Stations
(plotted on a Site Diagram)

Most jurisdictions maintain or have access to an accident record system and can obtain individual reports and get or develop accident data summaries in a variety of forms. The most detailed information is the individual accident report, which typically provides a narrative describing the accident and information as to contributing conditions. Individual reports should be located, pulled, and collated for use in the problem review activity.

Accident summaries generally provide short descriptions (in standard terms) of the characteristics of the accidents that comprise the accident history of a site. Collision diagrams are normally prepared for intersection or spot locations, and strip diagrams show a section or the complete length of a street or road. Accidents can be plotted on the condition diagram using symbols and notations to indicate the location, type, and salient characteristics of the accident. These collision diagrams usually cover a period of time of one to three years and are accompanied by a summary of accident statistics. Figure 1-4 shows a collision diagram, and Figure 1-5 presents a summary of accidents at the same location in tabular form.

For locations with relatively few accidents, accident summaries may have too few cases to be useful and the individual reports will be the only useful accident data. For sites with a substantial accident history, various forms of accident summaries often represent the most appropriate input for both problem diagnosis and data collection planning.

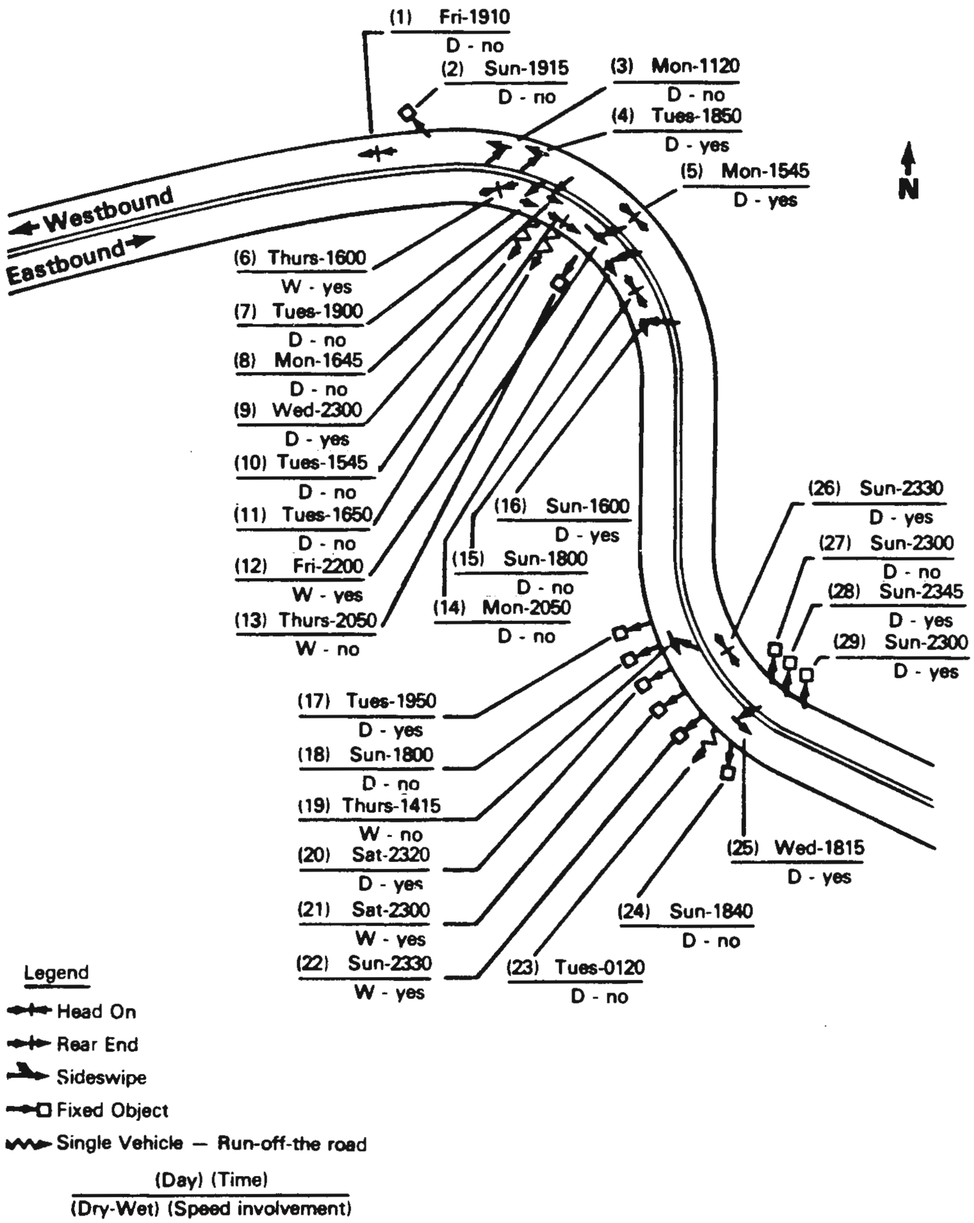


Figure 1-4.
Collision Diagram

ACCIDENT SUMMARY		
PROJECT: *Rural Site*		
PROJECT NO.: *193*		
PREPARED BY: *T.P.*		DATE *6/81*
DATA SOURCE: *Records*	AADT	Exposure Veh.___ or Veh. Mi. ✓
TIME PERIOD: *1973* TO *1976*	*10,135*	*10.77 x 10⁶*

Circumstance	Head-On	Side-swipe	Fixed Object	Rear End	Single Vehicle	Total
Total Accidents	4	9	11	2	3	29
Direction						
Eastbound	2	7	7	1	3	20
Westbound	2	2	4	1	0	9
Severity						
Fatal (#K)	0	0	0	0	0	0
Injury (# Inj.)	1(3)	3(3)	4(6)	0	1(2)	9(14)
Prop. Damage Only	3	6	7	2	2	20
Speed						
Safe	1	5	6	2	2	16
Too Fast	3	4	5	0	1	13
Vehicle Type						
Passenger Car	3	7	10	2	3	25
Truck	0	1	0	0	0	1
Motorcycle	1	1	1	0	0	3
Other						
Road Surface						
Dry	3	7	8	2	3	23
Wet	1	2	3	0	0	6
Icy-Snow						
Other						
Light Conditions						
Daylight	3	9	4	1	1	18
Darkness	1	0	7	1	2	11
Season						
Spring	1	4	3	0	0	8
Summer	3	1	3	1	2	10
Fall	0	3	1	1	1	6
Winter	0	1	4	0	0	5

(Accident Category spans Head-On through Total.)

Figure 1-5.
Accident Summary

Page 2 of 2

ACCIDENT SUMMARY

DAY AND TIME

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
A.M.								
12:01– 1:00								
1:01– 2:00		1						1
2:01– 3:00								
3:01– 4:00								
4:01– 5:00								
5:01– 6:00								
6:01– 7:00								
7:01– 8:00								
8:01– 9:00								
9:01–10:00								
10:01–11:00								
11:01–12:00	1							1
P.M.								
12:01– 1:00	1							1
1:01– 2:00								
2:01– 3:00				1				1
3:01– 4:00	1	1		1				3
4:01– 5:00	1	1					1	3
5:01– 6:00						1	1	2
6:01– 7:00		2	1				1	4
7:01– 8:00		1			1		1	3
8:01– 9:00				1				1
9:01–10:00						1		1
10:01–11:00			1			1	2	4
11:01–12:00						1	3	4
TOTAL	4	6	2	3	1	4	9	29

Figure 1-5. (Cont.)

Regardless of the initial form of the accident data (i.e., raw or summarized), ideally an analysis should be performed on at least 3 years worth of data. The following items should be summarized:

- Specific location
- Accident type
- Involved vehicles
- Severity
- Environmental conditions
- Time of day/day of week/month
- Vehicle (pedestrian) actions
- Contributory conditions
- Direction of travel

If the accident data are not plotted and summarized for the problem location, a collision diagram should be plotted on the Site Diagram or in the form shown in Figure 1-6 (which may be more convenient if the accident frequency is high).

While accident-related information provides insights into the nature and extent of problems which exist, it also provides valuable inputs for the Data Collection Plan. It provides suggestions as to where measures and observations should be made, what types to make, and when to make them. These inputs should be verified and finalized during on-site pre-data collection observations.

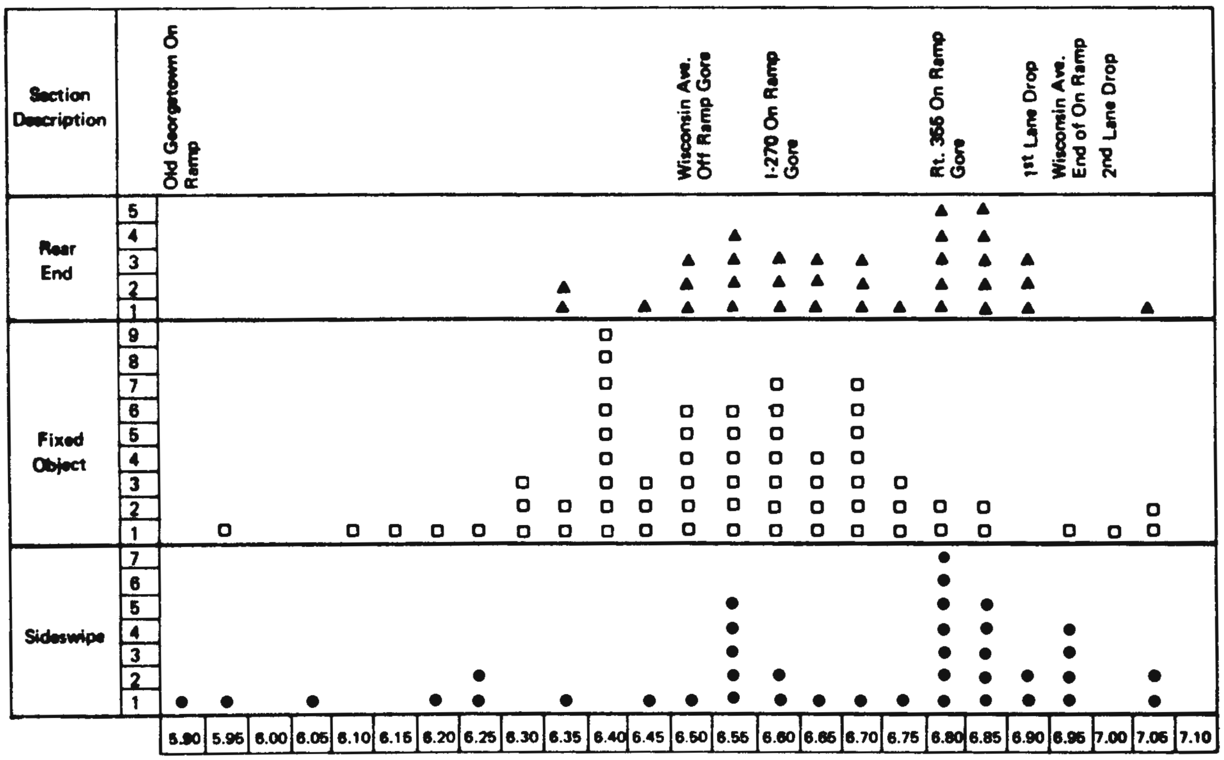


Figure 1-6.
Plot of Accidents by Type and Approximate Point of Impact

Given a reliable set of accident data, accident summaries provide the following type of inputs to the plan:

- Rates - Used for statistical analysis in evaluations.

- Location - The location of accident clusters will identify the section(s) where driver problems are most likely to occur and where data should be collected. However, it should be noted that erratic maneuvers or traffic conflicts related to a specific accident type are likely to occur upstream of the location of the accident cluster. The accident location will also provide some input as to the number of observers which may be required, and/or the types of equipment which may be needed to provide adequate coverage.

- Type(s) - The types of accidents will provide suggestions as to the types of erratic maneuvers or traffic conflicts which should be included in the data collection plan. For example, clusters of rear-end accidents suggest that braking (or brake light application), sudden stops, swerves, etc., should be considered as candidate erratic maneuver measures and that rear-end traffic conflict data should be collected. A cluster of sideswipe accidents suggest that "late" lane changes should be considered as a candidate measure. In short, for accident clusters of a certain type, one asks the question: What are the driver behaviors/vehicle maneuvers which are the most likely precursors to this type of accident?

- Severity - Accident severity alone provides little information for planning purposes. However, when considered in conjunction with "Accident Type," it can frequently help to identify the speed component of the accidents and thereby provide some insight as to the utility of speed as a measure.

- Time of Day/Day of Week/Month - This type of accident summary can provide several types of diagnostic and planning information. First it can provide insights as to the subgroup of the driver population which is having problems. For example, if a substantial proportion of the accidents occur during "rush hours" on week days, the problem may simply be related to capacity and may not be attributable to an "informational" cause. If, on the other hand, problems occur more frequently off-peak or when the tourist population makes up a substantial proportion of the traffic stream, then the problem is more likely to involve the information system. Inputs such as this not only help to identify the nature of the problem, but also suggest when the Site Survey should be conducted to maximize the probability of observing the types of problems that drivers are experiencing. The time-of-day summary also identifies night driving problems. When night problems are identified, this suggests an assessment of illumination, sign reflectivity, delineation and marking, etc. This type of accident summary also helps to identify the most useful time sampling periods for data collection. While it is sometimes desirable to sample throughout a given day or week, this is not always necessary, and to the extent that cost is a major consideration, the most representative time periods and days of the week can be chosen from the time-based accident summary.

Accident summaries can be of substantial benefit in problem identification and in specifying the "what, where, and when" for the Site Survey, Operations Review, and Field Data Collection. It should be kept in mind that recent changes (less than 5 years) in the site must be considered when assessing accident data. For example, changes in geometrics via reconstruction, introduction of signals, changes in signal timing, and other changes in the information system (including marking and delineation) should be included. The existence of such changes requires that accident summaries be constructed to reflect periods before and after the change. Not only will this provide a more accurate picture of the current situation, but the before/after change comparisons may further aid in problem identification and improvement development.

User Complaint Files

Complaints can be an excellent source of information for problem diagnosis and data collection plan development because they usually represent a driver viewpoint of the problem. While the availability of only a few complaints may not be particularly useful, a consistent pattern of complaints deserves consideration during the Site Survey, and may suggest candidate measures.

If a formal complaint file does not exist but complaint data have been received, such a file should be established. The file should be organized by location. The following are typical of the complaints which indicate information system problems.

- Driver was placed in a hazardous position because he/she did not see a warning or regulatory sign.
- Drivers complain that they are confused about path and roadway boundaries.
- Complaints from parents that cars are not stopping at school crossings.
- Driver complaints about a blind curve or a series of curves.
- Drivers report they have taken an incorrect action because of confusion over signs, signals or markings.
- Drivers indicate they are unable to follow routes or get to their destination.

Traffic Operations Data Review

Traffic Data

All available traffic data should be assembled and analyzed in order to help determine what additional information should be collected to provide the best characterization of traffic operations at the site. Operational data that may be useful in planning and diagnosis are primarily volume, speed, and traffic compostion (vehicle mix) and outputs derived from these, e.g. gap availability, headway, etc. Operational data derived from capacity analysis, input-output analysis, origin-destination studies, travel time, etc., can also be useful. A discussion of these types of data, including their definition and use is covered in detail in the Transportation and Traffic Engineering Handbook.*

*Baerwald, J. E. (Ed.), Transportation and Traffic Engineering Handbook, ITE, Arlington, Va: 1976.

Device Blockage Due to Large Vehicles

A problem that should be identified during the Historical Data Review is the potential for visual blockage of traffic control devices due to large vehicles. The increasing use of vans, campers, and pick-up trucks with caps, in addition to the normal truck traffic, has increased the probability that the visual field of an automobile driver may be blocked by larger vehicles. This blockage problem has implication for the location and number of traffic control devices. If the data on traffic mix indicates a high percentage of "large" vehicles, the problem of blockage should be flagged for verification during the Site Survey.

Supplemental Data

In addition to routine traffic data that may exist for a problem location, special studies (e.g. TOPICS, Area Transportation Studies, corridor reviews, O-D studies, etc.), may have been conducted, thus providing data that could shed additional light on the problem. Other sources of information include highway maintenance and operations personnel, the police, and persons who live or work near the problem location. Talks with these groups and/or interviews with drivers and pedestrians could serve to develop new information or verify information from the Accident and Traffic Data Reviews.

Review Output

At this stage in the Planning Phase, a data file (Site File) should be established. The user should also develop a list of "Things to Look For and At" (see Table 1-1) during the subsequent Site Survey and Operations Review.

Table 1-1.
Types of Things to Look For and At

- Specific locations where accidents occurred
- Location of traffic control devices, signal timing, etc.
- Hazards
- Roadway alignment (vertical and horizontal curvature)
- Sight distance restrictions and device blockage
- Sources of driver confusion
- Vehicle speed (subjective)
- Vehicle actions (sudden stops, late lane changes, centerline crossings, etc.)
- Pavement condition
- Environmental factors (weather, time of day, level of illumination, etc.)

Summary

In summary, the overall objective of reviewing historical data is to use the information to describe the site and its attendant problems so that the appropriate improvements can be developed and evaluated. Where the historical data are insufficient to diagnose the nature and/or extent of the problem, operational performance data needs must be identified. Further, measures of effectiveness must be identified to evaluate the effectiveness of any improvement. This information inputs directly into the Field Data Collection Plan.

DATA COLLECTION PLAN CONSIDERATIONS

Overview

Because of the diversity in project size, site details, and agency resources, the following activities should be tailored for each specific project. Many of the activities may be combined or omitted as the situation warrants, and the sequence of events leading to the collection of data may vary from project-to-project. However, for completeness, a "full blown" data collection plan development is presented.

Site Familiarization

Following the review of historical data, it is often useful to visit the site before proceeding further with the planning activities. In cases where the historical data is relatively recent, and where staff members are familiar with the site, this step may be unnecessary, and the first site visit could be deferred until the Site Survey and Operations Review. Also, where the project is relatively simple and/or where the site visit entails substantial time and cost due to its location, this visit can be deferred, particularly if a suitable photolog exists. Site familiarization is thus a desirable step in the planning process. While the Site Survey and Operations Review is structured and designed to obtain the detailed information necessary to finalize the data collection plan, the purpose of site familiarization is to obtain a current overview of the site's physical and operational characteristics.

The Site Familiarization Visit should be used to update and/or fill in gaps in the historical data. Factors such as changes in, and the current condition of, the information system and changes in geometrics should be checked, and a "feel" for current operations should be obtained. This visit can also be used to identify potential problems with respect to the location of observers and/or equipment. For example, if there are no overpasses or high terrain vantage points within the site, certain types of film data and/or certain direct observational measures will be impractical, and can be deleted from consideration in developing the Data Collection Plan.

Data Collection Plan Elements

After the Site Familiarization Visit and prior to the Site Survey and Operations Review, it is useful to assess the information generated to date, and to begin to consider certain key elements of the Data Collection Plan. An initial review at this stage will save time and effort when the plan is developed and implemented.

Since all the Positive Guidance data collection procedures are not necessarily applicable to every project, the intent of this volume is to present a general discussion of key Data Collection Plan elements applicable both to the improvement development phase of all projects and to evalutions.

Identification of Candidate Measures

The term "candidate" is used because the initial product of this activity is an identification of potential measures in the form of a "shopping list." This listing of measures is then reviewed from the standpoint of available equipment and personnel, and some measures are rejected on the basis of a lack of resources. The remaining candidates will be evaluated during the Site Survey when the final choice of measures is made and the Data Collection Plan finalized.

Candidate measures, including Measures of Effectiveness used in an evaluation, are identified in a number of ways. The Review of Historical Data should not only aid in the diagnosis of problems, it should also result in the identification of some of the diagnostic measures required to verify the specific nature of the site's problems.

MOE's must be: (1) Directly related to the project's objectives, i.e., valid; (2) stable and repeatable, i.e., reliable; (3) amenable to data collection--given a particular equipment/personnel situation, i.e., feasible; and (4) of value in diagnosing a problem, i.e., meaningful. Validity, reliability, feasibility, and meaningfulness are the primary MOE selection criteria.

Table 1-2 presents a number of validated measures for typical highway situations. In addition, MOE's have been used to evaluate the traffic control devices shown in Table 1-3. While specific improvements will not have been generated at this juncture in the project, personnel generally have a feel for the types of traffic control devices that will be used. Thus, using the site's characteristics, potential solutions, and engineering judgment will yield a range of candidate MOE's.

Finally, a basic way to identify candidate measures for both diagnosis and as evaluation MOE's is to analyze driver performance requirements. For those sites with little or no available historical data, the analysis of performance requirements may be the sole means of identifying candidate measures.

Table 1-2. MOE's for Typical Highway Situations

SITUATION	MOE's
ALIGNMENT, HORIZONTAL CURVE	Spot Speed; Upstream; Entry; Apex; Exit; Downstream. Lateral Placement. Encroachments; Shoulder; Centerline. Brake Applications.
ALIGNMENT, VERTICAL CURVE	Spot Speed; Upstream; Entry; Sag (or); Crest; Downstream. Brake Applications. Time Headway (Downgrade).
CONSTRUCTION AND MAINTENANCE ZONES	Brake Applications. Conflicts. Delay. Encroachments. Lateral Placement. Last Minute Lane Change. Speed.
CHANGE IN CROSS SECTION- Lane, Shoulder Width Reduction	Spot Speed. Brake Applications. Lateral Placement.
INTERCHANGES, DIVERGE AREAS	Distribution of points of entry into inside lane; decel. lane. Speed; mainstream (reduction); at gore area; on ramp. Decel. lane speed profile. Erratic Movements.
INTERCHANGES, LEFT EXITS, TANGENTIAL OFF RAMPS	Erratic Movements. Conflicts. Speed. Lateral Placement
INTERSECTIONS, SIGNALIZED	Conflicts. Delay. Travel Time. Time Through Intersection. Speed. Lateral Placement. Brake Applications. Stop Line Encroachments.
LANE DROPS	Spot Speed; Upstream; Vicinity of sign; Beginning taper; End taper. Distribution of lane changes. Merging conflicts. Encroachments. Lateral Placement through transition area.
MERGE	Merge speed profile. Conflicts with through stream. Distribution of merges. Delay. Brake Applications.
NARROW BRIDGES	Speed. Lateral Placement. Centerline Encroachment. Conflicts.
OBSTACLES	Speed. Lateral Placement.
PASSING ZONES	Passing frequency. Passing and return type. Number of abortive passes. Conflicts with oncoming or overtaken vehicles.
PEDESTRIAN CROSSING: SCHOOL CROSSING	Compliance. Conflicts. Speed. Delay.
RAILROAD CROSSING	Head Turning Movements. Speed. Speed Profile.
STOP APPROACH	Speed Profile. Lateral Placement. Brake Applications. Encroachments on Cross Roadway. Erratic Deceleration.
TURN	Location of lane changes to enter decel. lane. Spot speeds; Upstream; Entry. Point of entry into decel. lane. Erratic maneuvers. Conflicts; opposing; through vehicles. Time through intersection.
TOLL PLAZAS	Speed. Lateral Placement. Conflicts.
WEAVING SECTIONS	Speed. Speed Change. Brake Light Applications. Conflicts. Lateral Placement.

Table 1-3. MOE's for Typical Traffic Control Devices

DEVICE	MOE
MARKINGS	. Lateral Placement . Encroachments . Compliance
GUIDE SIGNS	. High Risk Gore Weaves (Erratic Maneuvers) . Gore Weaves (Erratic Maneuvers) . Driving Slowly . Late Lane Changes . Brake Light Applications . Energy Efficiency
WARNING SIGNS	. Speed (profile) (Spot) . Lateral Placement . Brake Light Indications . Stop Line Conflicts . Compliance
SIGNALS	. Conflicts . Speed . Compliance . Energy Efficiency

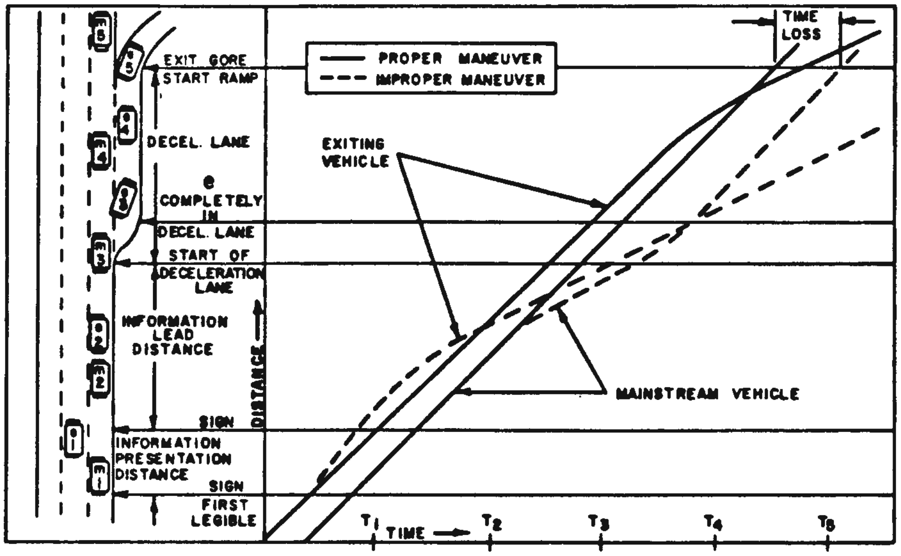
Analysis of Driver Performance Requirements

At this juncture in the project, project personnel should be in a position to specify the safest and most efficient manner in which to drive the site. This specification of driver performance requirements should be in terms of explicit statements of the sequence and location of proper driver actions, i.e., a specification of the points or sections where drivers <u>should</u> change (or maintain) speed and path.

Once performance requirements have been specified, measurement of deviations from these requirements can provide insights into the nature and extent of the site's operational problems. Knowing the nature of the problem in performance terms aids in the identification of both its cause(s) and potential improvement(s) and provides a basis for determining the effectiveness of an improvement. Thus, specifying performance requirements helps to identify appropriate candidate measures.

The specification of driver performance requirements also serve as a means for identifying information needs and gauging the adequacy of their satisfaction. That is, given the requirement to perform certain maneuvers at specified locations, an assessment can be made as to whether drivers have adequate and accurate information regarding the desired actions, and whether the information is appropriately located to provide sufficient time to make the required decisions and perform the maneuvers. Performance requirements can also be used during the Site Survey to identify information deficiencies. If the signing plans are accurate, and the topography of the site is known, a preliminary assessment of the information system can be accomplished prior to the Site Survey. Photologs can also be used for this preliminary assessment.

Figure 1-7 illustrates how to translate performance requirements into candidate measures using a freeway exit example. The figure and accompanying table shows the sequence of driver performance requirements and identifies alternative measures. The Figure shows that the alternative measures for any given performance requirement may vary from those directly related to the requirement to measures that are "surrogate" or substitute "indicators" of the more direct measure.



PERFORMANCE REQUIREMENT SEQUENCE	ALTERNATIVE MEASURES
1. Exiting drivers should be in the mainline lane adjacent to the deceleration lane previous to arrival at the beginning of the deceleration lane.	The measure related to this requirement is the percentage of exiting drivers entering the site in the lane adjacent to the deceleration lane. This measure can be alternatively stated as the percentage of exiting drivers initiating mainline lane changes after the beginning of the deceleration lane.
2. The deceleration lane should be entered in approximately the first one-third of the available space in order to provide sufficient distance for a smooth deceleration from exit speed to ramp speed.	One measure here is the percentage of exiting drivers who enter a point past the first one-third of the deceleration lane. Alternatively, the acceleration lane can be divided into several zones or section and the point of entry of all exiting vehicles can be observed. Another alternative is to observe the percentage of drivers who make only extremely late entries into the deceleration lane, e.g. those who encroach on the painted and or physical gore.
3. The deceleration lane should be entered at the posted mainline speed, i.e. 55 mph or, conversly stated, deceleration should not take place in the freeway lane.	The most elaborate measure would be a speed profile over the entire deceleration area. An alternative to this would be a spot speed at the point of entry to the deceleration lane. Another alternative (a surrogate for speed data) would be the observation of exiting driver brake lights in the mainline.
4. The speed profile from deceleration lane entry speed to ramp speed should be smooth.	The obvious measure here is the speed profile, as specified in the requirement. However, an alternative to this may be the observation of an erratic maneuver such as "severe" braking or some other indicator of a poor deceleration profile which can be readily observed and reliably judged.
5. The speed at the gore should be within 5 mph of the posted ramp speed.	The measure related to this requirement is obviously the spot speed. In the case of a site instrumented to provide a speed profile, this can be taken from the speed trap located at the gore. Alternatively, a radar spot speed or a manually timed speed trap can be used. A possible surrogate measure indicating high ramp entry speeds may be ramp shoulder encroachments or severe braking on the ramp.

Figure 1-7
Example of Driver Performance Requirements for an Exiting Maneuver*

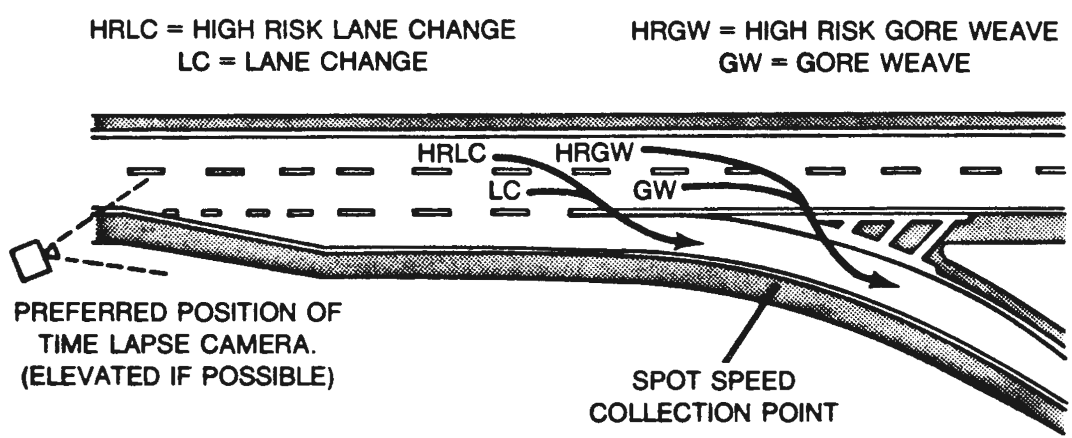
*The method recommended for translating performance requirements into information requirements is an "IDA" (Information-Decision-Action) analysis. See NCHRP Report 130 (Taylor, J.I., McGee, H.W., Seguin, E.L., and Hostetter, R.S., NCHRP Report 130 , Washington, D.C., 1972).

Operational Definition of Candidate Measures

After the availability of equipment and staff has been determined and the original list of candidate measures narrowed, the remaining candidates are operationally defined. The operational definitions are, at this point, preliminary in nature and will be finalized during the Site Survey. The reason it is necessary to develop operational definitions before the final measures have been selected lies in the fact that the feasibility of the measures will be established during the Site Survey. During the Site Survey, it is necessary to ensure that observers or equipment can be placed such that the desired observations can be reliably and accurately made and adequately sampled, and to ensure that the field of view is not hampered by blockage of vehicles, terrain, foliage, etc. It is also necessary to determine whether the observers and/or equipment can be unobtrusively placed.

An operational definition defines a measure in precise, observable terms and reduces the chances for error in data collection. While the definitions of standard measures such as speed and vehicle counts are obvious, many definitions of MOE's such as erratic maneuvers or traffic conflicts are not. Consider, for example, the erratic maneuver (EM) "gore encroachments" for an exiting maneuver. If two observers were to observe this EM in the field or to score it from film, and the EM was not operationally defined, one observer may count every occasion where the wheels of a vehicle touch the gore paint, while the other may count only those occasions where both wheels are completely over the paint line. If these two observers were involved in an evaluation of an improvement, one observer for the "Before" condition and the other for the "After" condition, the results of the difference in observational judgments could produce an erroneous conclusion.

Table 1-4 presents functional definitions for a range of measures (see also Part 2). These are translated into operational definitions by synthesizing site characteristics and data collection techniques and procedures with the MOE's. It should be recognized that an operational definition is always site specific and tailored to the project location. Figure 1-8, taken from Volume II, shows examples of these interrelationships.



MOE:	HIGH RISK GORE WEAVE	GORE WEAVE	LATE LANE CHANGE	DRIVE SLOWLY
OPERATIONAL DEFINITION:	A VEHICLE MOVEMENT INTO DECELERATION LANE ACROSS PAINTED OR PHYSICAL GORE, IN ADDITION TO CROSSING AT LEAST ONE THROUGH TRAFFIC LANE.	A VEHICLE MOVEMENT INTO DECELERATION LANE ACROSS PAINTED OR PHYSICAL GORE.	A VEHICLE MOVEMENT INTO DECELERATION LANE ACROSS PAINTED GORE EXTENSION LINE.	A VEHICLE SPEED < ONE STANDARD DEVIATION BELOW MEAN, 800 FEET IN ADVANCE OF PHYSICAL GORE POINT.
COLLECTION METHOD:	TIME LAPSE PHOTOGRAPHY	MANUAL CODING* OR TIME LAPSE *MANUAL CODING IS PREFERABLE IF TOTAL WEAVE AREA IS 1000 FEET OR LONGER.	TIME LAPSE PHOTOGRAPHY	MANUAL TIMING VIA ELECTRONIC STOPWATCH
COLLECTION PROCEDURE:	MEASURE OR COUNT ALL OCCURRENCES CONTINUOUSLY			SLOW AND MEAN SPEED DURING ALTERNATE PERIODS.

Figure 1-8.
Interrelationship of MOE's and Methods

Table 1-4. **Definitions for Selected MOE's**

MOE	Definition
CONFLICTS, TRAFFIC	A traffic event involving two or more road user's in which one road user performs some atypical or unusual action, such as a change in direction or speed, that places another user in jeopardy of a collision unless an evasive maneuver is undertaken.
(Nine Basic Intersection Conflicts)	(See Part 2 for applicable Figures)
1. Left-turn, same direction	
2. Right-turn, same direction	
3. Slow-vehicle, same direction	
4. Opposing left-turn	
5. Right-turn, cross-traffic-from-right	
6. Left-turn, cross-traffic-from-right	
7. Thru, cross-traffic-from-right	
8. Left-turn, cross-traffic-from left	
9. Thru, cross-traffic-from-left	
DRIVING SLOWLY	A vehicle speed greater than "X" standard deviation(s) below the mean speed, measured "Y" feet in advance of the physical gore.

Table 1-4. **(continued)**

MOE	Definition
DELAY	There are a number of kinds of delay. The two most prevalent are Approach and Stopped time. Each is measured Y feet in advance of the physical gore.
Approach Delay	The total amount of time, in vehicle seconds, lost by vehicles due to traffic conditions on the approach to a signalized intersection. For an individual vehicle, approach delay is considered to be the amount of time used to pass through an approach minus the amount of time used by an unimpeded vehicle to pass through the approach.
Stopped Time Delay	The time, in vehicle seconds, during which a vehicle is stopped with locked wheels on the intersection approach.
ENCROACHMENTS	Deviation from a prescribed path in a lane, intersection, or interchange as described by the existing pavement markings. An encroachment occurs when a wheel or wheels of an encroaching vehicle touches or goes across a lane line, centerline, edgeline, or other feature.
ERRATIC MANEUVERS	Deviations from an idealized track or trace through an interchange given a particular destination. The paths should be defined for both <u>exiting</u> and <u>through</u> traffic, and will differ for different types of interchange geometry. At locations up-stream of interchanges, <u>preparatory</u> and <u>through</u> maneuvers must be defined. (see Part 2)

Table 1-4. **(continued)**

MOE	Definition
Late Lane Change	A vehicle movement into the deceleration lane across the painted gore extension lane.
Gore Weave	A vehicle movement into the deceleration lane across the painted or physical gore.
High Risk Late Lane Change of Gore Weave	Same as above with the addition of crossing at least one through traffic lane.
PREPARATORY MANEUVER	Preparation for exiting, e.g., moving <u>into</u> the right lane for a right exit, etc.
THROUGH MANEUVER	Moving <u>out</u> of a lane, e.g., moving into the left lane at a right exit, etc.

Another aspect which must be considered in defining erratic maneuver and traffic conflict MOE's is the traffic context in which they occur. While some EM's, such as gore encroachments, are always "event" counts, there are others which are counted as an event in some traffic contexts but not in others. Consider, for example, the measure of speed reduction at a freeway exit. Suppose that it is not feasible to measure speed directly, and an alternate such as brake application (as indicated by brake lights) is chosen. In cases where an exiting vehicle is either the lead vehicle in a platoon or alone, its brake applications are scored. However, in the case where the exiting vehicle is not the lead vehicle, the slowing of the lead vehicle often causes the exiting driver to brake. In this situation, the brake lights of any non-lead vehicles are not to be counted, since braking was produced by a reaction to other traffic, rather than by a site-related factor.

This sort of definitional problem can be resolved in several ways. One way is to identify the characteristics of the traffic situation in which the EM should and should not be counted as an event. Another way is to record all observations of the EM, and to divide the subject population (exiting drivers in the case above) into subgroups (e.g., single or lead vehicles vs. vehicles in a platoon), and exclude one of the subgroups from the analysis. While the latter means of resolution is more easily applied by observers, and may result in more reliable field judgments, it has a disadvantage. It is necessary to be able to differentiate between the two subgroups in the data analysis phase.

This requires the use of more complex data collection forms. As data collection forms become more complex, the observers require more training (practice) in their use. Otherwise the reliability of the observation may suffer and/or the desired sampling rate may not be maintained. In other words, either the quality of the data will be reduced or the field time (and associated costs) will increase.

Another aspect of an operational definition is the specification of the required measurement accuracy. Since greater accuracy is frequently associated with high costs, either in data collection equipment, personnel, procedures, etc., or in data reduction and analysis, it is important to specify the accuracy early in the planning phase. In order to specify accuracy, consideration must be given to both diagnostic and evaluation requirements. From the standpoint of problem diagnosis, the issue is how much accuracy is needed to determine the nature and severity of the problem. For example, does the path of a vehicle have to be measured within plus or minus 1 foot, or is plus ar minus 3 feet enough? From the standpoint of evaluation, the issue is practical rather than statistical significance.

While most measures should be collected as accurately as equipment and personnel allow, specifying accuracy is an engineering judgment. In general, the nature of the problems will determine the accuracy required.

Selection of Equipment and Procedures

After candidate measures have been identified, operationally defined, and accuracy requirements specified, the next consideration is to make a preliminary selection of equipment and establish data collection procedures. In many cases, final decisions cannot be made unless or until the topographical features of the site are known. For example, film or video cannot be selected without ensuring that an appropriate camera location is available. The final decision as to the equipment and procedures to be used are thus made during the Site Survey. However, initial equipment and procedure choices and alternatives should be made at this point so that the necessary assessments regarding the feasibility of use can be made during the Site Survey.

Ideally, the choices should be dictated by the measures and measurement accuracy requirements. However, decisions are frequently made on the basis of available resources. Because of the wide variation in resources between agencies (and even within agencies at different time periods) little specific guidance can be offered.

Table 1-5 shows applicable data collection techniques for typical measures in terms of actuarial, observational, and interactive methods.

Actuarial - An actuarial data collection method uses historical records to quantify MOE's in terms of their past frequency or rate of occurrence.

Observational - This method gathers data by observing (usually unobtrusively) driver and/or vehicle behavior as it is occurring. The personnel and/or equipment used to gather data should not interact with what is being observed.

<u>Interactive</u> - In this method, the individual and/or equipment interacts directly with the drivers whose opinions, understanding or knowledge is being solicited, or whose behavior is being observed.

Using Table 1-5, an assessment should be made of the present or future availability of equipment and staff. This, coupled with an assessment of the site's characteristics, yields an indication of the feasibilty of using a particular MOE and measurement technique. For example, lack of equipment and personnel to reliably measure lateral placement would preclude its use as an MOE. Similarly, if there is no suitable vantage point to mount a camera, time-lapse techniques to record erratic maneuvers would not be feasible.

Part 2 provides a description of advantages and disadvantages of various types of equipment for different types of field data, and includes a discussion of field procedures related to the use of the equipment. Also discussed in Part 2 are field problems. A number of the decisions which must be made involve tradeoffs between field collection costs and data reduction costs. For example, time-lapse film or video data collection can provide high sampling rates for a number of different measures with a minimum of field personnel. However, depending upon what type of data are taken from the film or video, the data reduction time can be extensive. On the other hand, taking the same amount and type of data using a number of observers making manual observations would be very labor intensive in the field, but the data reduction task would be much less time consuming. Thus, an

Table 1-5. **Applicable Data Collection Techniques**

MOE	DATA COLLECTION TECHNIQUE	METHOD
ACCIDENTS	Accident Records	Actuarial
BRAKE APPLICATIONS	Manual Recording Time-Lapse Film Traffic Analyzer Traffic Counter Video Recorder Wear Patterns Interview Questionnaire	Observational Observational Observational Observational Observational Observational Interactive Interactive
COMPLIANCE	Police Records Manual Recording Time-Lapse Film Traffic Counter Interview Questionnaire	Actuarial Observational Observational Observational Interactive Interactive
CONFLICTS	Manual Recording Time-Lapse Film Traffic Counter Video Recorder	Observational Observational Observational Observational
DELAY	Complaints Aerial Photography Automatic Detectors Input-Output Studies Manual Recording Moving Vehicles Radar Speed Meters Time-Lapse Film Traffic Analyzer Traffic Counter Video Recorder Interview Questionnaire	Actuarial Observational Observational Observational Observational Observational Observational Observational Observational Observational Observational Interactive Interactive
DRIVING SLOWLY	Aerial Photography Input-Output Studies Manual Recording Moving Vehicles Radar Speed Meters Time-Lapse Film Traffic Analyzer Video Recorder	Observational Observational Observational Observational Observational Observational Observational Observational
ENCROACHMENTS	Accident Records Traffic Counts Aerial Photography Automatic Detectors Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recorder Wear Patterns Interviews Questionnaire	Actuarial Actuarial Observational Observational Observational Observational Observational Observational Observational Observational Interactive Interactive
ERRATIC MANEUVERS, LAST MINUTE LANE CHANGES	Accident Records Aerial Photography Automatic Detectors Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recording Interviews Questionnaire	Actuarial Observational Observational Observational Observational Observational Observational Observational Interactive Interactive
HEAD TURNING MOVEMENTS	Manual Recording Time-Lapse Film Video Recording	Observational Observational Observational
LATERAL PLACEMENT, MERGES	Aerial Photography Automatic Detectors Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recording	Observational Observational Observational Observational Observational Observational Observational
PASSING TYPE, PASSING TIME, PASSING DISTANCE, PASSING FREQUENCY, PASSING ABORTIVE	Aerial Photography Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recording	Observational Observational Observational Observational Observational Observational
SPEED, SPEED CHANGES	Accident Records Aerial Photography Input-Output Studies Manual Recording Moving Vehicles Radar Speed Meters Time-Lapse Film Traffic Analyzer Video Recorder	Actuarial Observational Observational Observational Observational Observational Observational Observational Observational
TIME HEADWAY	Aerial Photography Automatic Detectors Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recorder	Observational Observational Observational Observational Observational Observational Observational
TIME THROUGH INTERSECTION, TRAVEL TIME	Aerial Photography Automatic Detectors Input-Output Studies Manual Recording Moving Vehicles Radar Speed Meters Time-Lapse Film Traffic Analyzer Video Recording	Observational Observational Observational Observational Observational Observational Observational Observational Observational
VOLUME	Traffic Counts Aerial Photography Automatic Detectors Input-Output Studies Manual Recording Moving Vehicles Time-Lapse Film Traffic Analyzer Video Recording	Actuarial Observational Observational Observational Observational Observational Observational Observational Observational

organization with a large field staff but few office personnel might tentatively choose manual data collection, while an organization with a large office staff but few field personnel may choose film or video data collection.

There are also data reliability factors to consider. Film and video data can be reviewed by a number of staff members, and the data reduction accuracy can be checked, whereas manually obtained data cannot be checked except via a quality control procedure in the field. Thus, an organization with experienced and trustworthy field observers may opt for manual data collection, and an organization employing part-time, casual, or inexperienced observers may be better off with film, video or some other "non-manual" means of data collection to assure reliability.

SITE SURVEY AND OPERATIONS REVIEW

Overview

The purposes of the Site Survey and Operations Review are: To familiarize project personnel with the geometric and topographic characteristics of the site; to verify preliminary conclusions from the Historical Data Review; to identify potential driver problems that were not otherwise identified; and to provide those inputs necessary to finalize the Data Collection Plan, including the final selection of measures and a verification of the feasibility of using the equipment and procedures selected. The effort required for the Site Survey and Operations Review will vary as a function of the extent to which the engineering staff is familiar with the site and the size and nature of the project.

In order to conduct the reviews efficiently and minimize the field time required, it is desirable to structure the observations to be made. The structuring can be in the form of a listing derived from each of the planning activities, i.e., a "List of Things to Look For and At" on various sections of the site. The following are examples of the type of outputs from each of the planning activities relating to finalizing the Data Collection Plan.

- Review of Historical Data - Accident clusters identified on the condition diagram can be listed for a visual check for possible causes. Accident data can suggest the types of erratic maneuvers or traffic conflicts, and the probable location which would be expected to be associated with each significant cluster. Accident and/or traffic operations data may suggest that indicators of speed control problems should be listed. User complaints may indicate that visibility and detectability of signs or signals should be checked. Accident summaries such as time of day, wet/dry, etc. may identify when the Site Survey should be conducted.

- Identification of Candidate Measures - The candidate measures and their locations were identified during the Identification of Data Collection Plan Elements activity. The Site Survey and Operations Review enables the reviewer to make an informed (non-statistical) assessment of which measures are likely to provide some indication of the problems and/or for those cases where an improvement has been developed, which measures should be used in its evaluation.

- Operational Definitions and Selection of Equipment and Procedures - This activity, along with the previous one, identified the nature and location of all measures and the method of measurement. Observation checks to be made during the Site Survey ensure that the desired measures can be made at the desired locations with the equipment and procedures chosen. This involves assessing observer and/or equipment locations from the standpoint of factors such as operational definitions, obtrusiveness, visual line-of-site, availability of measurement reference marks (or objects), camera field of view, etc.

The Site Survey and Operations Review activities are thus necessary to establish the feasibility of all aspects of the Data Collection Phase and to determine the most effective combination of measures, procedures, and methods.

Site Survey

Drive-Through

The Site Survey typically begins with a Drive-Through of the location to determine what drivers see and to experience the problems that drivers may encounter. It also involves looking systematically at the location from an engineering point of view. Applying experience and judgment enables the reviewer to identify hazards and problems that have not yet been identified by the Historical Data Review, and to assess the severity of those that have been identified previously.

It is usually best for two people to conduct the Drive-Through--one to observe and drive, and one to observe and record. A tape recorder and a Condition Diagram provide a convenient means to record observations and comments, with the locations of various observations being marked on the diagram. The Condition Diagram should also be checked for completeness and accuracy during the Site Survey. Depending on the length of the site and the number of traffic control devices, it is often easier to check the information system on foot. If the site is surveyed on foot, observers must assure that safety precautions such as wearing orange vests, etc. are taken into account. If foliage exists during the time the Site Survey is being conducted, signs should be checked to ensure that visual blockage is not a problem. Potential truck blockage problems should also be checked.

The Site Survey may require more than one Drive-Through. For undivided sections, a Drive-Through should be conducted in both directions. At least one of the Drive-Through trips in each direction should be at normal traffic speed. It should start far enough upstream of the site to determine what driver expectancies are created on the approach to the site and to determine whether expectancy violations exist.

During the drive-throughs and the Operations Review which follows, close attention should also be given to potential observer and/or equipment locations. Each location should be confirmed and noted on the condition diagram.

Photographic Documentation

It is recommended that a set of 35 mm color slides be taken of the site before and after an improvement has been made. If a photolog does not exist or is out of date, it is frequently valuable to film or video-tape the drive-through. The ability to review the film, tape, and/or slides in the office will aid throughout a project in the determination of hazards, expectancy violations, detection and recognition problems, information loading, etc. If equipment is available, the cost of filming or taping a drive-through (particularly in "super 8") is low, and a savings in field time can usually be realized. That is, the Site Survey notes can be verified and, frequently, additional problems can be identified. If the photographic documentation reduces trips to the site, a substantial savings can be realized. Obviously, the greater the distance from the site to the office, the greater the importance of photographic documentation.

Operations Review

Following the drive-through, an Operations Review is recommended to aid in problem identification and/or verification. Whereas the drive-through provides a longitudinal look at the site, the Operations Review is cross-sectional in nature. While the Operations Review can be accomplished during the Site Survey, it is often desirable to view operations at different times (e.g., weekday, weekend, peak, off-peak) and/or under different conditions (e.g., day, night, dry, wet). This judgment is made on the basis of information from the Historical Data Review and/or the overall impression of the staff as to the nature of the problems.

The objectives of the Operations Review are: (1) To identify possible problems not identified via previous analyses; and (2) to verify (or identify) the operational effects of problems noted. For those measures related to the observation of particular driver actions or maneuvers (e.g., erratic maneuvers), it may be desirable to sample and record selected driver maneuvers to obtain an estimation of how frequently they occur. These estimates will in turn serve as a basis for estimating the amount of field time which will have to be scheduled in order to obtain sufficient samples of the measure. Conversely, unless the measure is judged to be crucial to the development or evaluation of the improvement, these estimates can serve as justification for rejecting the measure on the basis of excessive field time and/or cost.

Feasibility Assessment

The final output to be obtained is an assessment of the feasibility of using the data collecton methods chosen. Since some measures may be rejected and/or others added because of information or insights resulting from the Site Survey and Operations Review, the Feasibility Assessment activity should be done last. Its objective is to ensure that observers and/or equipment can be unobtrusively located where there is a clear field of view for collecting the required data.

DATA COLLECTION PLAN DEVELOPMENT

Overview

The Site Survey and Operations Review activities will have reduced the preliminary list of candidate measures to those which will be used to collect data for problem diagnosis and improvement evaluation. Further, the measures will have been confirmed with respect to operational definitions, equipment needs, personnel requirements, data collection procedures, etc. Thus, at this stage the Data Collection Plan should be in a form to be finalized, pending a final check during the Pre-Field Data Collection activities.

The Data Collection Plan varies with the size, scope, and purpose of a project. The plan discussed here assumes a complex project with multiple observers, a number of measures and a full scale evaluation. This discussion augments material contained in the Evaluation volume. Figure 1-9 shows the ten steps that comprise the "Before" Data Collection Plan of a full scale evaluation (See Volume II).

There are four major elements which should be included in any data collection plan, whether or not the project is a Positive Guidance one, and/or whether or not an evalution is being performed. The four elements are: (1) Condition limits (e.g. environmental, time, traffic, etc.) to be imposed on the data collection; (2) the observer and equipment locations and identification of measures (observations) to be made from each location; (3) data collection forms; and (4) sampling requirements and schedules for each measure. In addition to serving as documentation, the Data Collection Plan also becomes a field tool to be used by the supervisor of the field crew to coordinate all activities and to ensure that all requirements are met.

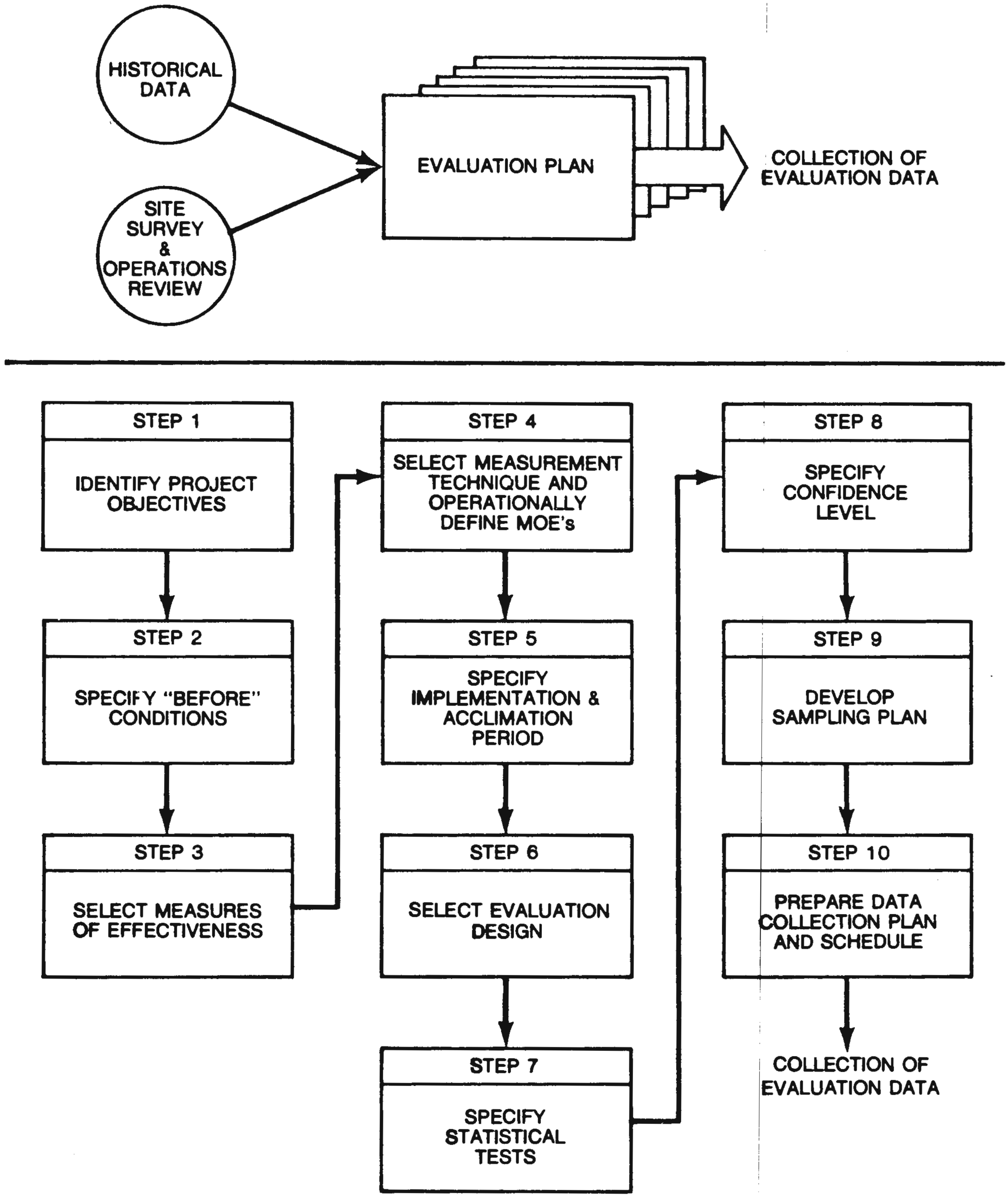


Figure 1-9.
Evaluation Plan - Functional Flow

Condition Limits

In many projects, it is desirable to collect data under only certain conditions of traffic volume, weather, light, etc. "Before" conditions are determined from an analysis of the range of environmental, driver and traffic conditions identified during the initial stages of a project. This information is used to specify target conditions and to identify target driver and/or vehicle populations.

While it is generally advisable to collect data under a representative range of conditions, it is usually neither possible nor desirable to gather data for every condition. It is often necessary to limit data collection due to time and monetary constraints. In addition, the nature of the problem may be such that only certain conditions are warranted. For example, data collected during dry conditions would be irrelevant if there is evidence that the problem being attended to only occurred under wet pavement conditions.

A review of problems and/or accidents generally focuses in on target driver and/or vehicle population as well as "Before" conditions. For example, if strangers getting lost is identified as the major problem, non-repeat drivers should be maximized. This can be accomplished by collecting data during weekends, holidays, and the tourist season. Similarly, when most accidents occur after dark, MOE's data collection should be performed at night.

The procedure to follow in specifying "Before" conditions is to develop a set of tentative "Before" conditions including target driver and vehicle populations, based on the review of Historical Data, the Site Survey and Operations Review, and an analysis of the problem. The information contained in Table 1-6 serves as a guide.

TABLE 1-6. **Typical "Before" Conditions**

Category	Condition
Weather	Clear Rain Fog Snow Other
Illumination	Day Night Twilight Illumination (Specify)
Pavement	Dry Wet Icy Type (Specify) Condition (Specify)
Traffic Volume	AADT (Specify) Peak (Specify) Hourly (Specify) Other
Season	Spring Summer Fall Winter Tourist
Target Populations	<u>Drivers</u> - Locals Strangers Tourists Commuters <u>Vehicles</u> - Passenger Commercial Recreational Other
Others	Foliage Striping Seasonal Events Legal/Enforcement

Just as each measure must be operationally defined for the field crew, Condition Limits must also be specified. While this is not as critical for problem diagnosis, it can be critical for evaluation and therefore must be considered in the planning process so that relevant conditions can be replicated. For example, if "Before" data are to be collected in early summer and the acclimation period dictates that "After" data will be collected in late fall, then different seasonal light conditions must be taken into consideration in planning the daily sampling periods. Otherwise some of the "After" data may be taken during dusk, whereas all of the "Before" data may be taken under full daylight condition. The resultant data sets may be non-comparable.

Ideally, operational definitions and Condition Limits should be such that field personnel do not have to make qualitative judgments. For example, volume limits should be specified in vehicles per hour, or in cases where reliable historical or current volume data are available, should be reflected in the time periods specified in the schedule. Field personnel should not have to make a judgment as to when, for example, volume is high or low. Similarly, weather Condition Limits such as rain or snow should be defined in non-judgmental terms, e.g., "when 10 percent of the drivers are using windshield wipers" or "when the road surface is uniformly wet." While some criteria such as the "windshield wiper" example may require a break in data collection in order to make the condition observation, such definitions will ensure comparable and representative data.

Observer and Equipment Locations and Data Collection Procedures

Observer and equipment locations, and their interaction with data collection procedures must be specified prior to data collection. The exact locations of equipment and observers can be shown on the Site Diagram relative to an identifiable reference, or the exact locations can be given on an accompanying narrative or table.

Observer and Equipment Locations and Data Collection Procedures for a freeway site example are shown in Figure 1-10 and described below. The site was a freeway location that used two observers to collect erratic maneuvers, volumes, speeds, and traffic composition. One observer collected volumes, speeds, and traffic composition (truck counts), while the other was responsible for the recording of erratic maneuvers and monitoring two recording counters and two CB Radios.

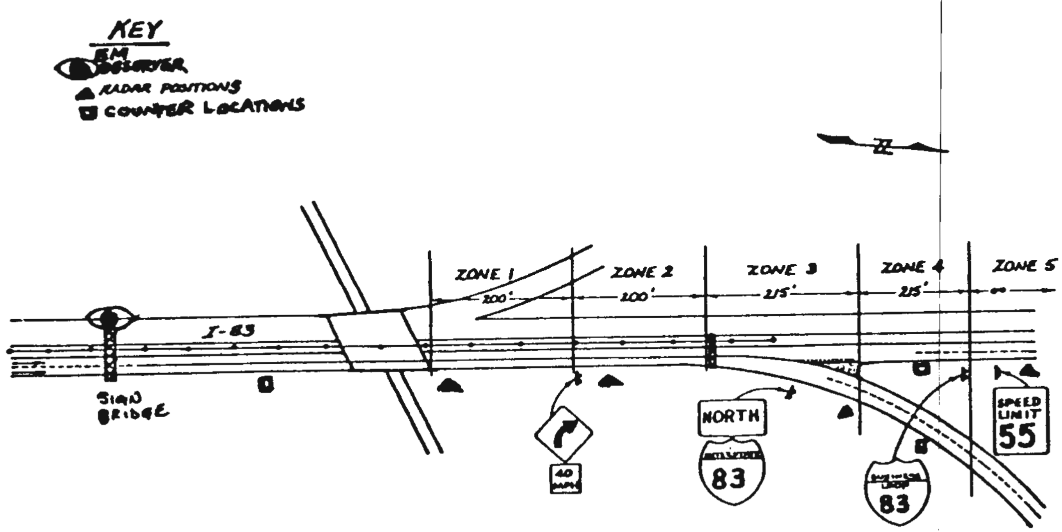


Figure 1-10.
Condition Diagram (Observer and Equipment Locations)

Location and Procedures Example Description

Observer 1 records volumes for both the exit and through movements from counters which are located downstream of the gore for each movement. These counters are read in accordance with a pre-determined Data Collection Schedule (See Figure 1-14 below). Traffic composition (truck count) is recorded manually at the gore for the two movements.

Using a radar unit, Observer 1 records speeds at four locations for single or lead vehicles. Free flow mainline speeds are obtained from an unobtrusive roadside position approximately 1,200 feet upstream of the exit gore. Preexit speeds are recorded at a point approximately 400 feet upstream of the exit gore. Gore speeds are recorded for both movements (exit and through) at points approximately 500 feet downstream of the physical gore. In all cases, Observer 1 must be hidden and/or camouflaged in order to avoid detection. In addition, the radar antenna must be camouflaged to appear as if it were roadside debris (e.g., a brown paper bag can be used) and placed at or near the roadside.

In order to have communication between the two observers, Observer 1 is equipped with a walkie-talkie and constantly monitors a specified CB channel; the channel is also monitored by Observer 2.

The primary function of Observer 2 is the manual recording of erratic maneuvers. This is accomplished from a high vantage point; 1,200 feet upstream of the exit gore. This vantage point provides a clear field of view of the entire site and allows for unobtrusive observation.

Nine different operationally defined erratic maneuvers are recorded by Observer 2: Late exit lane changes; late through lane changes; exit gore crossings; through gore crossings; braking; swerving; gore stopping; shoulder stopping; and backing. In addition to notation of the erratic maneuver types, each is coded to indicate whether it is the first of several committed by the driver, or the only one. During Site Survey and Operations Review observations, it was found that some drivers committed a number of EM's. Since it is necessary to know both how many EM's were committed, and the percentage of drivers committing them, the additional coding is required.

Two recording counters (tape print) are deployed in order to obtain continuous counts; one is located 200 feet upstream of the data collection sign bridge, and one is located on an entrance ramp 1,000 feet upstream of the observer sign bridge. Observer 2 monitors both recording counters to ensure proper functioning and to record periodic counts. The final task of Observer 2 is the continuous monitoring of two CB radios; one turned to a specified channel to allow constant communication potential between the two observers, and one tuned to channel 19 to gauge the success of the camouflage/concealment efforts of the observers and equipment.

Data Collection Forms

Form development is included as an element of the Data Collection Plan because in many situations the sampling rate and accuracy of a measure can be enhanced or curtailed by the design of the form. The design of the data collection forms is one aspect of the plan that is frequently overlooked, yet it is something that deserves serious consideration. Further, the time (cost) to design and check out a form is small compared to the potential benefits and avoidance of data collection problems.

Primary considerations in form design are simplicity and ease of use; i.e., it is important to avoid the need for observers to either search for the correct position on a page or to turn pages to make a tally. The goal is to minimize the amount of time required to mark or code the measure so that the actual observation time can be maximized. The problem is not very critical if the site involves very few observations and/or if the volumes are low. However, if the reverse is true, the percentage of events observed relative to those actually committed (the "capture" rate) can be significantly reduced by a poor form.

Poor form design can have several adverse effects that translate into erroneous conclusions and increased cost. First, a low "capture" rate can result in sample sizes which are too small to permit statistical analysis. While this problem can be overcome by increasing the amount of time in the field, either by increasing the length of the sampling periods or the number of days in the field, this is obviously costly. Secondly, erroneous evaluation conclusions can result from poor form design because as the observer becomes practiced, the "capture" rate will increase. Thus, if the same observer were to be used in both phases of an evaluation and, because of practice, the capture rate in the "After" phase was substantially higher, the results could show that the MOE rate had increased when in fact it had actually decreased.

Another benefit (and cost savings) that can result from good form design is a reduction in the number of field personnel required. Designing a form with a high capture rate could reduce field personnel needs, for example, from two to one. This is also important for sites where there are few good unobtrusive observation locations.

There are a number of data collection forms available for recording frequently used traffic engineering measures such as speed and vehicle counts. Tabulation forms to fit a number of different purposes are provided in the ITE Manual of Traffic Engineering Studies* as well as in the "Forms" section of this Volume. However, forms for collection of performance measures such as erratic maneuvers, traffic conflicts and lateral placement are usually tailored to the site and to the distribution of observations between observers. Figures 1-11 and 1-12 are examples of forms used for erratic maneuver and vehicle trace measures for the illustrative freeway site.

---

*Box, P., Oppenlander, J., Manual of Traffic Engineering Studies, ITE, Arlington, Virginia: 1976

Page ____ of ______

ERRATIC MANEUVER DATA SHEET

PROJECT: ____________________

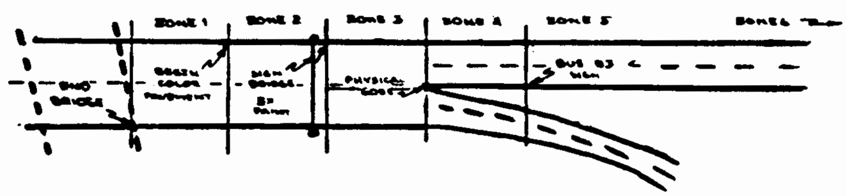
PROJECT NO.: ____________________

PREPARED BY: ____________________ DATE: __________

DAY: ____________________ TIME: ____________________

WEATHER: ____________________

SKETCH:



EM'S

ZONE	1	2	3	4	5	6
1						
2						
3						
4						
5						

Figure 1-11.
Sample Form for Erratic Maneuver Data Collection

Page ____ of ______

VEHICLE TRACE DATA SHEET

PROJECT: ____

PROJECT NO.: ____

PREPARED BY: ____________________________ DATE: __________

DAY: ______________________ TIME: ______________________

WEATHER: ____

NOTES: ____

____

TRACES:

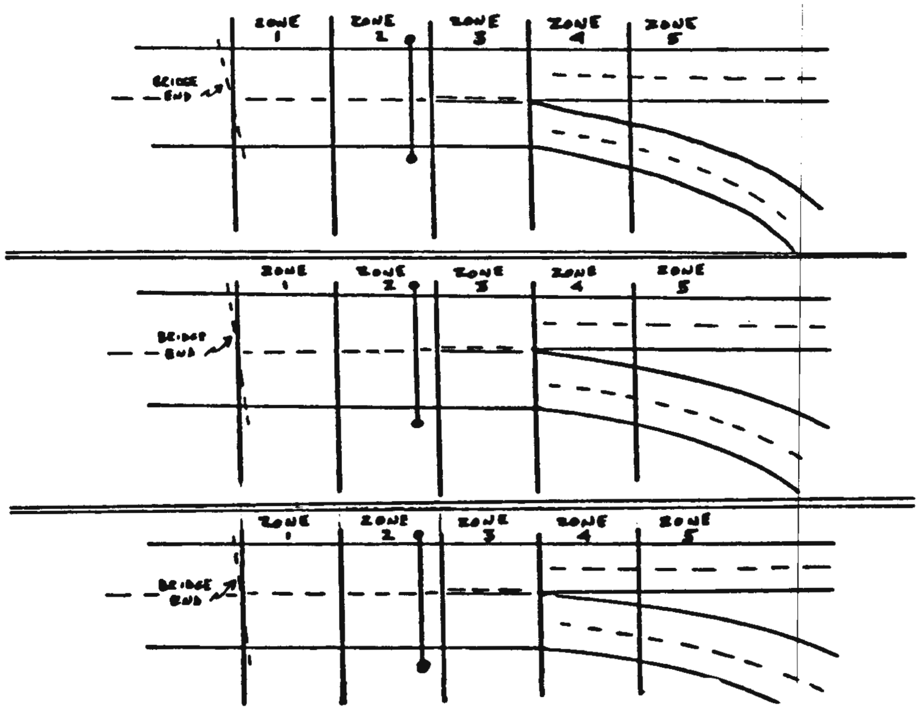


Figure 1-12.
Sample Form for Vehicle Trace Data Collection

Sampling Requirements And Schedules

In projects involving multiple measures and multiple observers, the MOE's will usually be sampled rather than continuously collected. The same observation or measure may also have to be collected by a given observer several times on different portions of the site. Further, equipment may have to be checked or serviced (e.g. film or tape changed), equipment output may have to be recorded (e.g., traffic counter output), etc. All of these activities must be scheduled for each measure and observer.

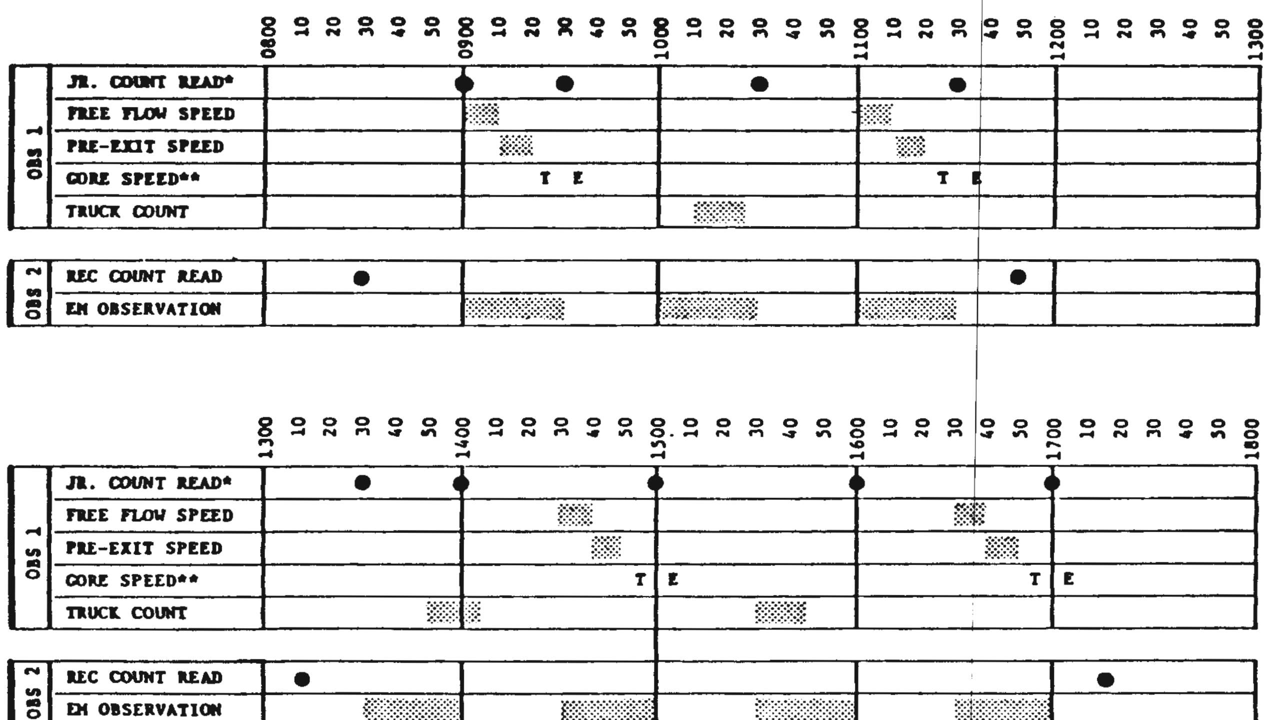
Figure 1-13 illustrates a simple repeated hourly time schedule of the type used for traffic conflict studies. Figure 1-14 shows an example of a daily data collection schedule of the type used for a more complex multi-observer project. The site for which the daily schedule was developed is the freeway site example.

Erratic maneuver (EM) observations, as shown in Figure 1-14, were specified in terms of time samples, i.e., seven ½-hour periods per day, rather than sample size. For purposes of data collection, the site was divided into five zones, defined by existing landmarks (pavement seams, trees, signs, etc.). Observer 2 recorded EM's on data collection forms that were designed to correspond with the noted zone divisions. The sampling plan for speed data called for either a 10-minute sample or 50 vehicles per location.

Since sampling requirements and schedule will vary for each project, there is no single universally applicable sampling plan format. Any readily understandable plan which specifies what each observer is to be doing and the time period (or sample size) required will be adequate.

Time	One Hour Time Schedule
0800	Start Observing Conflicts
0820	Stop Observing Conflicts and read counts on Data Form
0825	Move to Opposite Approach Leg
0830	Start Observing Conflicts
0850	Stop Observing Conflicts and read counts on Data Form
0855	Move to Opposite Approach Leg

Figure 1-13. **Sample Data Collection Schedule - Simple Repeated Hourly Time Schedule**



** Core speed; T = Through Movement; E = Exit
* JR.= Streeter-Amet "Jr." Counter

Figure 1-14. **Sample Data Collection Schedule Complex Daily Multi-Observer Project**

Samples are often drawn at random so that each element (i.e., vehicle, driver, condition, etc.) has an equal chance of being included. However, it is likely that there will be elements of selection, referred to as stratification. In stratified sampling, the entire population of elements is segmented into homogeneous groups (strata) and each stratum is independently sampled. Since "Before" conditions are structured in terms of target conditions and/or groups (e.g., wet weather, night conditions, commuters, trucks, etc.), these attributes are used to stratify the samples. It may also be useful to employ a systematic sampling technique. With this technique, the target population is divided into clusters of equal elements (e.g., all vehicles in a given time period) and each n^{th} cluster sampled. It is acceptable to use a systematic technique with stratified random sampling.

The selection of a sampling plan is based on a number of considerations. If there are not specific target conditions or time pressures, then a purely random sampling technique could be used. That is, dates and times for data collection during a year are selected using a table of random numbers. This technique can be augmented by systematic sampling. Once the first date and time is selected, every n^{th} day and time is sampled until the sample size requirement is met.

Given target "Before" conditions and groups, and "real-world" time pressures, a stratified sampling technique is often used. The "Before" conditions (Condition Limits) are used as the strata. Depending on the nature of the MOE's and target populations, data are collected on all attributes of interest until the desired sample size or greater is acheived. This may encompass all vehicles and/or maneuvers in the traffic stream, or only certain vehicles (e.g., trucks, RV's) or drivers (e.g., commuters, out-of-state license plates) or maneuvers (e.g., all passes or exit maneuvers). In locations with a high traffic volume or a large incidence of the MOE's of interest, it is often useful to employ a systematic, time-based sampling technique. For example, all vehicles of interest are sampled for one-half hour every 2 hours until the desired sample size is acheived. This technique is useful with time-lapse data collection.

FIELD VERIFICATION OF DATA COLLECTION PLAN

Overview

The purpose of performing the Pre-Data Collection Assessments is to ensure that the necessary level of data collection accuracy and reliability is achieved. The Verification is the final phase of the Planning Activity. Many of the Verification tasks can be conducted during the Site Survey and Operations Review, particularly for projects involving relatively few measures and/or observers.

The Verification involves a consideration of Equipment/Observer Locations, Data Collection Forms, Task Allocation, and Inter-Observer Communications. These activities not only provide necessary information regarding data collection methods, but they also familarize the data collection crew with the site, and provide training. For complex sites involving costly improvements and multi-observer teams, a full day should be scheduled for these activities. This usually allows time to complete all activities, make any necessary changes in forms, measures, etc., and provides a period for full scale supervised data collection practice.

Equipment/Observer Location Assessment

Three primary concerns in field data collection are: Measurement accuracy; equipment and observer reliability; and field crew and equipment unobtrusiveness. While accuracy and reliability are always important, the importance of unobtrusiveness will vary with the particular measure. It is noted that the discussion assumes covert data collection in order to avoid influencing driver performance. However, during site set-up activities, all usual safety precautions must be adhered to.

Unobtrusiveness is absolutely necessary for measures involving any sort of traffic violation where the behavior may be intentional, e.g., speed violation, passing violation, etc. and less important for measures involving "unintentional" behaviors, e.g. gore or edgeline encroachments, swerves, etc. However, since most projects usually involve both types of measures, the assurance of unobtrusiveness for all observers and equipment is nearly always required. Unfortunately, the best location for making observations and measures with the required accuracy is often a place where unobtrusiveness is not possible. Thus, while accuracy/reliability and obtrusiveness are discussed separately, there are frequently tradeoffs required. Further, since obtrusiveness checks usually involve less effort, it is recommended that they be performed first.

Obtrusiveness Checks

The increasing use of CB radios has made the problem of hiding observers and equipment much more severe. In the past, a visual check was adequate, and even if an occasional driver happened to see an observer or some equipment, the effect on the overall data was probably minimal. However, with the current level of CB use, the CB "warning" net can have enough longevity to have a substantial effect upon the observed sample. The severity of the problem increases on sites with a high proportion of truck traffic, since virtually all truckers use CB's.

While observers can usually be hidden, in many cases equipment cannot (due to design/operational constraints), and must, therefore, be camouflaged. Rags, paper bags, carboard boxes and the like can frequently be used to cover radar heads, time lapse cameras, etc. depending upon location, required mounting height, etc. Thus, if equipment cannot be hidden it can sometimes be made to look like road debris. With cameras, care must be taken to ensure that the camouflage material does not interfere with the lens and field of view. Also, unless a very slow frame rate is used and no film change is required during the data collection day, there is the additional problem of being able to change film or video cassettes without being detected. In other words, the solution to these kinds of field problems often requires ingenuity.

Following an initial visual check of all observers/equipment for obvious problems of visibility, the best means of making the final check is by monitoring the CB channels for a period of time. CB Channel 19 is most frequently used by drivers, particularly truckers, and this is the best choice for the checks. However, on rural sites with relatively low truck volumes, the most heavily used CB channel in the locality is sometimes a better choice. If the channel used most heavily is not known, it will be necessary to switch from channel to channel until it can be identified. CB checks require only passive monitoring and can be done in conjunction with the other Pre-Data Collection Activities. A final check for obtrusiveness should be performed with all observers/equipment in place. Since drivers may observe some of the set-up activities and warn other drivers, the checks for obtrusiveness should <u>not</u> be initiated immediately after the initial observer/equipment set-up is completed.

Accuracy/Reliability Checks

Accuracy and reliability asessments are primarily aimed at observers rather than equipment. In most cases, equipment calibration can be done off-site and, given that manufacturers' guidelines for use are followed, should provide reliable data at the level of accuracy for which it was designed. The use of time-lapse, however, requires the selection of a location with a camera angle and a field of view appropriate to the type of data to be recorded. If time lapse is to be used for identifying either normal or erratic maneuvers occurring <u>at particular locations</u> on the site, e.g., lane change location, point-of-entry into deceleration lane, merge point, etc., then it is necessary either to identify landmark references, e.g., pavement markings, seams, guardrail posts, etc., or to prepare references such as paint marks, tape, etc., which can be used as references in reducing the data. If heavy reliance is to be placed on film or video data, the safest procedure is to shoot some film or video prior to the final verification to ensure that all references can be seen and that there are no significant parallax problems. A "ground truth" scenario, as described in the next section, is the most accurate means of making this assessment.

Vantage points from which the location of erratic maneuvers and/or traffic conflicts is determined must provide for an accurate and reliable observation of the event to be made. Frequently the vantage may not be ideal, and some element of judgment will be involved to assess the suitability of the location. There are several ways of making this assessment. One way is to have several observers, one of whom is going to be the actual field observer, make observations independently and simultaneously, and to determine the inter-observer consistency. Another is to have one observer at the location designated for data collection and another at a location which is ideal for making the observation, and to assess the extent of agreement between the two. Both of these procedures require that the maneuvers in question occur with enough frequency to provide a reasonable sample, otherwise, a great deal of time can be spent waiting for the event to happen.

Ground Truth Scenario

Another way to perform the observer/equipment location assessment that can also be used to exercise the entire field crew and related equipment, is the "ground truth" scenario. Using this method, a staff member drives through the site several times in a pre-defined manner, i.e., at a specified speed and performing specified maneuvers at specified locations. The elements of the scenario (i.e. "ground truth") are then compared with the observations made and observer location and/or other problems identified. "Ground truth" scenarios should not be scheduled during periods of high traffic volume, and the maneuvers should not be performed in a manner that could endanger other drivers.

"Ground truth" scenarios are used for erratic maneuver or traffic conflict assessment when there is concern about the ability of observers to accurately judge the location of the maneuver. The behaviors assessed are usually routine, since most "dangerous" erratic maneuvers or traffic conflicts, e.g., backing from a ramp, running a stop sign or signal, etc., are obvious and require no judgment; visual line of sight being the only concern.

Data Collection Forms, Task Allocation, and Schedule Verification

The primary purpose of this verification is to make certain that reasonable sampling rates can be obtained with the data collection forms and the task allocations selected. This assessment is necessary only if an untested form is being used and only under conditions where single observers are observing multiple events under moderate to high volume conditions. It is usually wise to give the observer a period of practice with the form, since improvements are likely within a fairly short period of time. Also, observer feedback from such practice is very useful if changes in format are necessary. The objective is to have a format which minimizes search and recording time on the form and maximizes the time which traffic can be directly observed.

Field Check

Two procedures can be followed for these field checks. The first involves the primary field observer collecting data in the desired fashion, while several back-up observers each observe a portion of the measures, e.g., two maneuvers each. Since one or two types of behavior can be tallied without taking ones eyes off the roadway, the grouped data from the back-up observers serves as "ground truth" against which to compare the data from the primary observer. This provides an estimate of the "capture" rate and permits a determination of whether either the data collection form should be modified or the observer task load should be reduced.

Office Check Using Film or Video

Another procedure which can be used to evaluate all observers at the same time is to use film or video data as a "ground truth" against which to compare the data from any or all observers. Film has the disadvantage of requiring processing, and both film and video require data reduction before the assessment can be made. However, if an adequate camera vantage point is available and the delay can be tolerated, the procedure can provide better use of the data collection crew with regard to actual practice time.

Task/Schedule Check

For those data collection situations where different measures are sampled, single observers may be assigned multiple duties, e.g., a period of EM observation, a period of speed data collection, a period to record data from counters, and a film cassette change. If the site set-up is such that equipment and observer locations are fairly distant from one another, it is necessary to ensure that it is physically possible to perform all of the tasks within the limits of the data collection schedule. Sometimes, schedules which seem reasonable on paper are very difficult or impossible under field conditions. Further, a minor reallocation of tasks is frequently possible and can avoid problems of missing data and/or slipping schedules. With regard to schedule, it is always a good idea to identify for the field crew those schedule elements (measures or periods) which are most critical, so that if the schedule is disrupted due to problems such as equipment failure, the most critical data can still be collected manually.

Inter-Observer Communications Assessment

Some types of data collection methods may require that observers be in communication with one another via CB, hand signals, etc. An example is the situation where an upstream observer chooses a specific vehicle as a subject vehicle and calls, radios, or hand signals to downstream observers so that the performance of the chosen vehicle can be "tracked" through the entire site. In this case, it is necessary to make certain that all messages can be reliably seen or heard under all conditions which will prevail. Where visual signals are used, visibility related factors such as sun angle, overall brightness, etc., must be taken into consideration. With regard to radio communication, it is necessary to identify the least used channel in the data collection area and to identify a backup channel in the event that malfunctions occur or someone decides to use that channel during a data collection period. The message relay system should also be checked out to ensure that terrain features or local conditions do not produce interference such that vehicle identifications or verbal timing marks cannot be reliably transmitted.

SITE FILE

Overview

This activity orders all data generated during the Planning and Field Data Collection phase. As such, it essentially involves collating data from the Historical Data Review, the Site Survey and Operations Review and the Data Collection phases in a Site File established for the project.

As the project progresses, all data generated by the Improvement Development Phase of the Engineering and Human Factors Procedure of a Positive Guidance project are incorporated into the Site File and used for evaluation and to document the project results.

Collection of Data

Part 2 presents guidelines for Collecting Performance Data in the Field. It is important to collect all data in accordance with the Data Collection Plan, and to document any deviations that occur.

Figure 1-15 shows a functional flow for the Data Collection phase of a project incorporating a formal evaluation.

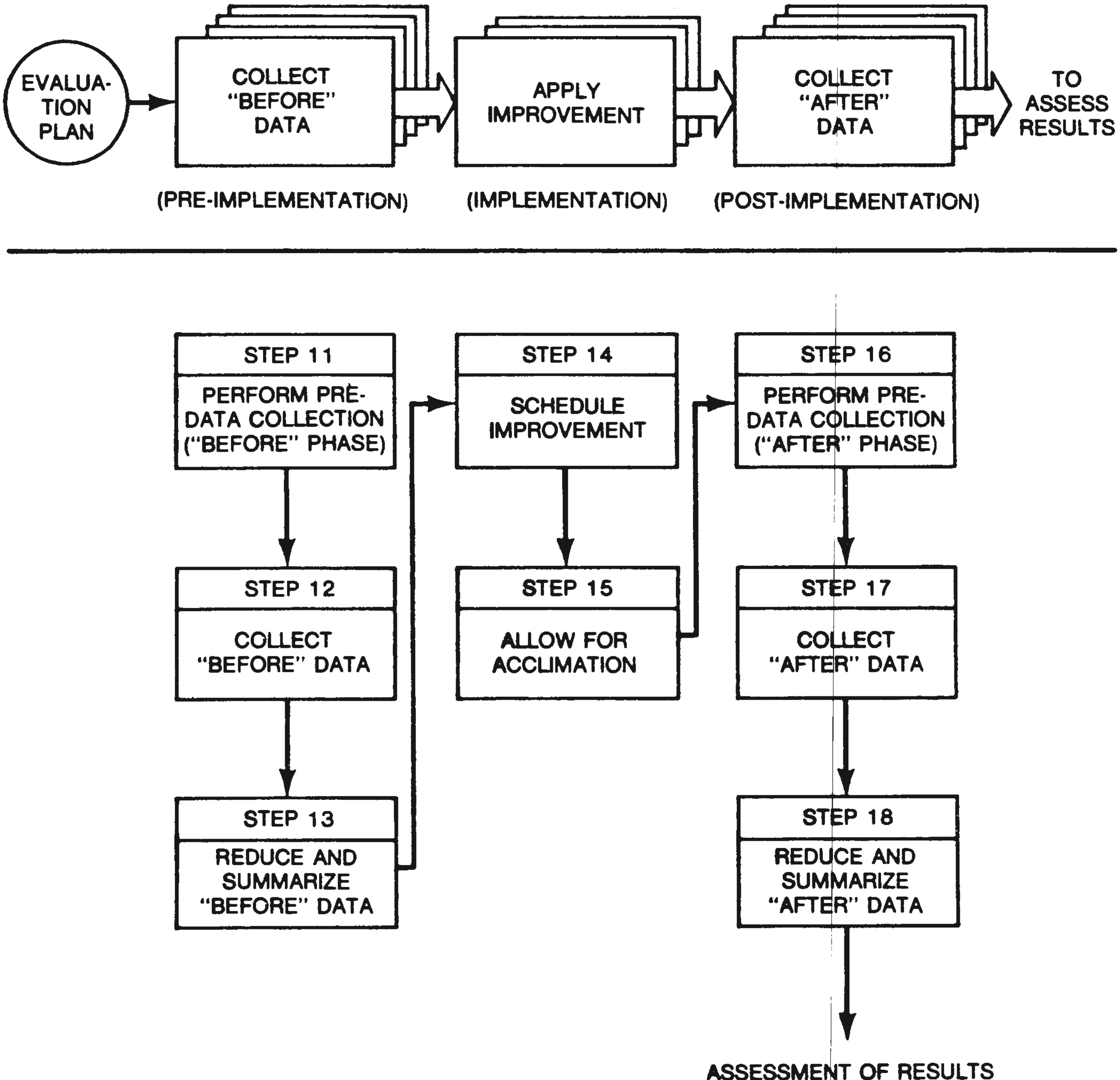


Figure 1-15.
Data Collection - Functional Flow

PART 2

GUIDELINES FOR PERFORMANCE DATA COLLECTION IN THE FIELD

INTRODUCTION

The material in this Part provides information on field data collection methods, procedures, and equipment for the collection of performance measures typically required to diagnose site problems and/or evaluate improvements. Much of the information comes from published sources. In some cases, this material is supplemented with discussions of field problems, solutions, guidelines, etc. based on experience in using the procedures and/or equipment.

Field data collection methods and procedures are discussed for the following measures.

- Erratic Maneuvers
- Traffic Conflicts
- Volume/Count
- Speed
- Intersection Delay
- Travel Time and Delay

ERRATIC MANEUVERS

Overview

Erratic maneuver (EM) observations (including encroachments and lateral placement deviations) constitute a major type of "surrogate" measure. Since EM's are usually site specific and measurement methods and procedures depend on site geometry and topography, only general guidelines can be provided. The crucial factors in collection of reliable EM data are: (a) Careful operational definitions of each EM including the traffic context in which it should be considered; (b) assurance of unobtrusive observation; (c) identification of appropriate sampling periods; and (d) selection of a location where they can be observed at the desired level of accuracy. Most of these factors are discussed in Part 1.

Measurement Methods and Equipment

Film or Video

Film or video is an ideal means of collecting reliable data. One its primary advantages as opposed to manual observation, is the sampling rate that can be achieved under high-volume situations. That is, with film or video, a 100 percent sample is usually possible whereas, with manual observation, some EM's can be missed while the observer is scoring a maneuver on a data collection form. This is particularly true if the observational task involves scoring numerous maneuvers and the data collection forms are not properly designed. Under low-volume conditions, this advantage of film or video may not be realized.

Another advantage of film or video is that it provides a permanent record. Thus, a number of correlates such as the traffic situation under which the EM's were observed can be assessed. Factors that may be missed by manual observers if not part of an operational definition can thus be considered after-the-fact. Further, "questionable" EM's can be viewed by a number of individuals, and a consensus reached, thereby improving data reliability. It should be noted that EM's to be scored from film or video require the same operational definitions as those which are manually observed.

For situations which require observation of a large number of EM's, film or video data collection can also reduce the number of field personnel. A camera and operator can frequently be used in place of two or three observers. It should be kept in mind that the camera operator can, given allowances in the schedule for changing film or tape cassettes, be used to collect supplemental EM's via direct observation as well as other types of data such as counts. The primary disadvantage of film or video is the data reduction time required. While film or video data reduction time can vary considerably depending upon the number and types of EM's being observed, it will, in any case, require more reduction time than data collected manually.

Camera Location

In addition to the above factors, the final decision regarding the use of film or video vs. manual observation rests with whether there is an adequate location from which to film or tape. Generally, a location above and behind the area of interest, e.g. an overpass, is best. This enables the camera and operator to be out of view of the traffic stream. However, even with this sort of a vantage point, some care must be taken to camouflage or hide the equipment and operator from traffic. Otherwise, the equipment/observer location and activity is likely to be detected by traffic traveling in the opposing direction and broadcast via CB radio. Obtrusiveness should be checked to determine whether traffic has detected the data collection location.

In situations where the camera location is not ideal, it may be difficult to determine whether or not all data can be captured. If the EM's for which capture is uncertain are critical, it is advisable to obtain pilot test data before making the final decision on data collection. Since some of the EM's of interest may not occur frequently, the most rapid means of evaluating the camera location is to perform a "ground truth" scenario (as described in Part I).

Another consideration with regard to camera location is the ability to detect references on the processed film or tape. That is, if it is necessary to identify the location of certain maneuvers, e.g., lane change location, point-of-entry into deceleration lane, etc., then references must be identified for data reduction. These references can be "natural" such as pavement markings, pavement seams, guardrail posts, etc., or prepared specifically for data collection such as paint marks, tape, etc. The "ground truth" scenario can also be used to verify the visibility of references on the film or video tape.

Filming Considerations

When film is used, a larger format, e.g. 16 mm, provides slightly better resolution . However, Super-8 is generally adequate for most situations, and the associated costs are lower. Selection of film type depends on the anticipated light conditions during data collection. Resolution and visibility of reference marks, edgelines, etc. can be reduced considerably if the film speed (ASA rating) is incorrect for the light conditions. If the sampling periods are to extend over the entire day, at least two speeds of film should be used and the change times should be specified on the camera operator's schedule. Even if all data are to be collected in normally bright daylight hours, some higher speed film should be carried in the event that heavy cloud cover decreases the ambient brightness. Color film is recommended over black and white for all purposes because it provides more adequate differentiation between vehicles and references and generally eases the data reduction task. It is usually less costly to have color film processed.

A rate of 2 frames per second is usually adequate. This permits 100 percent "capture" for most types of EM's, and provides a convenient ½-hour block of data for each 50-foot cassette. While the use of film as the primary means of obtaining speed is not recommended due to the time required to reduce the data, there may be occasions where it is necessary to determine the speed of vehicles from the film. In situations where film derived speed data are required or where the size of the field crew must be kept to a minimum and film must serve double duty for EM and speed observations, it is necessary to use a frame rate of at least 8 frames per second.

Manual Observation

Since many sites do not have an adequate vantage point for obtaining accurate film or video data, or an agency may not possess the necessary equipment, manual observation may often be the only means of obtaining data. From the standpoint of data accuracy and reliability, the primary concerns in manual observation are: Adherence to the predetermined schedule and/or sampling requirements; adequacy of the observer location with respect to making accurate and reliable observations; adequacy of the data collection forms and/or the distribution of observational tasks with respect to the percentage of actual EM's which can be observed and notated accurately; and, assurance of the unobtrusiveness of the observers (See also Part I).

Guidelines for Collecting and Scoring

Erratic Maneuvers on Freeways

This material is abstracted from a report by Mast and Kolsrud* and is intended to provide guidelines for filming and scoring EM's on freeways. The information is also applicable to video and manual observation.

Selection of the field of view is very important. The best location is above and behind the area to be filmed with the camera centered at the mid-line of the field of interest. Overpasses about 1,200 feet upstream from the beginning of the area to be filmed are excellent. The maximum area which can reasonably be filmed and easily scored is about 800 feet. The location of the camera to the rear makes the camera and operator inconspicuous, critically important in field work. Cameras may also be mounted on trees, lamp poles, sign standards or, if necessary, on heavy duty tripods. The mount should be rigid because the field of view must remain constant throughout the filming process. The same field of view must, of course, be used in the "Before" and "After" phases of an evaluation.

From the processed film, total traffic volume or, at gore areas, volume of exiting and through traffic is counted. A variety of EM's may then be scored as "stopping in the gore," "stopping and backing" or "last minute lane changes." The "last minute lane changes" are

---

*Mast, T. M. and Kolsrud, G. S. Report FHWA-RD-73-21. Diagrammatic Guide Signs for Use on Controlled Access Highways, Federal Highway Administration, Washington, D.C., December 1972.

recommended for evaluating guide sign improvements as they have been related to driver route negotiation difficulty.

Erratic lane change maneuvers are deviations from an idealized track or trace through an interchange given a particular destination. The theoretical paths must be defined for both exiting and through traffic (both groups should be assessed) and differ for different types of interchange geometry.

Figure 2-1 shows optimum paths (solid lines) for exiting and through traffic at three types of exits, and some of the maneuvers which may be defined as erratic or deviating from these ideal paths (dotted lines). At gore areas, the frequency of erratic maneuvers made by exiting vehicles is usually expressed per thousand exiting vehicles and the frequency of erratic maneuvers by through vehicles may be expressed per thousand through vehicles. Such expression permits comparison of these measures across interchanges whereas expression per thousand total traffic volume does not (because the likelihood of an erratic maneuver being made by an exiting vehicle is to some extent a function of the proportion of traffic which actually does exit).

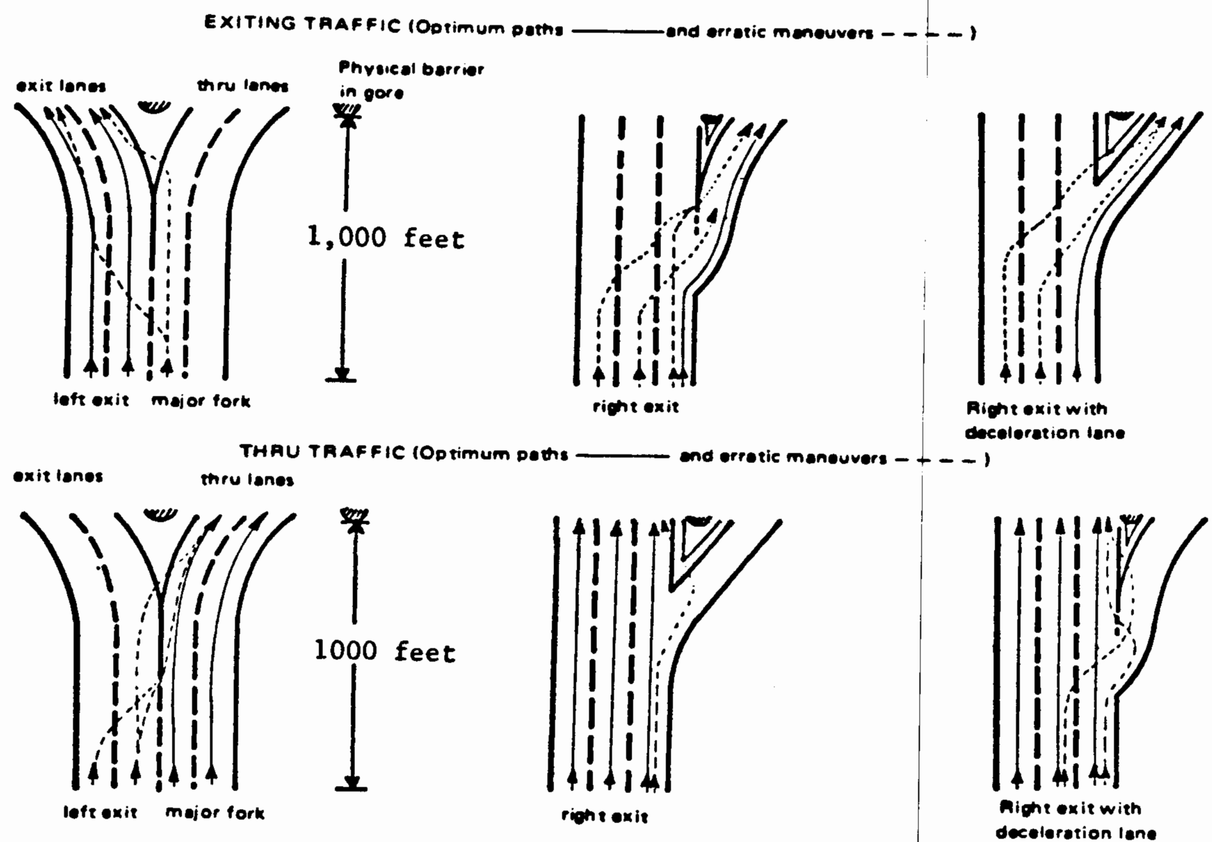


Figure 2-1. **Optimum Paths and Erratic Maneuvers for Exiting and Through Traffic at Freeway Exit Gores**

At guide sign locations upstream from the gore area, different maneuvers must be defined. Such definition should be done in terms of the behavior which will be required at the gore. Two types can be distinguished: "Preparatory" and "through" maneuvers. A preparatory maneuver means preparation for exiting. This is movement into the right-most lane for an upcoming right exit or into the left lane for an upcoming left exit. A through maneuver is one which could be related to proceeding through the interchange without exiting. For a right exit interchange, a through maneuver is a lane change <u>out</u> of the right lane. For a left exit interchange, a through maneuver is a move <u>out</u>

of the left-most lane. At major forks, preparatory and through maneuvers are movements across the midline from the lanes which will fork in either direction. Figure 2-2 shows preparatory and through maneuvers for right exit, left exit and major fork interchanges at an advance or exit direction sign location.

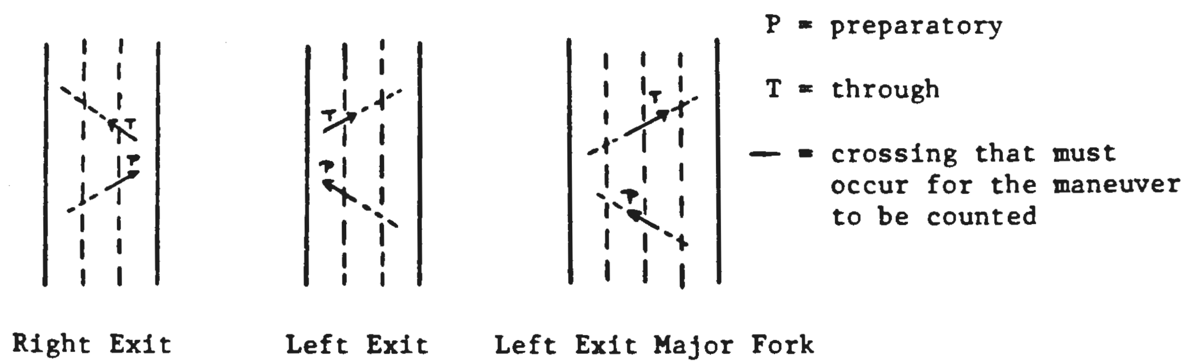


Figure 2-2. **Preparatory and Through Maneuvers Upstream of Exit Gores**

At right exits, the lane change must involve the right-most lane but may involve one or more adjacent lanes. At left exits, the lane change must involve the left-most lanes. At major forks, the lane change must involve crossing the midline. No scoring zone is shown since this is partly a function of available camera locations. About 800 feet of roadway can generally be covered which may extend from the sign upstream or from the sign downstream or may be arrayed symmetrically around the sign.

Since the actual vehicles which will exit are unknown at upstream sign locations, the incidence of preparatory and through maneuvers should be expressed per thousand total traffic volume.

TRAFFIC CONFLICTS

Overview

The information in this section has been abstracted from Appendix H "Procedures Manual for Traffic Conflicts Observers" and Appendix I "Instructor's and Engineers Guide" contained in NCHRP Report 219*. The procedures for the Traffic Conflicts Technique (TCT) provide a systematic method of observation and measurement of vehicle conflicts at intersections. The TCT material has been modified to reflect the use of traffic conflicts data as MOE's for a Positive Guidance project. When a traffic conflicts study is to be performed, readers should refer to NCHRP Report 219 for a full treatment of the subject.

Generally speaking, traffic conflicts data collection involves manual observation. However, given an adequate vantage point, it is also possible to collect data using film or video.

Traffic Conflicts Definitions

General Definition

A traffic conflict is an event involving two or more road users, in which the unusual action of one user, such as a change in direction or speed, places the other user in danger of a collision unless an evasive maneuver is taken. Generally speaking, the road users are drivers, but the definition also includes pedestrians and cyclists.

---

*Glauz, W. D. and Migletz, D. J. NCHRP Report 219. Application of Traffic Conflict Analysis at Intersections. Transportation Research Board, Washington, D.C. February 1980.

The action of the first user is unusual because it is not what one would expect most drivers to do under the same circumstances. (But, it does not have to be violent or extremely rare!) An example is when a driver brakes while going through an intersection even though there is no cross traffic. This restriction does, however, rule out actions that nearly all drivers take under the same conditions, such as stopping for a stop sign or red traffic signal, or reducing speed before turning. Thus, traffic conflicts do not include actions that result from obeying a traffic control device or that are normal responses to the roadway.

For a traffic conflict to occur, an actual impending collision is not necessary. An action or a maneuver that merely threatens another user with the possibility of a collision is sufficient. Also, some collisions occur without evasive maneuvers. They are included as extreme cases under this broad definition.

An intersection traffic conflict is described as an event involving several stages as follows:

Stage 1. One vehicle makes some sort of unusual or unexpected maneuver.

Stage 2. A second (conflicted) vehicle is placed in danger of collision.

Stage 3. The second vehicle reacts by braking or swerving.

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

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

Within this framework, a basic set of operational definitions can be stated, corresponding to the different types of maneuvers. Overall, 9 basic intersection conflict situations are useful in pinpointing operational or safety problems, and several others may be important in special situations. The following paragraphs describe each one. All are described from the viewpoint (direction of travel) of a driver that is being conflicted with (the second vehicle) rather than from that of the road user creating the conflict situation.

Operational Definitions - Basic Conflicts

Left-Turn, Same-Direction Conflict. A left-turn, same-direction conflict occurs when the first vehicle slows to make a left turn, thus placing a second, following vehicle in danger of a rear-end collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-3).

Right-Turn, Same-Direction Conflict. A right-turn, same-direction conflict occurs when the first vehicle slows to make a right turn, thus placing a second, following vehicle in danger of a rear-end collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-4).

Slow-Vehicle, Same-Direction Conflict. A slow-vehicle, same-direction conflict occurs when the first vehicle slows while approaching or passing through an intersection, thus placing a second, following vehicle in danger of a rear-end collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-5). The reason for the vehicle's slowness may not be evident, but it could simply be a precautionary action, or a result of congestion or some other cause beyond the intersection.

Opposing Left-Turn Conflict. An opposing left-turn conflict occurs when an oncoming vehicle makes a left turn, thus placing a second vehicle, going in the other direction, in danger of a head-on or broadside collision. The conflicted vehicle brakes or swerves, then continues through the intersection (see Figure 2-6). By convention, in this and the following conflict situations, the conflicted vehicle is presumed to have the right-of-way, and this right-of-way is threatened by some other road user. Situations such as a "conflicted" vehicle placed in danger of a collision because it is running a red light, for example, are not treated as traffic conflicts.

Right-Turn, Cross-Traffic-From-Right Conflict. A right-turn, cross-traffic-from-right conflict occurs when a vehicle approaching from the right makes a right turn, thus placing a second vehicle in jeopardy of a broadside or rear-end collision. The second vehicle brakes or swerves then continues through the intersection (see Figure 2-7 for the directions of the two vehicles).

Left-Turn, Cross-Traffic-From-Right Conflict. A left-turn, cross-traffic-from-right conflict occurs when a vehicle approaching from the right makes a left turn, thus placing a second vehicle in danger of a broadside collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-8).

Thru, Cross-Traffic-From-Right Conflict. A thru, cross-traffic-from-right conflict occurs when a vehicle approaching from the right crosses in front of a second vehicle, thus placing it in danger of a broadside collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-9).

Left-Turn, Cross-Traffic-From-Left Conflict. A left-turn, cross-traffic-from-left conflict occurs when a vehicle approaching from the left makes a left turn, thus placing a second vehicle in danger of a broadside or rear-end collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-10).

Thru, Cross-Traffic-From-Left Conflict. A thru, cross-traffic-from-left conflict occurs when a vehicle approaching from the left crosses in front of a second vehicle, thus placing it in danger of a broadside collision. The second vehicle brakes or swerves, then continues through the intersection (see Figure 2-11).

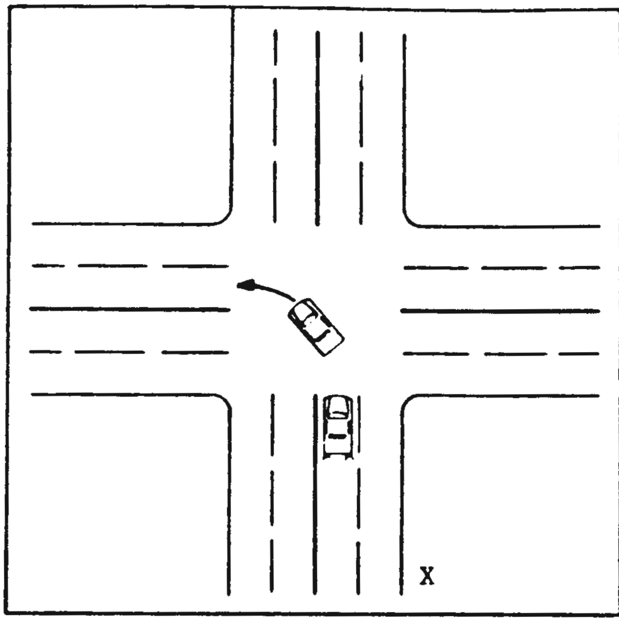


Figure 2-3. Left-turn same direction conflict.

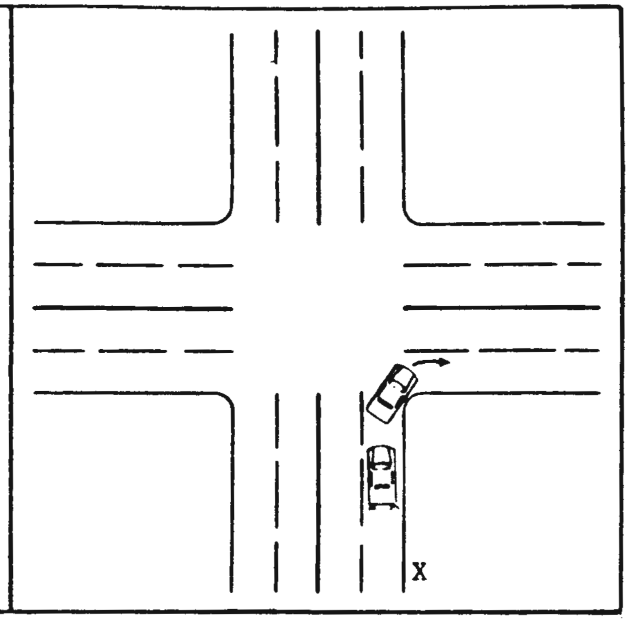


Figure 2-4. Right-turn, same direction conflict.

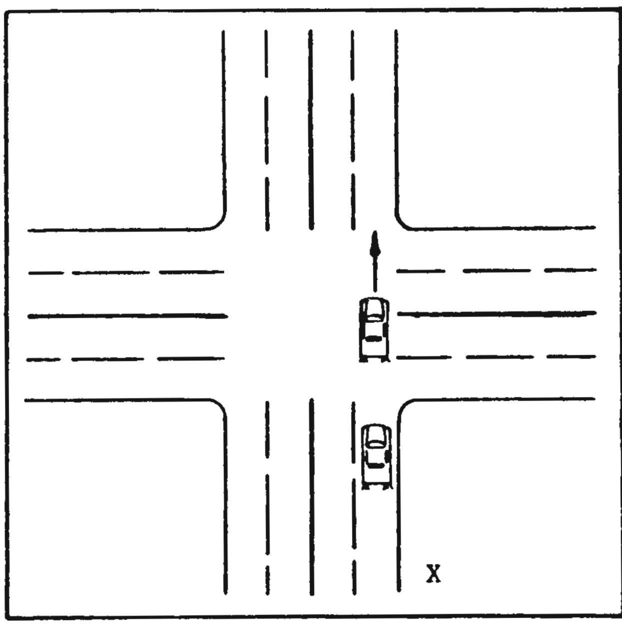


Figure 2-5. Slow-vehicle, same direction conflict.

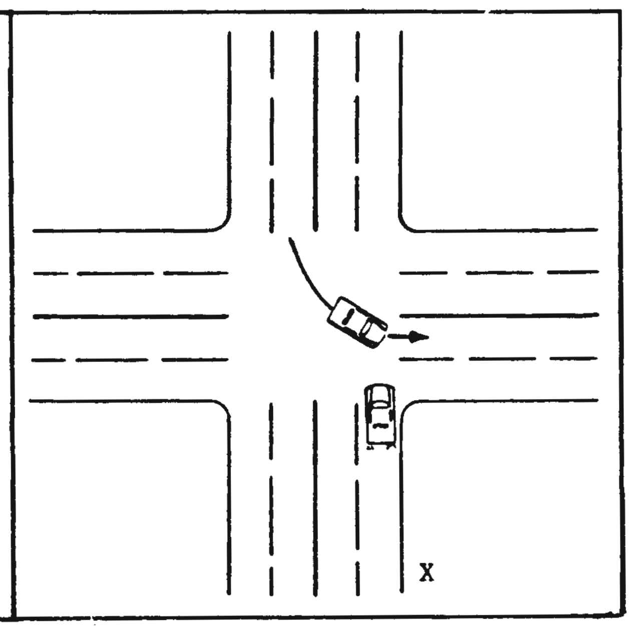


Figure 2-6. Opposing left-turn conflict.

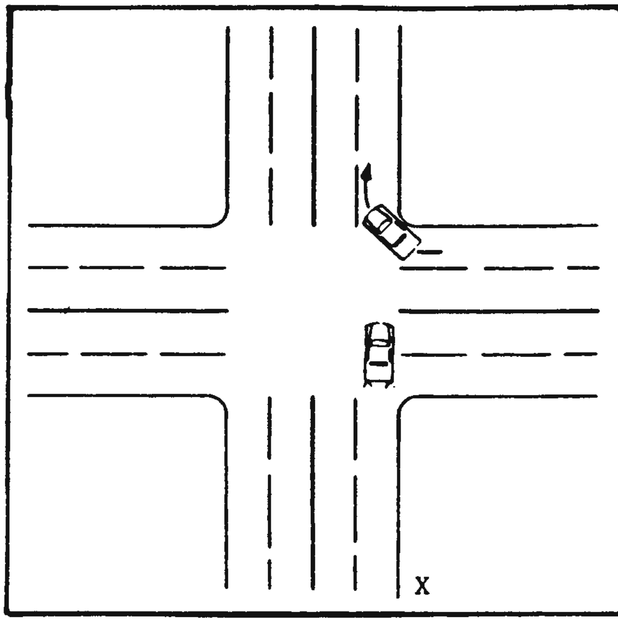


Figure 2-7. Right-turn, cross-traffic-from right conflict.

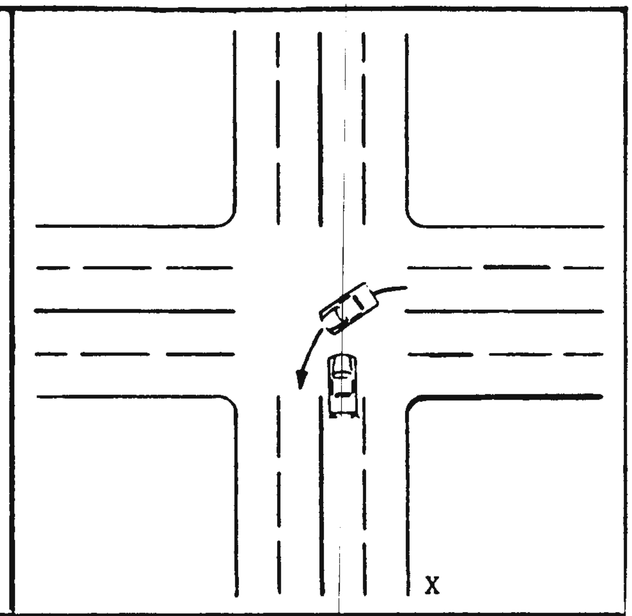


Figure 2-8. Left turn, cross-traffic-from right conflict.

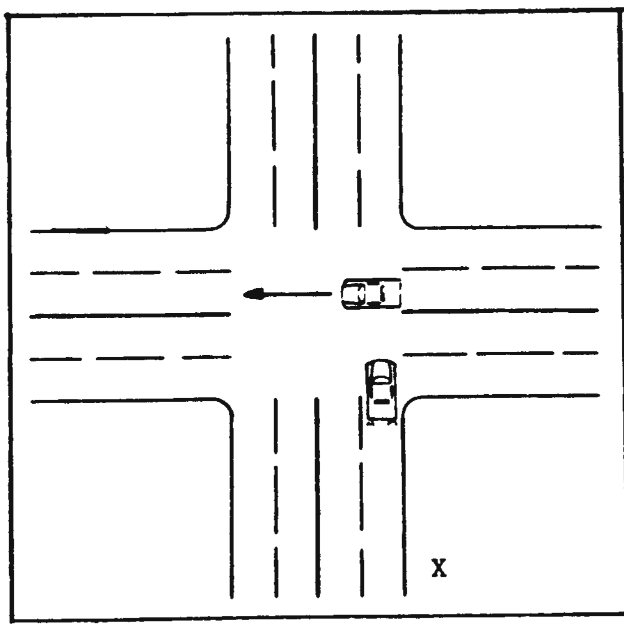


Figure 2-9. Thru, cross-traffic-from right conflict.

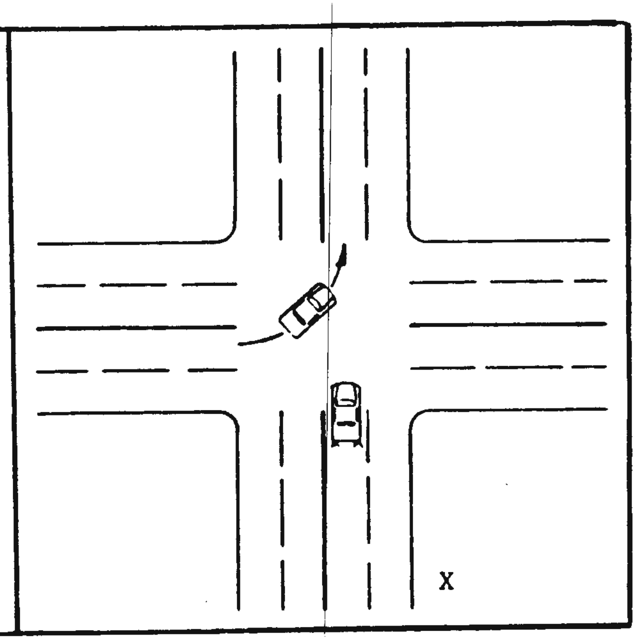


Figure 2-10. Left-turn, cross-traffic-from left conflict.

Operational Definitions - Secondary Conflicts

Secondary Conflicts. In the foregoing nine conflict situations, when the second vehicle makes an evasive maneuver, it may place yet another road user (a third vehicle) in danger of a collision. This type of event is called a secondary conflict. Nearly always, the secondary conflict will look much like a slow vehicle, same-direction conflict (or a lane-change conflict, which has not yet been described). The difference is that, in a secondary conflict, the conflicted vehicle is responding to a vehicle that, itself, is in a conflict situation (see examples in Figures 2-12 and 2-13). By convention, do not count more than one secondary conflict for any initial conflict. Even if a whole line of cars stops because the first one turns left, count it as just one secondary conflict.

Lane Change Conflicts. Under certain special conditions, one may be asked to watch for and record other types of traffic conflicts. One of these is the lane-change conflict, which occurs when a vehicle changes from one lane to another, thus placing a second, following vehicle in the new lane in danger of a rear-end or side-swipe collision. The conflicted vehicle brakes or swerves, then continues through the intersection (see Figure 2-14). However, if the lane change is made by a vehicle because it is in danger itself, of a rear-end collision with another vehicle, the following vehicle in the new lane is said to be faced not with a lane-change conflict situation, but with a secondary conflict situation.

Right-Turn, Cross-Traffic-From-Left Conflict. Another unusual conflict is the right-turn, cross-traffic-from-left conflict. It occurs when a vehicle approaching from the left makes a right turn across the center of the roadway and into an opposing lane, thus placing a vehicle in that lane in danger of a head-on collision. The conflicted vehicle brakes or swerves, then continues through the intersection (see Figure 2-15). This conflict is sometimes observed when the cross street is narrow, or when large trucks or buses make right turns. Note that the first vehicle must cross the center line for there to be a conflict!

Opposite Right-Turn-On-Red Conflict. An opposing right-turn-on-red conflict can only occur at a signalized intersection with a protected left-turn phase. It happens when an oncoming vehicle makes a right-turn-on-red during the protected left-turn phase, thus placing a left turning, conflicted vehicle (which has the right-of-way) in danger of a broadside or rear-end collision. The conflicted vehicle brakes or swerves, then continues through the intersection (see Figure 2-16).

Pedestrian Conflicts. There can also be pedestrian conflicts. They occur when a pedestrian (the road user causing the conflict) crosses in the front of a vehicle that has the right-of-way, thus creating a possible collision situation. The vehicle brakes or swerves, then continues through the intersection. Any such crossing on the near side or far side of the intersection (see Figures 2-17 and 2-18) is liable to be a conflict situation. However, the pedestrian movements on the right and left sides of the intersection are not considered to create conflict situations if the movements have the right-of-way, such as during a "walk" phase.

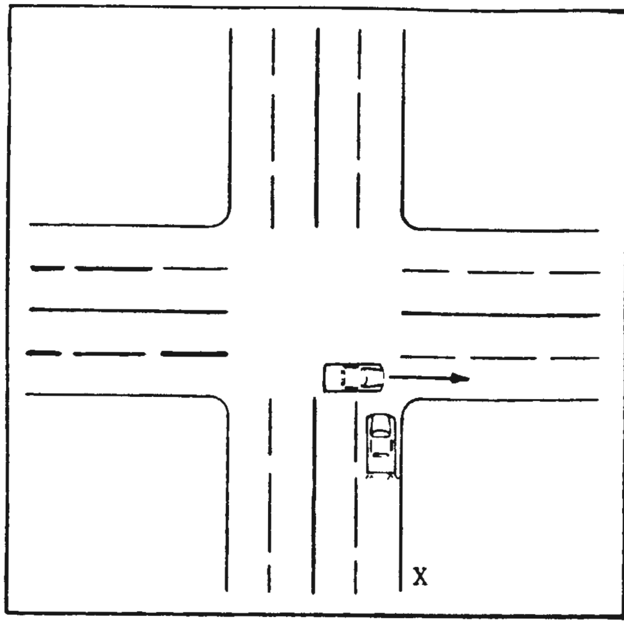


Figure 2-11. Thru, cross-traffic-from left conflict.

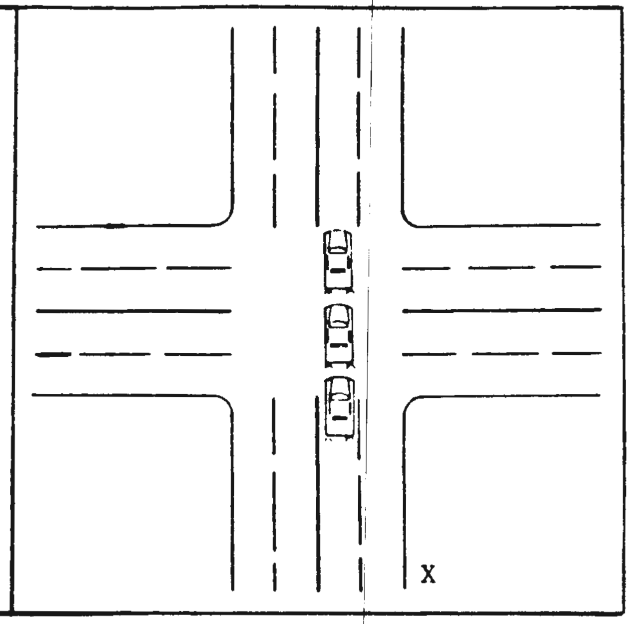


Figure 2-12. Slow-vehicle, same-direction secondary conflict.

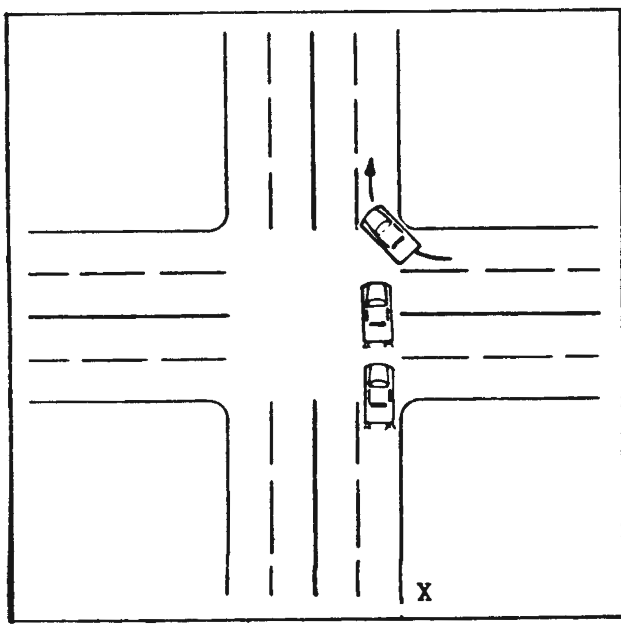


Figure 2-13. Right-turn, cross traffic-from-right secondary conflict.

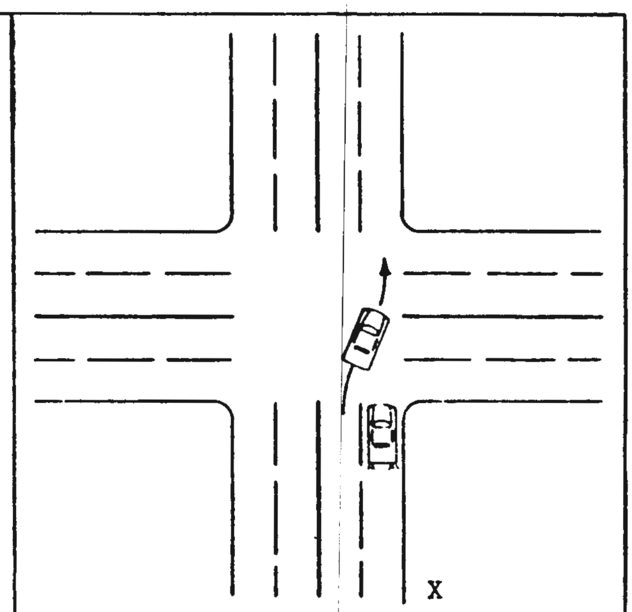


Figure 2-14. Lane-change conflict.

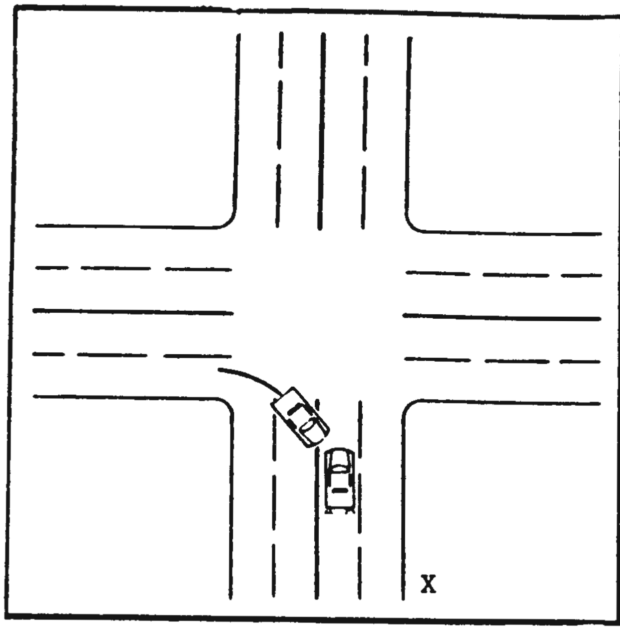


Figure 2-15. Right-turn, cross-traffic-from-left conflict.

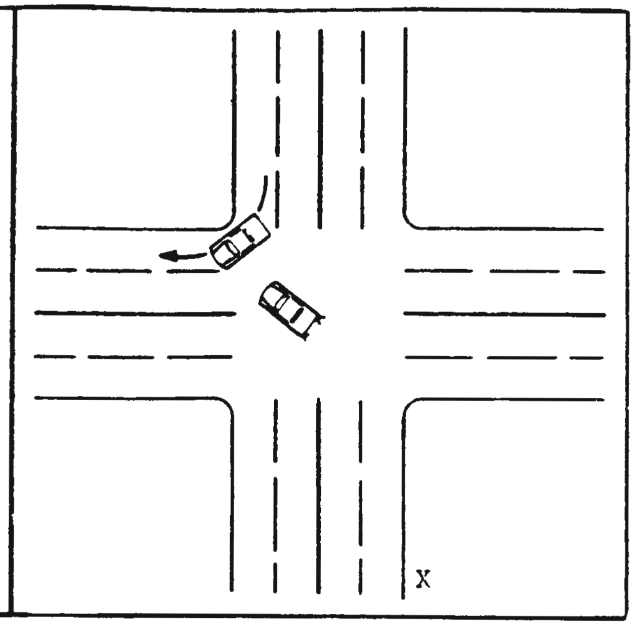


Figure 2-16. Opposing right-turn-on-red conflict.

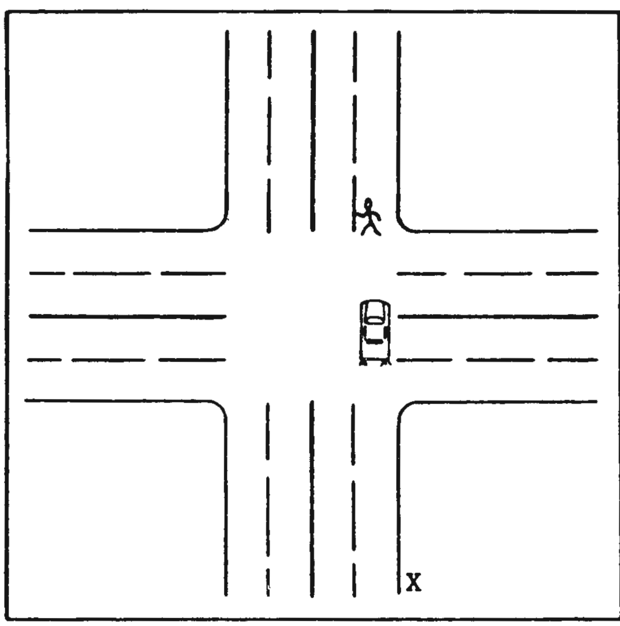


Figure 2-17. Pedestrian, far-side conflict.

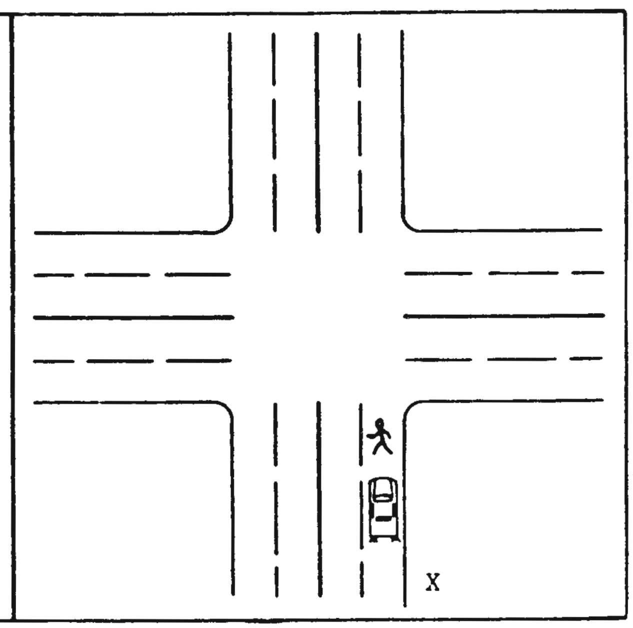


Figure 2-18. Pedestrian, near-side conflict.

Traffic Volumes

Along with a traffic conflicts survey, traffic volume counts, turning movement counts, or traffic classification counts are also made. These cannot be done by the observer making the traffic conflicts counts. They are done either by another person or by the same person before or after the traffic conflicts observations. See the following section for a discussion of Traffic Volume/Count Data.

One kind of traffic volume is always observed and recorded along with the traffic conflicts. That is the mainline, one-way volume. All vehicles moving into the intersection in the same direction as the traffic being observed are counted.

Starting the Traffic Conflicts Survey

A traffic conflicts survey includes making conflicts counts along with collecting other data needed to make a complete study package. Since the material presented in this volume discusses data collection activities designed for a Positive Guidance project, some information pertaining to a traffic conflicts study has been omitted. Readers should refer to NCHRP Report 219 if they are undertaking a full traffic conflicts study. It is noted that the material in Part 1 overlaps many of the pre-data collection activities described in NCHRP 219.

Preparing for the Survey

Before leaving for the study location, all of the equipment and materials needed for the survey should be assembled. These include:

- Observation procedures
- Schedule of survey locations
- Map showing location of test sites
- Supervisor's telephone number
- I.D. card
- Mechanical count board
- Tablet
- Pencils
- Watch
- Stop watch
- Camera with film (at least 20 exposures for a 4-leg intersection)
- Folding chair (optional)
- Water
- Data collection forms

The count board should have enough mechanical counters to record traffic volumes on all approaches of a standard 4-leg intersection (i.e., three counters per approach). This will be more than enough to record the most common traffic conflicts. Any additional counts can easily be recorded by hand. The count board can also be used, of course, to do traffic volume counts, if requested.

Spare pencils and a tablet for additional notes are a necessity. A watch is needed to note count start times, and a stop watch is needed to accurately determine signal timing. To adequately record the physical features of the study location about five photographs per approach are needed.

A folding chair should be included in case one is unable to use a car or if the temperature makes observation from the car uncomfortable. Drinking water is highly desirable, especially on hot days.

Finally, a complete set of data collection forms, including extras, are needed as follows: Physical Inventory,* On-Site Observation Report,* Traffic Volume Counts, and Intersection Conflicts.

Arriving at the Site

Since Positive Guidance planning activities include the selection of observation locations and site familiarization (see Part 1), material relative to these activities contained in NCHRP Report 219 has not been included.

Once at the site, the observer should park the vehicle off the roadway. One should not use a vehicle that could be mistaken for a police or other official car.

The observer should be hidden or inconspicuous from the traffic on the study approach. When a suitable location is not available along the right side of the approach, the observer will have to observe conflicts from the left side. Observer comfort and, of course, safety are also deciding factors.

Observation positions are not as critical during a standard traffic volume count, if required. Such counts usually include all turning movements on all approaches at the same time. The observer will then usually need an observation position much closer to the intersection,

---

*Part of the Site Survey and Operations Review for Positive Guidance projects.

which may even permit volumes to be recorded from a corner of the intersection. However, if conflicts and volumes are counted at the same time by two observers, the volume observer should also remain inconspicuous.

Once the observation positions are determined, the required number of data collection forms (this depends on the amount of data to be collected) should be prepared. All heading information should be completed and double checked before any data are collected. The count board has to be "zeroed." If there is more than one observer, watches will have to be synchronized. (Make sure that watches and stop watches are wound.)

For uniformity in the field study, observations should always start at the prescribed times, and count periods should always be of the prescribed length. To start on time, the observer will have to arrive at the test site at least 30 minutes before starting to count. This is the minimum time required to become familiar with the intersection and prepare for data collection. If there is much auxiliary data to be collected, the observer might have to arrive 1 hour before the start time.

A very important preliminary activity is to watch the traffic, and become familiar with the major traffic movements, the signalization characteristics, and any unusual activities. Also, locations of nearby driveways, parked vehicles, or other features that may cause traffic problems should be noted.

Conducting The Survey

After arriving at the site, the observer should make certain that one has proper supplies, checks basic traffic operations, etc.; the observer should then be ready to conduct the survey.

Time Scheduling

Whether the survey lasts for several hours or several days, the observation process is conveniently thought of as being in 1-hour blocks. The traffic engineer in charge will determine how many, and which, hours are to be used for this data collection.

For illustration, suppose a 1-hour block begins at 0800 (8:00 a.m.). Table 2-1 shows how the 1 hour is split up into several activities. During the first 20 minutes, the observer should observe and count traffic conflicts from one of the designated approach legs of the intersection. After 20 minutes, the count should be stopped and reported on the special forms and then the observer should move to the opposite approach and prepare for a second count starting on the half-hour. The same procedure should be followed on this approach. (If there are two observers, one will be alternating approaches every half-hour.) Then, the process should be repeated during succeeding hours, as required. Usually, after every 2 or 3 hours of a survey, a break will be scheduled.

Table 2-1. **A One-Hour Time Schedule**

0800	Start observing conflicts
0820	Stop observing conflicts, and record counts on data form
0825	Move to opposite approach leg
0830	Start observing conflicts
0850	Stop observing conflicts, and record counts on data form
0855	Move to opposite approach leg

For consistency, it is best to start counting exactly at the hour and half-hour marks. An exception can be made for signalized intersections, where the signal cycle may not be in phase with one's watch. In such cases, one should start observing after the hour or half-hour marks the first time the signal turns red for his/her approach. Then, a stop watch should be used in order to observe for just 20 minutes after the start. This should be coordinated with one's partner (if any), so both are counting at the same time.

Using the Count Board

At nearly all intersections a mechanical count board is necessary to "record" conflict counts. Some traffic events happen very rapidly, so one's attention must be focused on the road and vehicles rather than on pencil and paper. After some practice, the count board allows one to record the events "by touch," without looking down. The type of count board is not important. One designed for making traffic volume counts is very acceptable. Another is shown in NCHRP Report 219.

The mechanical counters should be used to record the most common occurrences (the ones with the highest counts). The one that is most frequent, clearly, is the traffic volume count on the approach leg. The counter used for this event should be positioned in the most convenient place--maybe the lower right corner.

The other kinds of events, listed in order of decreasing frequency, are as follows:

1. Most frequent:
   Left-turn, same-direction conflict.
   Slow-vehicle, same-direction conflict.
   Right-turn, same-direction conflict.

2. Less frequent:
   Opposing left-turn conflict.
   Right-turn, cross-traffic-from-right conflict.
   Left-turn, cross-traffic-from-right conflict.
   Thru, cross-traffic-from-right conflict.
   Left-turn, cross-traffic-from-left conflict.
   Thru, cross-traffic-from-left conflict.

3. Least frequent:
   All secondary conflicts.
   All special conflicts.

It is recommended that the count board be used for the most frequent events. The least frequent events can be written directly on the forms when they occur.

Before a 20-minute count is begun, the observer should make sure that all counters are reset to zero. After the count is completed, all figures should be recorded from the counters to the form, and double checked. A common error is to reset the counters before recording the results, which obviously "erases" all the hard work. Do not make that mistake!

The Conflict Form

A recommended, general-purpose form for recording traffic conflict counts is shown in Figure 2-19. The heading information, which is self-explanatory, should be filled out in advance. The diagram in the upper right corner indicates the approach-leg numbering system. That is, traffic approaching from the north is on leg 1, etc. A separate traffic conflicts form should be used for each approach leg.

INTERSECTION CONFLICTS

Location ______________________ Leg Number ______________

Day ____________ Date ______________ Observer ______________________

Conflict - C, Secondary Conflict - SC

COUNT START TIME (MILITARY)	TOTAL APPROACH VOLUME	Left Turn Same Direction		Slow Vehicle		Right Turn Same Direction		Opposing Left Turn		Left Turn from Left		Cross Traffic from Left		Left Turn from Right		Cross Traffic from Right		Right Turn from Right							
		C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC
TOTAL																									

Severe Conflicts:

Possible Causes of Slow Vehicle Conflicts:

Other Notes and Comments:

Figure 2-19.
Traffic Conflicts Recording Form

The start time should be recorded for each 20-minute count in the first column. If, for any reason, the count was for other than 20 minutes, record actual time in the left margin. The results should be copied from the count board into the proper columns for the form, making sure all marks are legible.

The common types of conflicts each have separate columns for recording. (Note, however, that at signalized intersections the cross-traffic conflicts may not be very common.) If any special types of conflicts are observed very often, or if the traffic engineer requests any extra kind of counts, additional columns are provided for their recording. It should be made certain that they are clearly labeled.

Sometimes, conflicts of a severe nature will be observed, such as obvious "diving" of the front end of a vehicle, squealing of brakes, rubber skid marks, violent swerves, honking of horns, shaking of fists, etc., and even collisions. Special note should be made of such conflicts. These notes are very important, especially if such severe conflicts occur very often.

Try to determine the causes for same-direction conflicts. Is the problem just past the intersection (a driveway, shopping center, traffic back-up, etc.), a "blind" spot, unclear or missing pavement markings, erratic signal operation or what? Also, by using one's best judgment, comments should be added about what is thought to be wrong with the traffic operations at the intersection and how they can be improved.

On completion of a survey, or portion thereof, the counts should be added in each column. If one is working with a partner, data sheets should be exchanged and each other's forms checked for completeness and accuracy. Otherwise, one's own forms should be double checked, making sure all the heading information is correct, all blanks are filled out, and all entries are clearly readable.

Collecting Auxiliary Data

Traffic conflict counts are not meaningful unless they can be related to the existing site conditions. The site data needed may include: physical inventory, intersection diagram, signal timings, photographs, on-site observation report, and traffic volumes. Positive Guidance projects require a Site Survey and Operations Review procedure that should provide the physical inventory, intersection diagram, signal timings, photographs and on-site observation reports. The reader should refer to NCHRP Report 219 for additional information on these activities.

Traffic volume data collection is discussed in the next section of this volume. Each agency has standardized procedures for collecting most of these data, but general guidelines are given in NCHRP Report 219 using example forms.

Special Problems

Changes in the weather may interrupt or postpone the conflict study. Normally, observations are not performed during inclement weather, such as rain, snow, or fog.* If the roadways are completely wet or visibility is reduced, observation should be stopped. The observer

*Unless the Positive Guidance Analysis shows such conditions to be germane, and data are deemed necessary for diagnostic purposes.

should do other tasks, such as collecting auxiliary data, until roads are in a near-normal condition or until a decision is made to postpone data collection for the day.

Other problems may also occur. Before a site is scheduled for study, it should be determined if any construction is planned that could alter the normal traffic-flow patterns. Unscheduled emergency repairs by the street department or utility companies will also disrupt flow. If this occurs, the observer should speak with the person in charge to learn the extent of the work and how long it will take. Other disruptive events such as accidents, stalled vehicles, police arrests, etc., will also occur from time to time. The observer should always have a contingency plan that can be adopted when problems occur.

Safety Considerations

An important item that should not be overlooked is safety. Any time observers are working near moving traffic there will be some drivers that will not see them. Of course, when collecting volume and conflict data, the observer should be hidden. But when walking along the roadway or taking pictures from the middle of a lane, the observer must be seen. Clothing that will attract attention should always be worn. All street and highway agencies maintain a supply of fluorescent orange vests for this purpose. If the observer is to enter the roadway, it should be done during a gap in the flow of traffic. The observer should not try to stop or direct traffic.

Data Analysis

The conflict data, as collected in the field, are usually not sufficient for decisionmaking. They must be compiled and analyzed to determine if they indicate favorable or unfavorable traffic operations, typical or unusual situations, an improvement or a worsening.*

Various levels of sophistication can be used in the statistical analyses. One can automate the process using computers or analyze the data by hand. This decision depends on the amount of data and the level of analysis.

This discussion assumes that manual procedures of a fairly straightforward nature will be applied. Users can easily automate these steps, if desired. Such automation is particularly useful if a data base is to be developed for future comparisons.

Initial Review

As the data are returned from the field, the first step should be an immediate scanning for completeness or obvious errors. This should be done while things are still fresh in the minds of the observers. Many simple mistakes can readily be corrected at this time, but not after a few days when details are forgotten.

---

* See Volume II for a discussion of the use of traffic conflict data in an evaluation.

Some of the items to check are indicated as follows:

- Accountability for all forms. Are any missing and, if so, why?
- Proper completion of heading information. Are all blanks filled? Are leg numbers and observation times consistent on all forms? Is observer's name on the form?
- Are all data entries completed? Are they legible? Do they "make sense"?
- Are there comments? Are they clear and understandable? Are there any observer questions?

Data Summations

The raw conflict counts, themselves, are not as useful as certain sums and rates. Figure 2-20 shows a form that can be used in the office to assist in the manual calculation of these quantities.

As a first step, combine the conflicts and secondary conflicts in each category for every 20-minute period. Assume that the data in Figure 2-20 were collected in the field. Figure 2-21 shows the summary form of these same data. For example, at 1730 hours the observer recorded four (4) left-turn, same-direction conflicts, and three (3) left-turn, same-direction secondary conflicts. Enter the sum (7), on the analysis form. Continue this process for each period and category.

Next, determine the sums of the counts in the various categories to create the new categories shown in the last four columes of Figure 2-21. The components of each sum should be self-evident. These sums are the most likely to be suggestive of the presence or lack of operational or safety problems. The individual counts, from which the sums are derived, provide more detailed information that may help in pinpointing specific areas or suggesting certain countermeasures. Note that no grand total (e.g., all conflicts) is calculated. Such a total is not particularly useful as a diagnostic or evaluative measure.

Next, create the totals for each approach leg for the time covered by the data sheet. This time is typically 4 to 8 hours within 20 minutes of observation per hour for an observer on each leg. That is, 4 to 8 entries may be on a sheet, which would correspond to 80 to 160 minutes actual observation on that leg. Figure 2-21 also shows these totals.

The final step is to divide each total by the total (one-way) traffic volume counted for the leg and recorded on the Intersection Conflicts sheet in the field (See Figure 2-19). This yields the set of conflict rates. It is convenient, during this step, to multiply the answers by 1,000 so that more convenient numbers result. In Figure 2-21, with 16 left-turn, same-direction conflicts and 281 total approach vehicles, the conflict rate is (16/281) (1,000) = 56.9 conflicts per 1,000 vehicles.

INTERSECTION CONFLICTS

Location **MAPLE AND PINE** Leg Number **3**

Day **TUESDAY** Date **JULY 18, 1978** Observer **SMITH**

Conflict - C, Secondary Conflict - SC

COUNT START TIME (MILITARY)	TOTAL APPROACH VOLUME	Left Turn Same Direction		Slow Vehicle		Right Turn Same Direction		Opposing Left Turn		Left Turn from Left		Cross Traffic from Left		Left Turn from Right		Cross Traffic from Right		Right Turn from Right							
		C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC
1400	31	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0						
1500	47	2	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0						
1630	86	3	3	5	1	2	0	0	0	1	0	0	0	2	0	0	0	2	0						
1730	117	4	3	5	1	2	1	1	0	0	0	0	0	1	0	0	0	2	0						
TOTAL	281	9	7	11	2	7	1	1	0	1	0	0	0	3	0	2	0	4	0						

Severe Conflicts: **NONE**

Possible Couses of Slow Vehicle Conflicts:

Other Notes and Comments:

Figure 2-20.
Illustrative Field Data

INTERSECTION CONFLICT SUMMARY

Location MAPLE AND PINE Leg Number 3

Day TUESDAY Date JULY 18, 1978 Observer SMITH

COUNT START TIME (MILITARY)	Left Turn Same Direction	Slow Vehicle	Right Turn Same Direction	Opposing Left Turn	Left Turn from Left	Cross Traffic from Left	Left Turn from Right	Cross Traffic from Right	Right Turn from Right	All Same Direction	All Cross Traffic from Left	All Cross Traffic from Right	All Cross Traffic
1400	0	0	2	0	0	0	0	1	0	2	0	1	1
1500	3	1	1	0	0	0	0	1	0	5	0	1	1
1630	6	6	2	0	1	0	2	0	2	14	1	4	5
1730	7	6	3	1	0	0	1	0	2	16	0	3	3
TOTAL	16	13	8	1	1	0	3	2	4	37	1	9	10
RATE	56.9	46.3	28.5	3.6	3.6	0	10.7	7.1	14.2	131.7	3.6	32.0	35.6

Comments:

Figure 2-21.
Illustrative Summary Data

TRAFFIC VOLUME/COUNT DATA

Overview

Projects employing erratic maneuvers and/or traffic conflicts MOE's require volume/count data so that rates can be determined. All projects involving "Before/After" evaluations require count data, since volumes may differ in the two collection periods. In this case, rates (proportions) are the best means of statistically comparing the data. Frequently, vehicles counts will be required for each movement, e.g., exiting vs. through vehicles, turning vs. non-turning vehicles, etc. Also, where projects are designed to provide a time sampling of MOE's, counts must be taken for each specific time period during which the observations are made. Where the time samples extend over an entire day, including commuter peaks, a comparison of rates for the various periods can sometimes provide insights as to the nature of the problem and/or help to identify the "target" group at which the improvement should be aimed, e.g., commuters vs. non-commuters.

When the performance characteristics of vehicles are relevant, for example, at a project involving a merging area, vehicle type is an important element of the count. When this activity is fairly complex, e.g., where several types of trucks and cars must be identified, it is advisable to provide the observers with some training and practice before the full scale data collection is initiated. If it is not possible to provide trained observers, or if it is necessary to conserve the number of field personnel used, film or video, if used for erratic maneuver observations can also be used to obtain volume and vehicle type data. With film or video, there are disadvantages due to increased data reduction time.

With regard to traffic mix, each vehicle type of interest should be operationally defined in clearly observable terms rather than being left to the judgment of the observer. This is particularly important for projects such as those where, for example, "truck" blockage of signs is assumed to be operative. For such a projects, it is not adequate simply to note performance with and without "trucks" as a lead vehicle. Rather, the vehicle types which produce visual blockage should be identified (e.g., tractor trailers, R.V.'s, vans, etc.) to avoid judgments. This is more critical when the project involves evaluation and when the same observer may not be used in both phases.

General Guidelines

While the guidelines given above apply to volume and count data taken in conjunction with driver performance MOE's, the following guidelines are applicable to all projects:

- As a general rule, counts taken during a Monday morning rush hour and a Friday evening rush hour in an urban area will show unusually high volumes.
- Most manual counts are taken during one or two hours of the morning peak, and during one or two hours of the evening peak on weekdays. Typical periods are 0700 through 0900 and 1600 through 1800 hours (7 a.m. to 9 a.m. and 4 p.m. to 6 p.m.). A 15-minute count interval is generally desirable. Highway capacity studies have determined, however, that 15-minute

intervals are not fully adequate to establish the Peak Hour Factor* (PHF) and that 5-minute counts are preferable. In fact, the use of cycle-by-cycle counts at a signalized intersection is desirable, to get the PHF and the Load Factor.**

- The highest volume hours at certain kinds of land uses such as high schools, hospitals, or factories may not coincide with regular street traffic, peak hours. The highest shopping center volumes are normally found on Saturday morning or early Saturday afternoon. High shopping loadings also occur on nights that regional department stores are open, and involve both an inbound peak (generally occurring between 1900 and 2000 hours), and an outbound peak from about 2000 to 2100 hours.

- Counts taken to record truck classification (size and weight) often span a total period of 12 to 16 hours.

- Traffic counts should normally not be taken on holidays,*** nor on the day before or after a holiday. Adverse weather conditions that could affect flow should be avoided, although a light rain will have little effect on industrial or office traffic.

- Seasonal factors must be considered in addition to the obvious recreational aspects. Counts involving school or college activities would be inaccurate if taken during the school vacation periods which would greatly diminish traffic volume. Shopping traffic is generally highest at Easter, Thanksgiving, Christmas, and during special events or sales.

---

*Peak Hour Factor is a ratio of the volume occurring during the peak hour to the maximum rate of flow during a given time period within the peak hour. It is measure of peaking characteristics, whose maximum attainable value is 1.0. The term must be qualified by a specified short period within the hour; this is usually 5 or 6 minutes for freeway operation and 5 to 15 minutes for intersection operation; for example, "a peak-hour factor of 0.80 based on a 5-minute rate of flow."

**Load Factor is a ratio of the total number of green signal intervals that are fully utilized by traffic during the peak hour to the total number of green intervals for that approach during the same period. Its maximum attainable value is 1.0.

***Unless the Positive Guidance analysis shows the holiday period to be when a problem occurs, or when it is desirable to collect EM or traffic conflicts data during a holiday period to maximize the opportunity to observe tourist traffic.

> Other abnormal conditions are produced by widespread labor strikes, recessions, energy shortages, and street or bridge repairs on the same or parallel routes. When counts must be taken during abnormal conditions, it is essential to note the unusual condition on the data collection forms.

Given these guidelines for the collection of count data, the material in this section, taken from the Manual of Traffic Engineering Studies,* provides information on measurement methods and equipment for a variety of different collection situations.

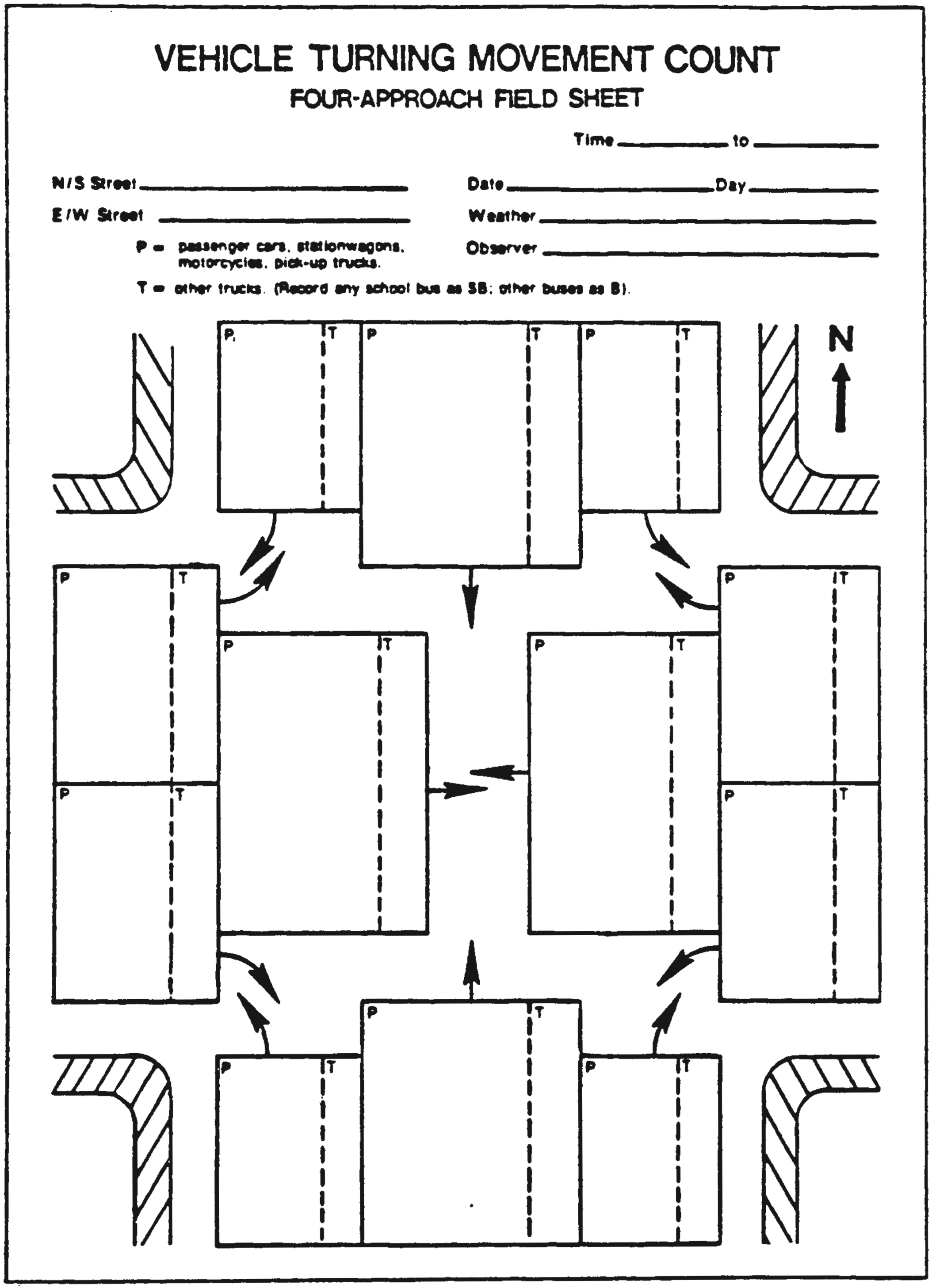
Manual Measurement Methods and Equipment

In its basic form, manual counting consists of one person with a pencil making tally marks on a field sheet. At low-volume intersections, all movements including vehicle classification can be tallied using a typical field sheet such as the one shown in Figure 2-22. Such studies can also include street crossings by pedestrians, subclassified as children or adults. At very low volume points, other data such as traffic control violations may also be recorded.

One person can handle 6 to 12 turning movements depending upon the degree of simultaneous flow and volumes. Thus, the typical intersection of a local/local or a local/collector intersection can be handled by one checker. At higher volume intersections--especially those controlled by traffic signals--it is usually necessary to have two or more persons counting the vehicular movements. Figure 2-23 shows a two-approach field sheet that may be used for this type of count. It is important that a north arrow be added to each field sheet and that the sheet be held in the correct position that corresponds to the north direction.

---

* This material is utilized by permission from the Institute of Transportation Engineers, 525 School Street, S.W., Suite 410, Washington, D.C. 20024.



VEHICLE TURNING MOVEMENT COUNT

FOUR-APPROACH FIELD SHEET

Time ________ to ________

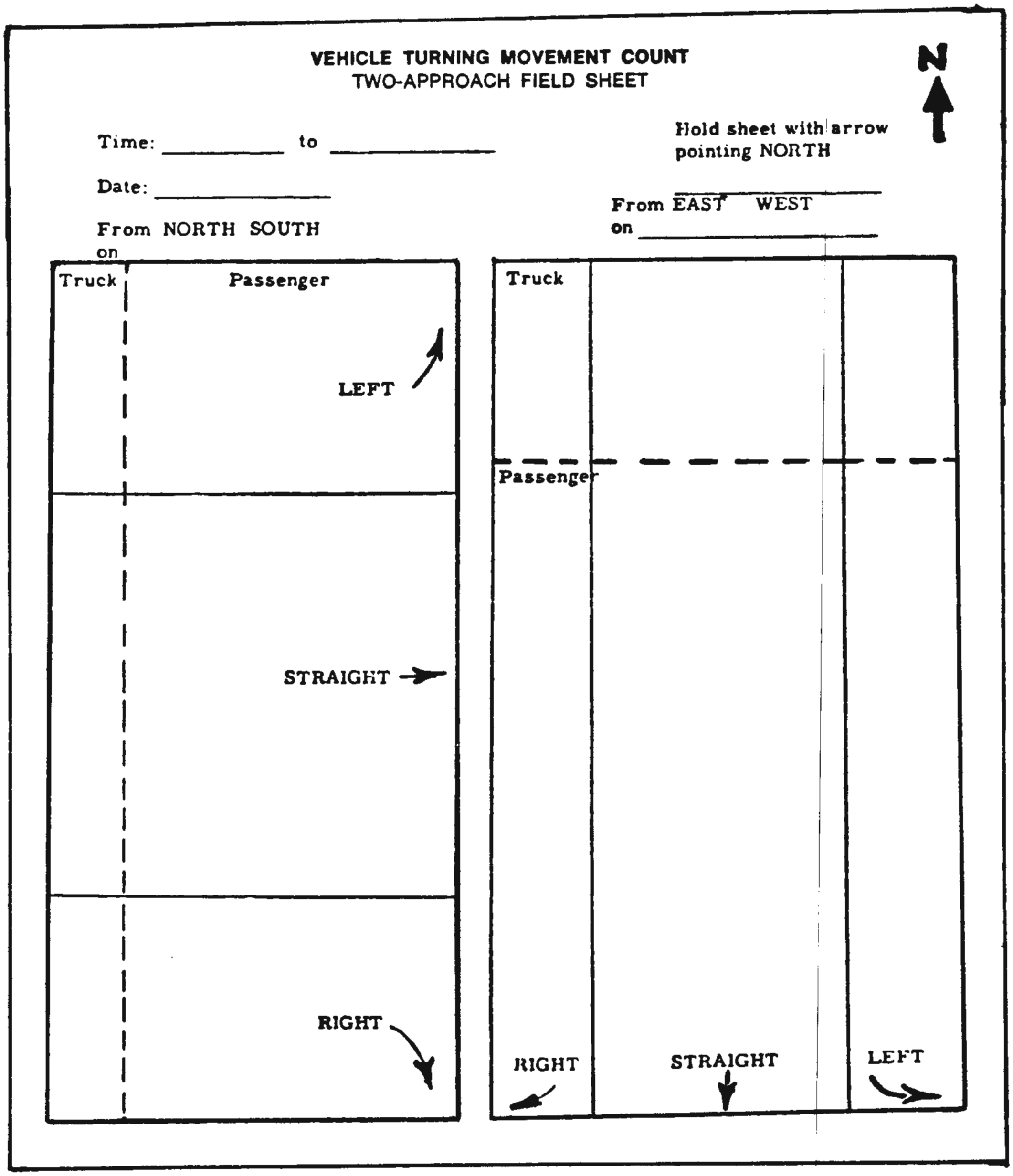
N/S Street ____________ Date ____________ Day ________

E/W Street ____________ Weather ____________

P = passenger cars, stationwagons, motorcycles, pick-up trucks. Observer ____________

T = other trucks. (Record any school bus as SB; other buses as B).

Figure 2-22.
Example of Intersection Field Sheet



VEHICLE TURNING MOVEMENT COUNT
TWO-APPROACH FIELD SHEET

Time: ________ to ____________

Date: ____________

From NORTH SOUTH
on

Hold sheet with arrow pointing NORTH

N

From EAST WEST
on ____________

Truck | Passenger

LEFT

STRAIGHT

RIGHT

Truck

Passenger

RIGHT | STRAIGHT | LEFT

Figure 2-23.
Example of 2-Approach Field Sheet for High Volume Intersection

When traffic conflict data are collected, NCHRP Report 219 recommends the form shown in Figure 2-24 be used to collect volume data.

Counts of traffic turning in and out of high-volume driveways may use a special form shown in Figure 2-25. The sheet also provides space for tabulation of pedestrian or bicycle traffic utilizing the sidewalk across which cars move in entering or leaving the driveway.

Vehicle classification can utilize a simplified passenger car/truck breakout. For such usage, cars, station wagons, pickup and panel trucks and motorcycles are classed as "P." Other trucks and buses are tallied as "T." School buses may be separately recorded as "SB."

A more detailed breakout of commercial vehicles, by numbers of axles and/or weight, is often required. The degree of truck classification should be related to the purpose of the count. Unless special classification is needed for roadway or bridge design data, the inclusion of pickups and panel trucks and other light trucks having only four tires as passenger cars is completely consistent with capacity and flow analysis. These vehicles have similar performance characteristics to passenger cars, whereas the acceleration capability of heavier trucks is decidely different. A simplified method of instructing traffic checkers into distinguishing trucks from passenger cars is to have them classify any vehicle having more than four tires as a truck, and any motor vehicle with two through four tires as a passenger car.

<u>TRAFFIC VOLUME COUNTS</u>

Location ____

Day ____________ Date ______________ Time Period ____________________

Observer ____

COUNT START TIME (MILITARY)	Leg No. ______			Leg No. ______			Leg No. ______			Leg No. ______		
	⤴	→	⤵	↰	↑	↱	↲	↓	↳	↖	←	↙
TOTAL												

NOTES AND COMMENTS:

Figure 2-24.
Traffic Volume Count (Conflict Data)

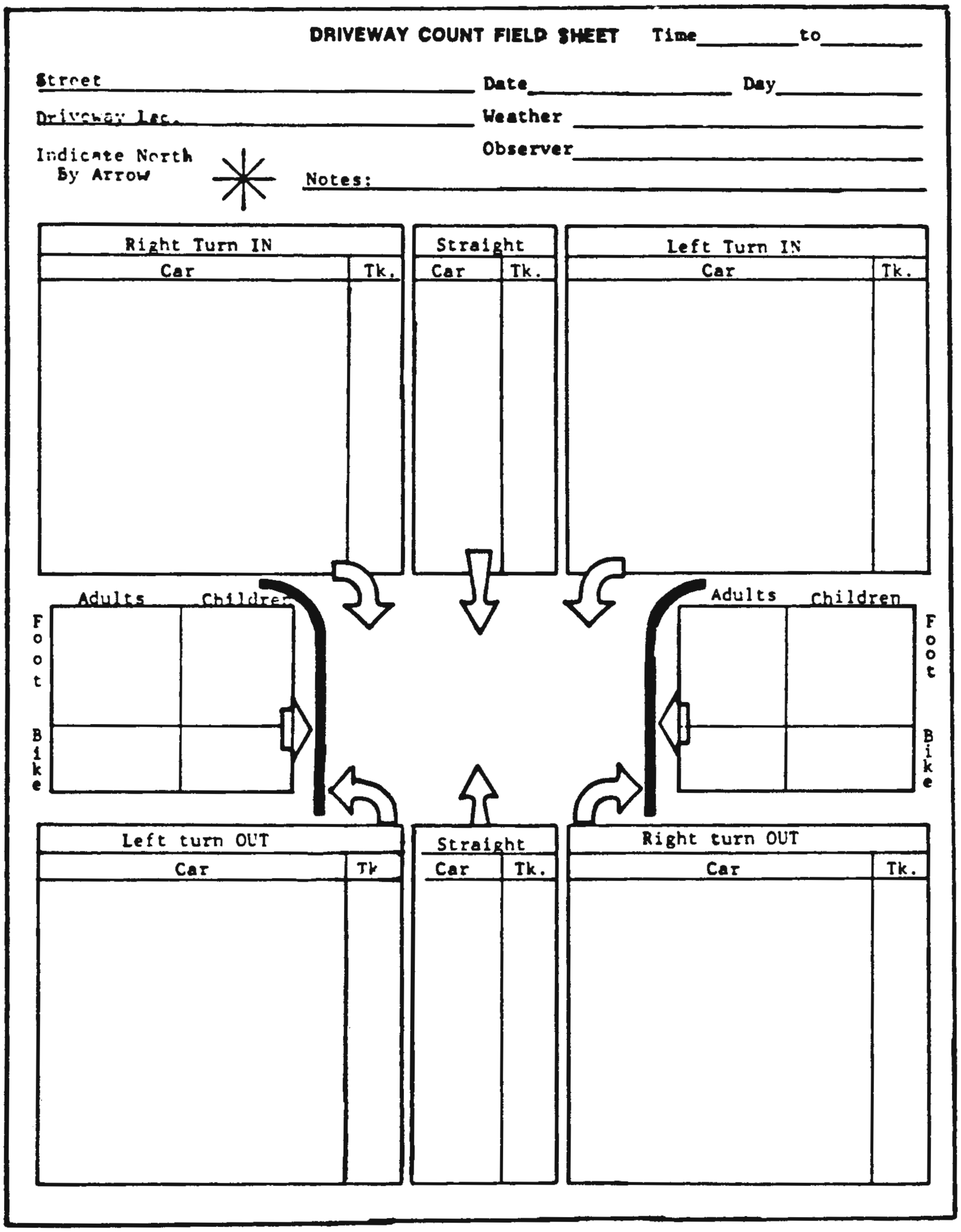


Figure 2-25.
Example of Driveway Count Form, Including Pedestrian and Bicycle Conflicts

Figure 2-26 illustrates a pedestrian count field sheet. The form may also have angled boxes in the center of the intersection to note diagonal crossing movements.

When pedestrians are tallied, those of junior high age (12 years) and over are customarily classified as adults. Persons of grade school age or younger are classified as children.

Many suburbs and even older areas of established communities have not installed sidewalks for pedestrian use. Specialized studies of low-volume intersections including bicycle and pedestrian traffic that would use sidewalks, if in place, may utilize the form such as illustrated in Figure 2-27. Pedestrian and bicycle riders are each counted twice (when approaching and when leaving the intersection). This form makes no provision for intersection crossing movements by pedestrians, and the form shown on Figure 2-26 should be used also, if such detail is needed.

Mechanical hand counters may be used with most of the field sheets. In the simplest form, a one, two, or three tally counters may be used for only the heaviest passenger car movements, with recording of trucks and low-volume turns being made by tally marks. More complex arrangements on counting boards are also utilized.

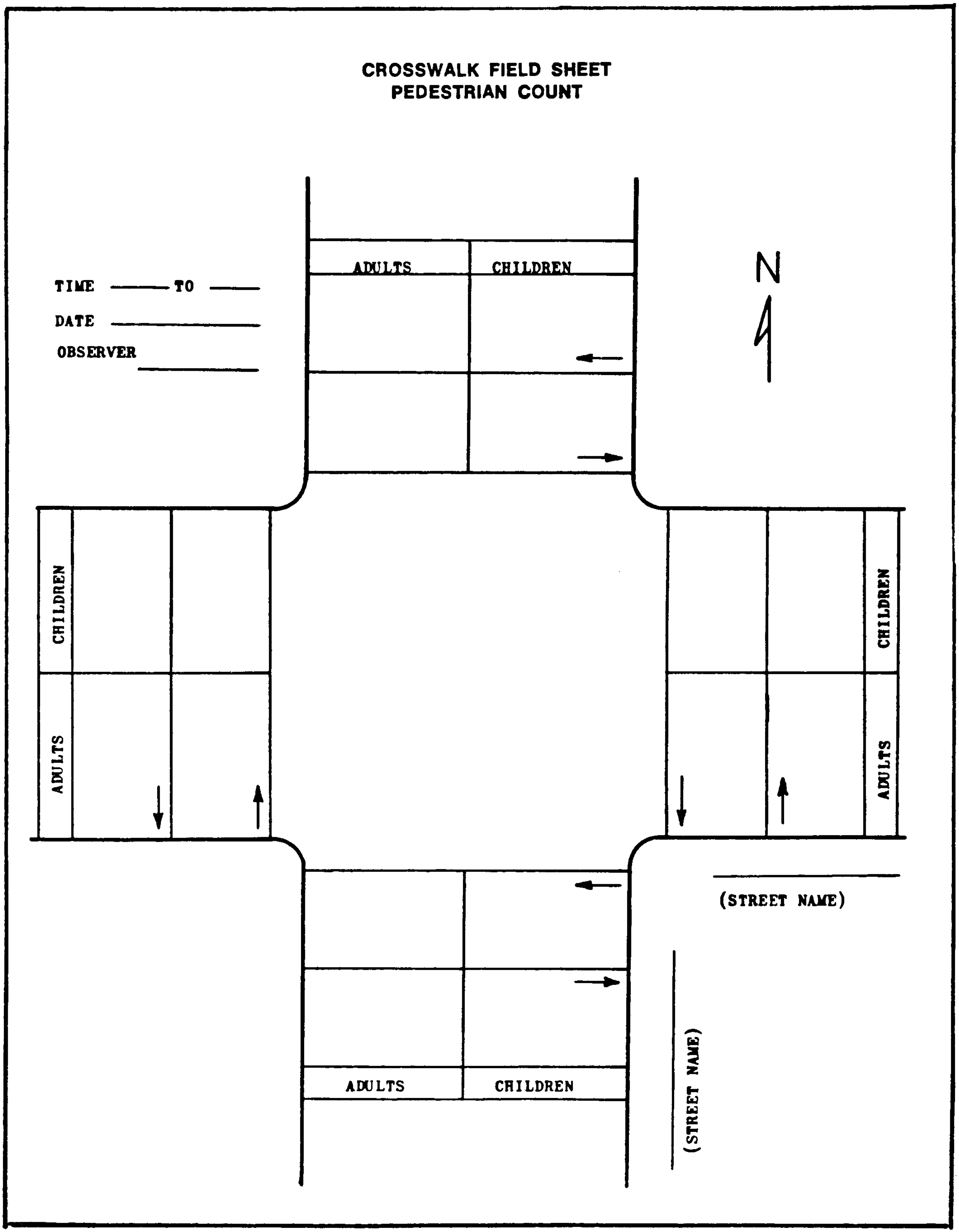


Figure 2-26.
Example of a Pedestrian Count Field Sheet

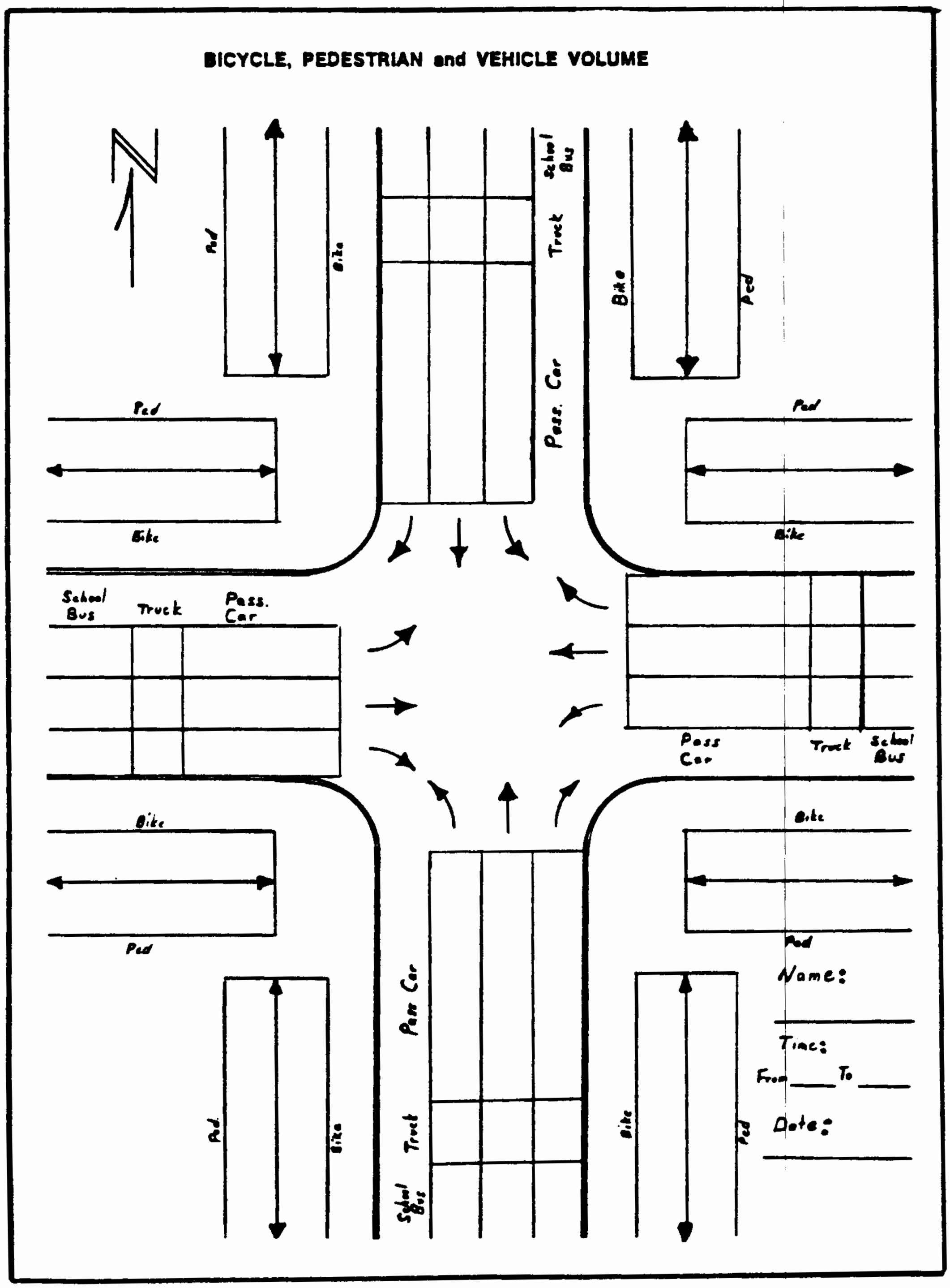


Figure 2-27.
Example of Form for Count for Sidewalk Use (or demand) by Pedestrians and Bicycle Riders.
(Form includes intersection vehicle turning movements. For pedestrians or bike riders crossing within intersection see Figure 2-26)

When each counting period ends, the checker records the registered number of vehicles for each movement. The checker may then reset each counter to zero (in light traffic condition), or the counter may continue to be operated and the count cumulated. In the latter case, the prior period reading must be subtracted to obtain the actual count for each period. This should be done (or noted) at the end of the day, before leaving the site.

Traffic checkers should be stationed where their car can be parked without adversely affecting traffic flow or sight distance. Wherever possible, the checker should be seated in a car. This is important in cooler climates and also simplifies the storage of forms, extra pencils, etc. It facilitates the count coordination where more than one person is needed at a given intersection. The car provides for personal safety in high crime areas, and for personal comfort in any area.

The car should be placed where the checkers have a full view of the count location. Sight blockage problems such as trucks or buses stopping or parking that would affect the view must be considered. An elevated position is obviously ideal, but seldom available. Areas depressed more than about 2 feet below the street grade will usually create problems of sight obstruction.

Mechanical Methods and Equipment

Sophisticated mechanical equipment, such as cameras, may be used to record data for an hour or less. Most automatic counts are taken at specific locations for periods ranging from a day to a week. In either case, the equipment is portable. Fixed, permanent counting stations are used to record traffic volumes continuously.

Automatic recording should be considered for most counts requiring over 12 hours of continuous data at a single location, if the desired information can be obtained mechanically. This type of counting has its greatest application where only a simple tabulation is needed of numbers of vehicles (no separation of vehicle type, direction, turning movements at intersection or driveway, pedestrians, lane use, etc.). Under certain conditions, directional counts or even lane use can be obtained mechanically.

Most automatic counts, however, are gathered and used for:

- Determination of hourly patterns (particularly the selection of peak hours),
- Determination of daily or seasonal variations and growth trends, and
- Estimating annual traffic (used in pavement structural design calculations).

Mechanical Counters - Portable

There are three general types of portable counters:

- The "Junior" is a continuous-type counter with a visible dial and uses a dry cell battery.
- A special version of the Junior is called the Period counter. It has a time clock which may be set to turn it on at any specific time, and then run it only for a definite length of time.
- The Senior counter contains a clock, a reset-type counter, a stamping and/or punching machine or counter pens, a roll of tape or a circular chart and a battery (wet cell or dry cell).

These counters use pneumatic road tubes from which air impulses are received due to moving traffic and transmitted to the counter. The counter logs one vehicle for each two impulses. The visual register of a Junior counter (the accumulator) must be read and recorded at the beginning and completion of counting period, because no printed record is available.

The printed tape Senior recorder stores the impulse in an accumulating register and upon clock actuation prints the results on a continuous adding machine tape. Typical printed tape recorders print either at 15-minute intervals or every hour. In either type, at the end of each hour, the counter is automatically reset to zero.

The circular chart recorder can record volumes from zero up to 1,000 vehicles for intervals of 5, 10, 15, 20, 30, and 60 minutes. These can be recorded for 24 hours or up to 7 days, depending upon the equipment. The traffic counter pens move out on the graph in response to vehicle actuation, and upon determination of the pre-set counting period, the pen arm resets to zero position in the center of the graph.

Punch tape recorders are also available. The tape from this type of counter can be processed in the office through a translator which, when connected to a keypunch machine, will produce punch cards or tape for computer tabulation.

Under certain conditions, photographic equipment can also be utilized to conduct traffic counts. This generally requires special equipment and an elevated position.* Time-serial pictures are taken to give a periodic or virtually continuous inventory of traffic flow. Due to the expense of the equipment, and the necessity of security, attendants are utilized. The film of traffic movements is generally taken at speeds of 60 to 300 frames per minute. The volume is counted manually by projecting the film, frame by frame, onto a screen. Data reduction is therefore expensive and time-consuming. The costs associated with this equipment generally limit its application to research studies.

Practically all portable traffic count equipment used is either the Junior or Senior types with road tubes. The road tube consists of a flexible, rubber hose fastened to the pavement at right angles to the path of expected vehicle travel. One end of the tube is sealed, and the other end is attached to a pressure actuated switch. The passage of a vehicle wheel over the tubing displaces the volume of air, thereby creating a detectable pressure at the switch. This pressure causes switch contacts to complete an electric circuit and actuate the recorder. Each two actuations registers as one vehicle.

---

*See also the section on the collection of erratic maneuver data using film or video.

Road tube placement is important because a location such as a tree or pole is needed to anchor the recorder. The tube should be clear of the turning paths of vehicles to reduce multiple counts due to a single vehicle crossing the tube at an angle. This generally means a placement of 100 feet from an intersection or a major driveway. The road tube should not be placed in an area subject to skidding, such as on a sharp curve, or subject to heavy acceleration or braking. The pavement area should be reasonably smooth with no holes to lacerate the tube, nor should the tube be placed over railroad tracks.

Location should be selected where there is a minimum probability of vehicles parking at the curb and standing on the hose. Similarly, areas of potential backup of standing vehicles waiting for signals, trains, toll booths, drawbridges, etc., should be avoided.

Where a median barrier exists, it is readily possible to obtain directional counts. Two separate counters are normally employed at such locations. Reasonably good directional counts of four-lane or wider two-way roads can also be secured by ending the road tube 4 to 6 feet before the centerline.

The portable counters have many limitations, including a maximum of about four traffic lanes of coverage, an under-counting due to simultaneous passage of cars in parallel lanes, an over-counting due to three- or four-axle trucks, and to vehicles crossing the road tube at an angle. Accuracy is seldom greater than 90 percent.

Other limitations include the inability to detect turning movements of traffic, and general inability to classify vehicles. Battery life is a problem, as is the relatively heavy weight of the Senior counter. Vandalism may be a major concern. The presence of snow or ice on the pavement may inhibit or render useless the road tube as a detection device. It is vulnerable to tire chains, street sweepers, snow plows, and skidding vehicles. Obviously, the road tube cannot be used on a gravel or dirt surface and, therefore, the use of portable counters is basically limited to paved roadways.

On a route with very substantial numbers of multi-axle vehicles, adjustment factors to correct some mechanical count road tube errors can be calculated from classification-type counts (see Manual Measurement and Equipment). The factor is determined as follows:

Manual Count	Type Vehicle	No. Axles	Total Axles
1500	Pass. Car	2	2x1500=3000
750	Truck	3	3x 750=2250
500	Truck	4	4x 500=2000
	. . . TOTAL . . .		7250

1. Machine count would show 7250/2 = 3625. Actual count is 2750.

2. The truck adjustment factor is 2750/3625 = 0.76.

3. If a raw count from a machine count reads out 5000 vehicles for the same route, the corrected machine count is 1500 x 0.76 = 1140. 5000 - 1140 = 3860 vehicles.

Practically all pedestrian counting has been performed manually. At very high density crossings, such as in CBD areas, manual counting is impractical, but photographic equipment has been used successfully.

Mechanical Counters - Permanent

Permanent or semi-fixed type counters may use a variety of detection or sensing devices including the road tube, electric contact plates, photocells, radar, magnetic or magnetometer detectors, ultrasonic and infra-red detectors, and induction loops.

Some permanent installations have only the sensor located at the counting station and the impulses are transferred to a central location for recording. Transmission is via leased telephone wire, radio, or other means, depending upon the requirement, availability, and costs. Other systems utilize a separate manual pickup of tapes that are taken to the central office.

Due to the limitations of the road tube, it is practically never used in permanent counting. Other types of detectors are listed below:

- Electric Contact
- Photo-Electric
- Radar
- Magnetic
- Induction Loop
- Ultrasonic

Permanent counter sensors or detectors have certain of the limitations described under portable counting equipment. The chief disadvantages include inability to classify vehicles or to detect turning movement at intersections. The detectors should be located so as to clear weaving sections at ramp entries or exits near highway interchanges. Similarly, locations near intersections or major driveways should be avoided.

Data Reduction and Analysis

Count Summaries

Tabulated summaries are customarily made of both manual and portable mechanical counts. Data processing printouts are normally prepared for the permanent counter station data.

Figure 2-28 illustrates a tabular summary sheet for an intersection turning movement count. Figure 2-29 shows a 24-hour tabulation by weekday for a 7-day mechanical count (also see Count Expansions).

For capacity analysis, development of intersection design and operational measures, and for accident analysis, peak-hour graphic summaries are desirable. Figure 2-30 shows a summary sheet or a four-leg intersection. Space is provided for a tabulation of entering traffic. The PM volumes are indicated in parentheses. Modification of this form for use at "T" intersections are illustrated in Figure 2-31.

TABULAR SUMMARY OF VEHICLE COUNTS

Observer ______________ Date ________ Day ________ City ______________ R = Right turn
S = Straight
INTERSECTION OF ______________ AND ______________ L = Left turn

TIME BEGINS	from NORTH				from SOUTH				TOTAL North South	from EAST				from WEST				TOTAL East West	TOTAL ALL
	R	S	L	Total	R	S	L	Total		R	S	L	Total	R	S	L	Total		

Figure 2-28. **A Tabular Summary Sheet for Intersection Turning Movement Count**

CONTINUOUS COUNTING
WEEKLY SUMMARY

Sta.No. ________ Route ______________ Direction ______ Year ______

Date: ______________ Weekday ________

Hour Begin	Mon.	Tues.	Wed.	Thurs.	Fri.	Sub-total	Sat.	Sun.	Total for Week
AM									
00 00									
01 00									
02 00									
03 00									
04 00									
05 00									
06 00									
07 00									
08 00									
09 00									
10 00									
11 00									
12 00									
PM									
13 00									
14 00									
15 00									
16 00									
17 00									
18 00									
19 00									
20 00									
21 00									
22 00									
23 00									
TOTAL									

Av. Weekday Vol. ______ Av.Day Vol. ______

% Av.Weekday						100			X
% Av. Day of Week						X			100
Weather*						X			X

*C = Clear, R = Rain, S = Snow, I = Ice

Remarks ______________

Compiled by ______________

Date ______________

Figure 2-29. **Form for 24-hour Tabulation 7-day Mechanical Count**

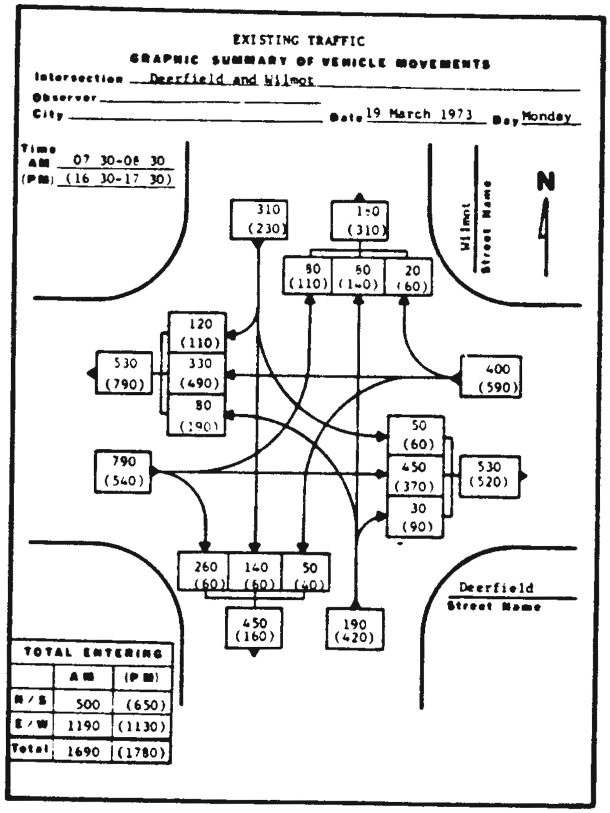


Figure 2-30. **Example of a Summary Sheet for a Four-Leg Intersection**
(Space is provided for a tabulation of total entering traffic)

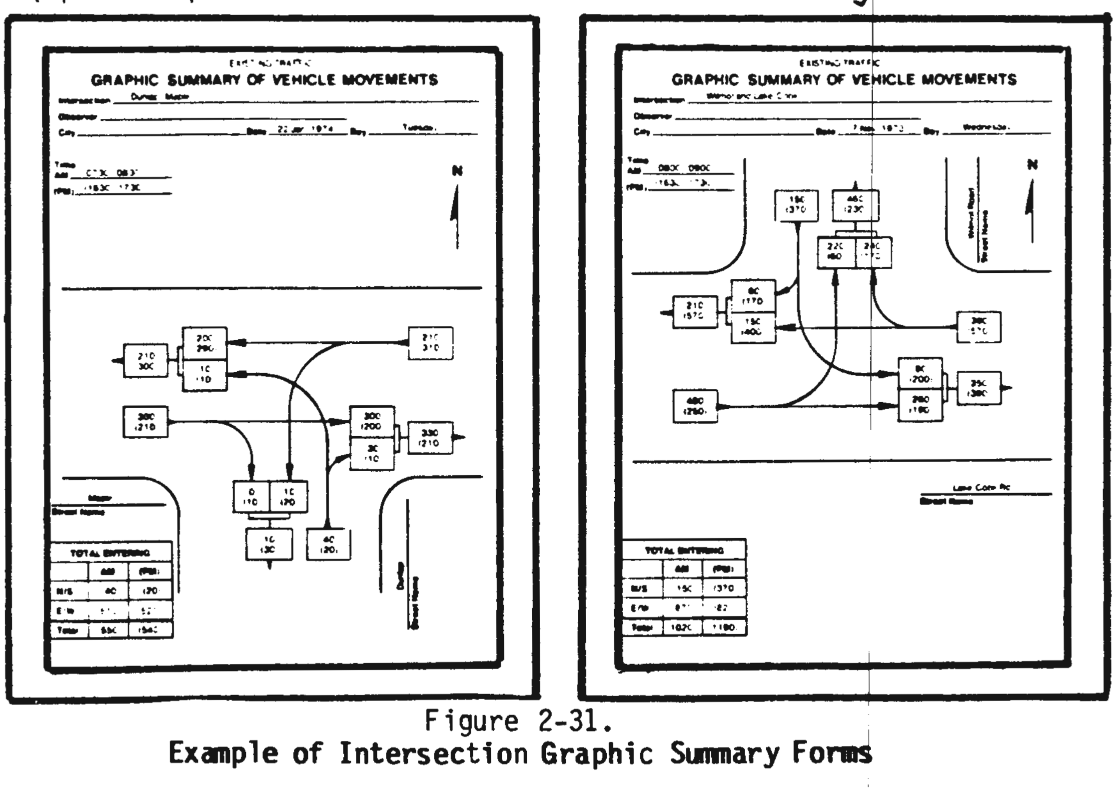


Figure 2-31.
Example of Intersection Graphic Summary Forms

Vehicle classification counts may be summarized by intersection leg (Figure 2-32), or graphically tabulated by turning movement (Figure 2-33).

SUMMARY
CLASSIFICATION SHEET FOR VEHICULAR TRAFFIC

Hour ____ to ____

Location ________________________________ Date ____________

________ Leg of Intersection

Hour Beginning	Passenger Cars		Single-unit Trucks			Bus		Tractor-truck Semitrailer			Full Trailer Combination		Total	Extra Axles	Machine Counts
	Local	Out-of-State	4 Tired	6 Tired	3 Axle	School	Other	3 Axle	4 Axle	5 or more Axles	4 Axle	5 Axle			
Total															

Figure 2-32. Classification of Vehicular Traffic Form

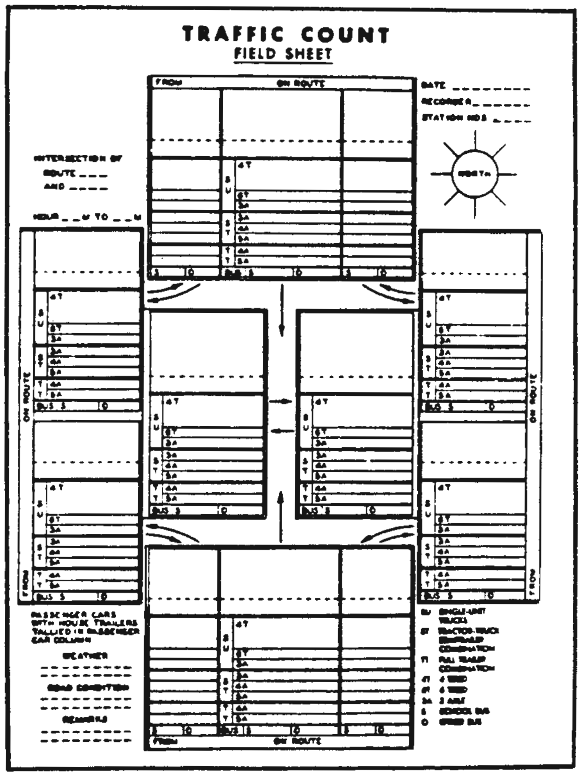


Figure 2-33. Classification Count Field Sheet

When vehicle occupancy counts are collected by manual observations, they are summarized by directions. The number of occupants counted (including drivers) is determined by multiplying occupancy group times the number of occupants in each group (1, 2, 3, etc.). The total number of occupants counted during the study period is divided by the total number of cars counted. This yields the average occupancy per vehicle. The average may be calculated by selected time periods, providing that a sample of at least 500 vehicles is available for the shortest time interval and direction of travel that is selected.

Limits of accuracy in mechanical counting equipment and variations in flow from day-to-day preclude the use of exact numerical values. Counts and factors should be rounded to not more than three significant figures and not closer than the nearest 10 vehicles, except for special vehicle classifications. Thus, a 24-hour count of 24,673 vehicles would be given as 24,700.

Count Expansions

Most traffic counts are taken in 15- or 30-minute periods and summarized into at least 1-hour intervals. However, short count sampling can be utilized where counts are taken for 5-, 10-, 15-, or 20-minute periods at specific locations with the checker then shifting to another intersection. Such counts are expended directly to 1 hour by the use of an appropriate multiplier (such as four times a 15-minute volume, etc.). These counts are best limited to streets carrying over 2,000 vehicles per day.

Short counts can be expanded by use of a "control" station. Where many sample counts are needed in a given area, a central location representative of overall traffic flow is selected. The location should service the general type of traffic being checked. It is counted by 10-minute intervals, continuously during the sample period. The "multiplier" at the control station is then calculated for each sample period counted at the other locations.

For example, if a given intersection was counted in the 1710 to 1720 time period, the control station count during this time period is divided into its peak-hour volume. As an illustration, the control station count might be 55 vehicles entering the intersection between 1710 and 1720. If the total entering movement at the control station was 550 vehicles during the peak hour, division of this by the 10-minute figure would give a multiplier of 10.0. A sample count at another intersection where 40 vehicles were counted from 1710 to 1720 would thus be expanded by a multiplier of 10 or to an estimated 400 vehicles for the same peak hour as at the control station.

All counts are really samples. While the above example was a 10-minute sampling, a 1-hour, a 1-day, a 1-week, or even a 1-year count is also a sample of the overall long-term traffic flow. Even permanent counter stations merely sample specific locations along a few routes of the many in a given area.

The most common expansion of "factoring" is to equate the 24-hour count of a given day to the ADT (average daily traffic). This is defined as the total volume during 265 days, divided by 365. In urban areas of over 2,000 population, it has been found that normal weather traffic volumes on weekdays fall within a range of 10 percent of the ADT, therefore, no application of adjustment factors is needed.

A rural count of 24-hour duration, which is to be expanded to an ADT or one of the other annual averages, is usually expanded by application of a day-of-week factor plus a monthly factor. These are best derived from permanent counter stations, but can also be developed by the use of week-long counts taken monthly for 1 or 2 years. The counts are averaged and then counts on specific weekdays (or months) are divided by the average. Figure 2-32 shows the type of form used to develop daily variation figures utilizing periodic 1-week counts.

The reader is referred to the Manual of Traffic Engineering Studies for examples illustrating the calculation of seasonal and weekday factors and the application to estimate ADT.

SPEED DATA

Overview

Most projects involving problem diagnosis and information system improvement evaluation will require the collection of speed data. Even on sites where high speed is not judged to be a problem, an improvement which results in a reduction in speed variance is likely to result in concomitant improvements in smoothness of traffic flow and safety. In addition, a wide variety of evaluations may benefit from the use of speed data as an auxiliary measure of effectiveness.

While the emphasis of this section is on spot speed measurement, speed profiles are also useful in some situations. Good speed profile measurement requires specialized equipment, generally not available in most State and local agencies. However, a reasonable approximation of speed profile can be derived from a series of spaced spot speed measures.

In addition to utilizing speed data for evaluation, it may be necessary to use other types of speed information in assessing site problems, e.g., to determine of the validity of existing speed signing. The procedures presented in this section for determining Advisory Speed for Curves and Critical Intersection Approach Speed have been abstracted from the Manual of Traffic Engineering Studies.

Advisory Speed for Curves

The maximum comfortable speed on a horizontal curve is determined by a test car. The vehicle is equipped with a ball-bank indicator that is read along with the speedometer near the middle of the horizontal curve. The maximum speed for comfortable travel is defined by a reading of 10 degrees on the ball-bank indicator, which provides an average measure of the side friction of the test car. This critical value represents the transition point at which the centrifugal force begins to cause a feeling of discomfort to the driver within the curve.

Before each test run is started, the ball-bank indicator is leveled to read "zero" when the vehicle is positioned on the tangent (straight) section in advance of the horizontal curve. The speed of the initial test run is usually some multiple value of 5 mph and is selected to provide a reading of less than 10 degrees on the ball-bank indicator. Succeeding observations are then made at increasing 5 mph increments until the reading on the ball-bank indicator exceeds 10 degrees.

No special data form is necessary for recording the information, but the typical field sheet in Figure 2-34 can be adapted by using one column for speedometer values and another column for the corresponding ball-bank indicator readings. The critical speed is determined by a linear interpolation of the two speeds with ball-bank indicator readings that are nearest to and on each side of 10 degrees. Several runs are often made in each direction to verify the selected advisory speed.

SPOT SPEED STUDY
FIELD SHEET

Date ____________ Location ____________ Direction ____________

Time ____________ Weather ____________ Road Surface Condition ____________

SECONDS	mph for 88 ft	mph for 176 ft		PASSENGER VEHICLES		BUSES		TRUCKS		TOTAL
					No Veh		No Veh		No Veh	
1	60.0	120.0								
1-1/5	50.0	100.0								
1-2/5	42.8	85.7								
1-3/5	37.5	75.5								
1-4/5	33.3	66.6								
2	30.0	60.0								
2-1/5	27.2	54.5								
2-2/5	25.0	50.0								
2-3/5	23.0	46.1								
2-4/5	21.4	42.8								
3	20.0	40.0								
3-1/5	18.7	37.5								
3-2/5	17.6	35.2								
3-3/5	16.6	33.3								
3-4/5	15.7	31.5								
4	15.0	30.0								
4-1/5	14.2	28.9								
4-2/5	13.6	27.2								
4-3/5	13.0	26.1								
4-4/5	12.5	25.0								
5	12.0	24.0								
5-1/5	11.5	23.0								
5-2/5	11.1	22.2								
5-3/5	10.7	21.4								
5-4/5	10.3	20.6								
6	10.0	20.0								
6-1/5	9.6	19.3								
6-2/5	9.3	18.7								
6-3/5	9.0	18.1								
6-4/5	8.7	17.6								
7	8.5	17.1								
7-1/5	8.3	16.6								
7-2/5	8.1	16.2								
7-3/5	7.8	15.7								
7-4/5	7.6	15.3								
8	7.5	15.0								
8-1/2	7.0	14.1								
9	6.6	13.3								
9-1/2	6.3	12.6								
10	6.0	12.0								
11	5.4	10.9								
12	5.0	10.0								
13	4.6	9.2								
14	4.2	8.5								
15	4.0	8.0								
			TOTAL VEHICLES							

Figure 2-34.
Typical Field Sheet for Spot Speed Studies

Critical Intersection Approach Speed

An important part of intersection traffic control device application (except signals) is the determination of safe approach speeds. A Sight Angle Board can be used in the field to compute the critical speeds. Details for constructing this board are shown in Figure 2-35. The computation form is given in Figure 2-36.

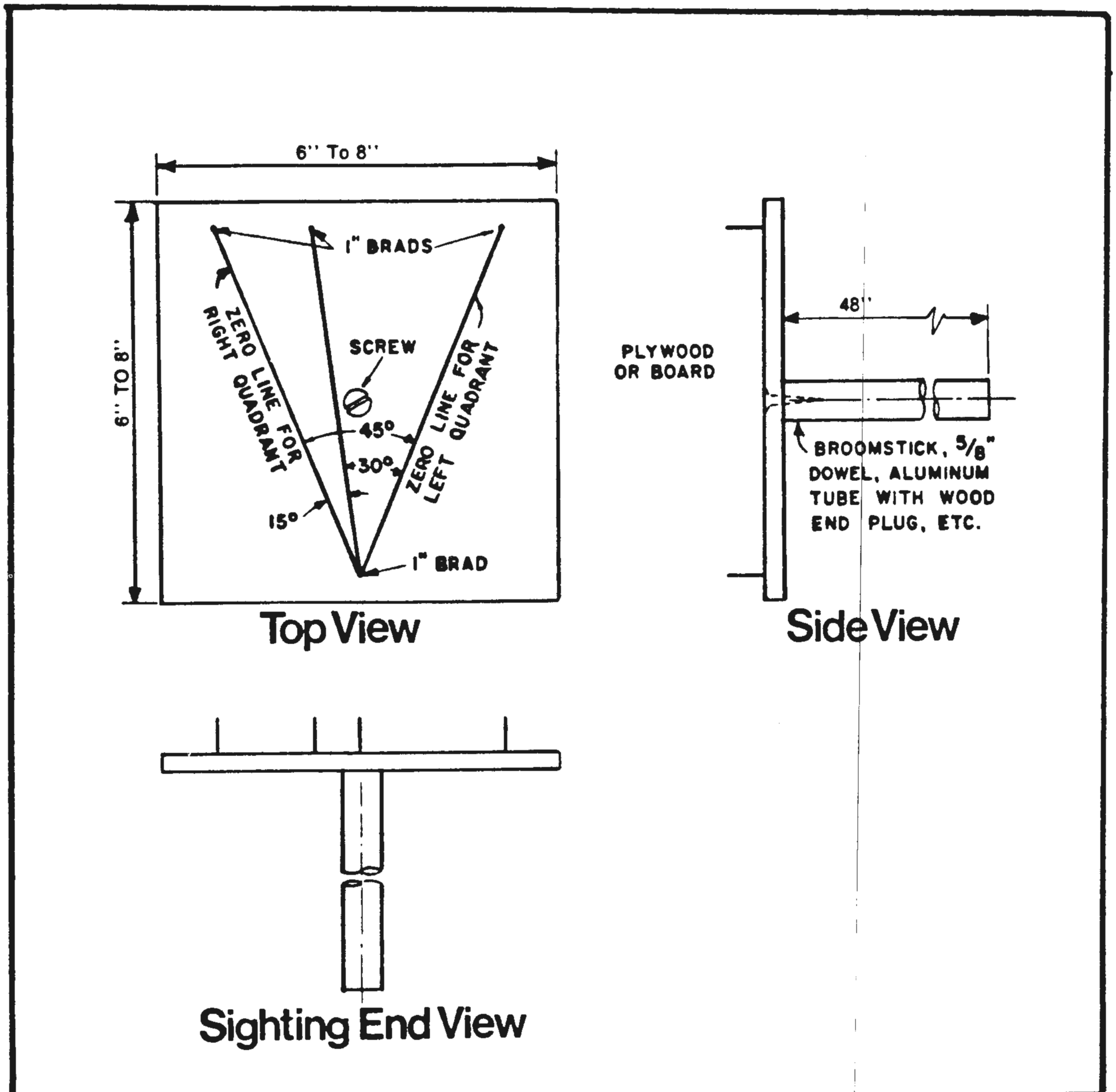


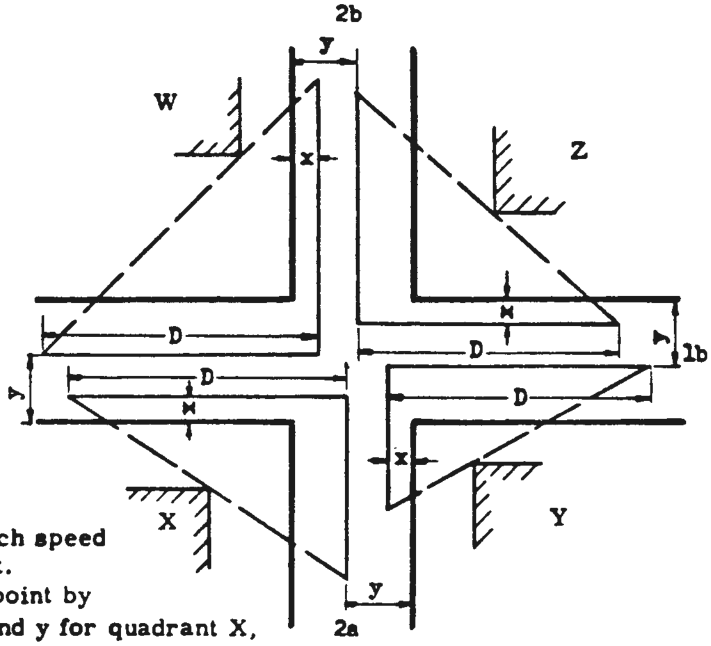
Figure 2-35.
Construction Details for a Sight Angle Board to Measure Safe Approach Speed

CRITICAL APPROACH SPEED COMPUTATION

(SIMPLIFIED FIELD METHOD USING SIGHT ANGLES)

x = 6 ft.
y = 1/2 street width + 3 ft. (two-way)
y = street width − 4 ft. (one-way street)

D = 70 ft. (20MPH limit)
D = 90 ft. (25 MPH limit)
D = 120 ft. (30 MPH limit)



Procedure:

1. Assume (1a) approach speed same as speed limit.
2. Establish collision point by measurement of x and y for quadrant X, and mark.
3. Measure distance D for assumed speed, along approach line (1a) (x distance from curb), and mark point.
4. Set up sight angle board, facing toward collision point and with zero angle line along approach line (1a)
5. Estimate relative location of approach line (2a) at distance y from curb.
6. Sight maximum angle as limited by obstruction X.
7. Classify speed range from table below. This is the maximum safe speed for approach (2a) when (1a) is at speed limit. The reverse is also true (if (2a) approaches at speed limit, above value is maximum safe speed for (1a)).
8. Repeat angle measurement for quadrant W, using proper approach lines (y distance from curb (1a) x distance from curb (2b). Check table for safe approach speed (2b).
9. Measure out distance D on approach (1b) and follow above steps for quadrants Y and Z.

APPROACH SPEED LIMIT	CLASS			
	I (Over 45°)	II (30° to 45°)	III (15° to 30°)	IV (Less than 15°
20 MPH	20 MPH & Over	13 to 19 MPH	5 to 12 MPH	0 to 4 MPH
25 MPH	25 MPH & Over	16 to 24 MPH	6 to 15 MPH	0 to 5 MPH
30 MPH	30 MPH & Over	20 to 29 MPH	10 to 19 MPH	0 to 9 MPH

Figure 2-36.
Critical Approach Speed Computation
(simplified field method using sight angles)

Manual Methods and Equipment

The use of manual speed measures is frequently more advisable than radar for field data collection related to problem diagnosis and improvement evaluation; even though the time required to obtain a given sample size may be slightly longer than with radar. From an accuracy standpoint, there is basically no difference between manual measures and other methods, particularly if digital electronic stopwatches (which reduce reading error) are used.

While the conventional method of setting up a speed trap is adequate under most conditions, there are situations where trap location requirements cannot be met. That is, the setup of a single observer manual speed trap under certain terrain conditions requires a correction for parallax in order to avoid measurement error. The conditions under which a single observer can accurately measure trap speeds involves terrain such as a road cut which provies a high vantage point. Under such conditions, marks on the surface of the pavement, e.g., pavement seams, etc., can be used as references for the trap, parallax is not a problem, and the conventional method can be used. However, in many cases the observer must be located near or at the level of the roadway, and the trap references must be vertical, e.g., sign supports, references marked on guardrail, etc. Here, parallax distortion poses a problem which, unless corrected, affects the accuracy of the speeds measured.

Conventional Manual Speed Trap

For sites where paper conditions prevail, the following procedure, contained in the Manual of Traffic Engineering Studies, is recommended.

A measure course is first laid out at the site. Recommended lengths are summarized in Table 2-2 for various ranges of average speed of the traffic stream, along with the appropriate conversion factors. That is, the proper constant for the selected course length is divided by the time for a vehicle to traverse this course to obtain the spot speed of the observed vehicle. A course length of 147 feet is convenient for studies in urban areas, and the constant is 100 in this situation. In any event, determination of the measured course should be made so that the minimum time recorded is not less than 1.5 seconds, and average speeds are timed in the range of 2.0 to 2.5 seconds.

Table 2-2.
RECOMMENDED COURSE LENGTHS FOR SPOT SPEED STUDIES

Average Speed of Traffic Stream (mph)	Course Length (feet)	Conversion Factor to Change seconds to mph
Below 25	88	60
25 to 40	176	120
above 40	264	180

A typical spot speed study plan is illustrated in Figure 2-37. The measured course begins at a point designated by a transverse crack in the pavement, or by a transverse mark made on the pavement. The observer stands at the end of the measured course, and a similar reference mark or an object directly across the roadway is employed to aid in the timing operation. Care must be exercised in selection and layout of the measured course so that the observer can clearly see the lines or marks.

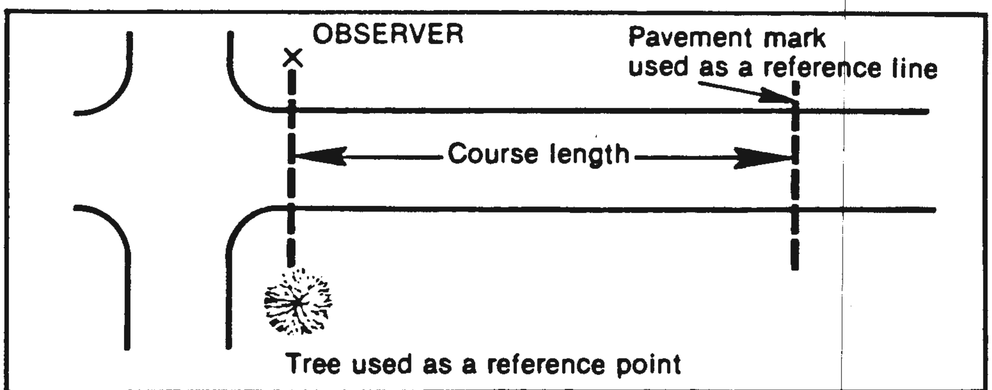


Figure 2-37.
Typical Spot Speed Study Plan

If the observer can take a position at some elevation above the speed course, such as on a bridge or slope, then the observation of a predetermined location on the vehicle, such as the front wheels, can be enhanced. On the other hand, the opportunity for introducing bias into the speed measurements is increased as the necessary reference markings become more visible to approaching drivers.

As the front wheels (or other part) of the vehicle cross the mark or crack at the beginning of the measured course, the observer starts the stop watch. The watch is stopped at the instant that the vehicle passes the observer. A tally is recorded on the line of the field sheet for the lapsed time.

Correcting Parallax Error

When two observers are operting a manual speed trap, they have the same view as timers at a track meet, i.e., sighting perpendicularly across the lanes of travel at the start and the finish as shown in Figure 2-38.

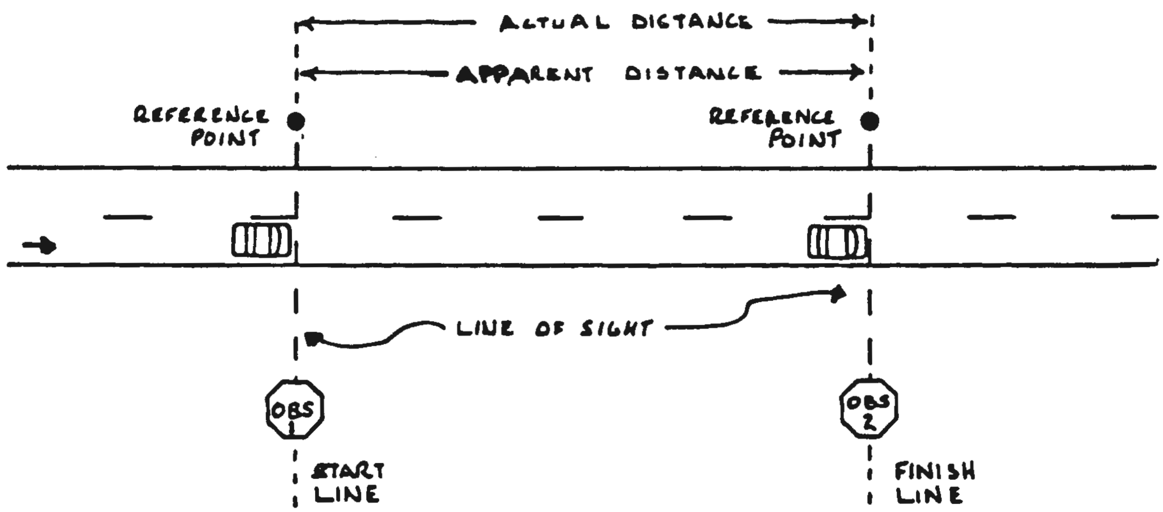


Figure 2-38.
Two-Observer Speed Trap (No Parralax Error)

In this situation, the actual distance between the beginning and end points of the speed trap (measured on the road surface) and the apparent distance (as seen by obervers) are equal and the speed measurement is accurate.

However, when a single observer must handle the timing chores, and if the same reference points are used, then there is a difference between the actual and apparent distance called parallax error (Figure 2-40).

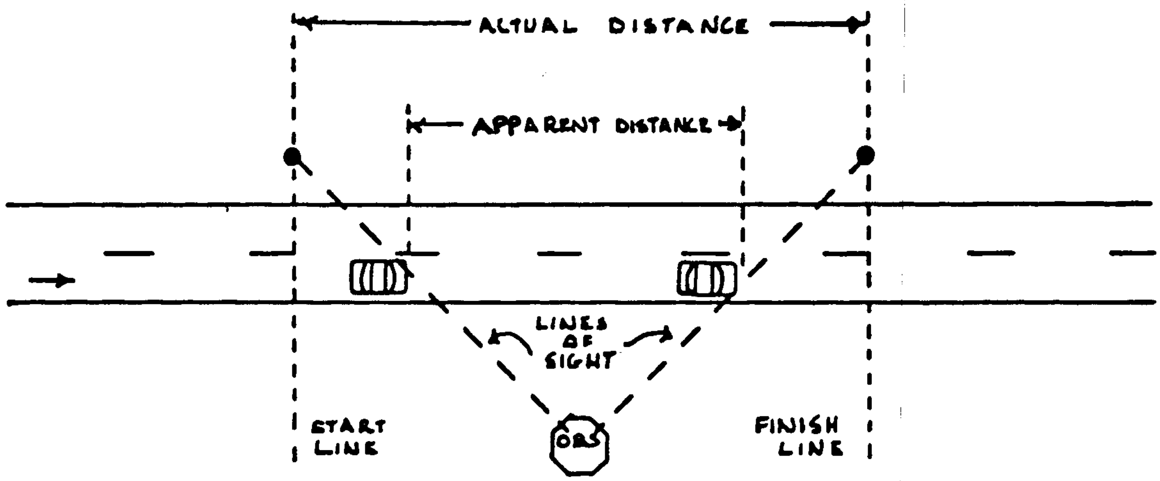


Figure 2-39.
Parallax Error Correction (Apparent Distance Method)

Parallax error may be corrected either by establishing and measuring the apparent distance (Figure 2-40) and using that measurement as the trap length in the speed calculations, or by moving the reference points until the actual and apparent distances coincide (Figure 2-41).

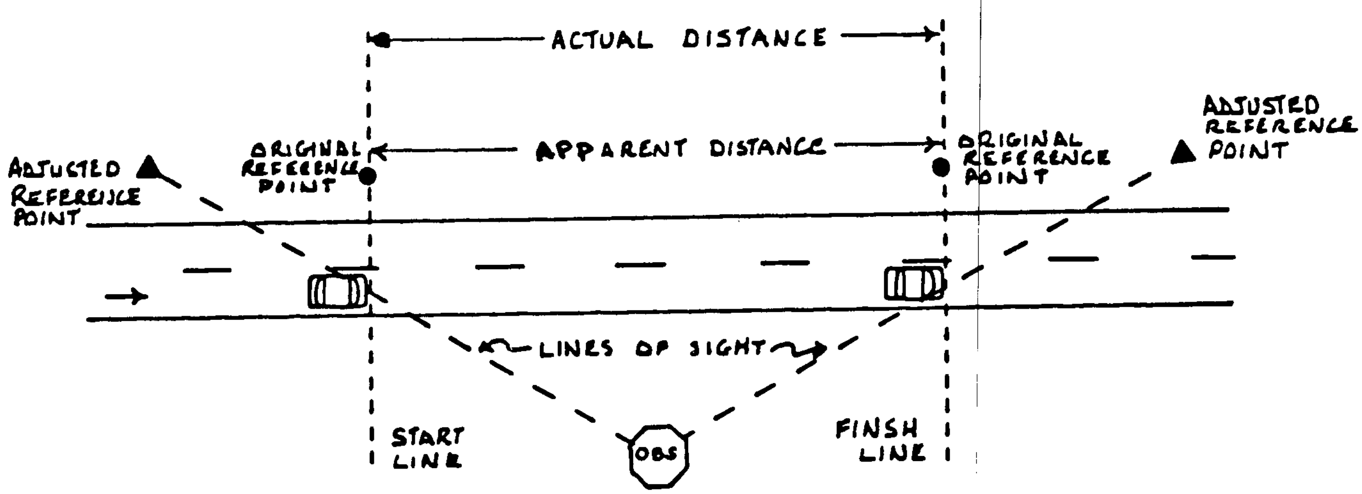


Figure 2-40.
Parallax Error Correction (Reference Point Movement Method)

Apparent Distance Method

Estabishment and measurement of the parallax distance is the easier solution to the correction of parallax error and may be used if a specific trap length is not required. The establishment of apparent distance requires an observer and one aide (in radio communications) and is accomplished as follows:

(1) The unobtrusive observer location to be used is chosen and marked, and the sighting references for the upstream and downstream ends of the speed trap are chosen. Usually existing reference objects such as signal posts, guardrail sections, trees, telephone poles, etc., are available. These can be marked with paint or tape to increase conspicuity if necessary. If no existing reference objects are available, sighting references can be created using poles marked with paint or tape. Depending upon the observer position, tape or paint marks on the roadway or shoulder surface can sometimes be used as sighting references.

(2) Once the references are chosen and marked, the observer takes the observation position selected and the aide takes a position near the roadside in the vicinity of the upstream sighting reference.

(3) Via radio link, the observer identifies a "test" vehicle approaching the speed trap and gives a pre-arranged verbal signal (e.g., "mark," "now," etc.,) when the "test" vehicle breakes the line-of-sight with the reference. The aide identifies the approximate location of the "test" vehicle when the signal was given by the observer and moves closer to that point. This procedure is repeated until the aide can identify the exact point on the roadway where the front of a "test" vehicle is located when the observer signal is given. Once the aide is located directly across from the point where the observer line-of-sight is broken by the test vehicle, several more "test" vehicle trials should be conducted to ensure reliability. This point is then marked with tape or paint.

(4) Following the establishment of the leading edge of the trap, the aide then moves toward the downstream sighting reference and the procedure is repeated until the downstream edge of the trap is determined and marked.

(5) The trap distance is then measured for converting the time measures to speed.

Reference Point Movement Method

If a speed trap of a specified length is desired, the sighting references must be adjusted so that the "apparent" distance is the same as the actual distance (as shown in Figure 2-40). While the overall procedure is the same as the previous one, this adjustment is most easily accomplished using an observer and two aides. After selecting the observer location and measuring and marking a speed trap of the desired length, the procedure is as follows:

(1) Aide #1 stands at the roadside at the upstream end of the trap (noted as "original reference point" on Figure 2-40), while Aide #2 stands upstream of Aide #1. Aide #2 stands at an off-road location where it will be possible to place a reference post or other marker once the location is established.

(2) Using Aide #2 as a sighting reference, the observer then chooses a "test" vehicle and gives a verbal signal when the front of the vehicle crosses the line of sight between the observer and Aide #2 (the sighting reference).

(3) Aide #1 notes where the front of the "test" vehicle is in relation to the chosen start line (the leading edge of the trap). If the location of the "test" vehicle is upstream of this line when the signal is given, Aide #2 is moved downstream toward the start line. If the location of the "test" vehicle is downstream of the start line when the observer signal is given, Aide #2 is moved further upstream from the start line. Thru repeated adjustments in the position of Aide #2 (acting as the sighting reference), a location is found where a "test" vehicle crosses the line of sight at the desired start line of the speed trap.

(4) Once the reference location is found, Aide #2 then installs a reference marker, and several more "test" vehicle trials are performed to ensure that the reference marker can be adequately seen and the location of the reference is reliable.

(5) Steps 1-4 are then repeated to establish the reference location for the downstream edge of the trap.

Automatic Methods and Equipment

Various devices are available for measuring the instantaneous speeds of vehicles at a location on the roadway. Practically all speed checks are now made with automatic equipment. The special equipment can be grouped accoridng to the two categories or road-detector meters and Doppler-principle (radar-type) meters. In any case, specific instructions are provided by the manufacturer for operation.

Road Detector Meters

The road-detector meters operate from pneumatic tubes, tape switches, or loop detectors on or in the pavement. The separation of road detectors should be 2 to 15 feet to minimize the opportunity for a passing vehicle to close the connection in the road-detector meter during a speed measurement. Impulses from these vehicle dectors are transmitted to a recorder or meter that indicates the time of passage between two detectors that are spaced a known distance apart or the actual speed of the vehicle. If the recorder measures the elapsed time, then this time interval is converted to the corresponding spot speed by the equation shown below. The sample field sheet shown in Figure 2-34 can be utilized with any automatic device by listing the appropriate speeds in the blank column (see Data Reduction).

$$V = \frac{D}{1.47T}$$

Where V = spot speed (mph)
D = course length (feet or mile)
T = elapsed time (seconds)

Doppler Principle Meters

The Doppler-Principle Meters use radar or ultrasonic beams that are directed at the moving vehicle. The reflected signal is shifted in frequency, and this frequency change is proportional to the speed of the vehicle. Speeds may be read directly from a dial or digital readout and/or indicated on supplementary recording equipment. Again, the sample field sheet (Figure 2-34) can be utilized for spot speed studies that are conducted with a Doppler-Principle Meter by tabulating the range of speed values in the blank column.

While radars are easy to use and can provide reasonable samples in a short period of time, there are some problems which should be pointed out regarding their use.

First, there is some restriction on the location from which radar speeds are taken. That is, the ideal position from which to take radar speeds is where the angle between the radar device and the path of the vehicle being measured is zero. In other words, a radar mounted as near as possible to the edge of the lane being measured is ideal. As this angle increases, the cosine error is increased. The primary problem with this "design" principle is that it sometimes conflicts with an even more important consideration of having unobstrusive observers that do not influence the measures being made. Where the observer can be hidden at a location where the angle is minimized, the problem does not exist. Further, if the radar unit is one in which the head can be separated from the readout it can often be camouflaged and mounted, for example, on a guardrail to alleviate the problem. A paper bag or piece of cloth placed over the unit has no effect on its operation. and can camouflage the unit.

The second disadvantage lies in the potential inaccuracy of speeds taken on roadways with a high percentage of large trucks. That is, if a speed is being taken on a car being followed by a large truck, the radar may actually read the truck speed because of the large "shadow." While this may be no problem in a stable platoon situation, it leads to inaccuracies in situations where a large truck is "closing" on a car being measured. The problem can be solved by providing the radar operation with appropriate instructions on the selection of subject vehicles.

A third disadvantage is the difficulty of taking accurate speeds in interior lanes of multi-lane facilities. This problem gets more acute as the volume of the "outside" lane increases and becomes virtually impossible under peak traffic conditions on some facilities.

A fourth disadvantage is that the readout of some radar units is designed to remain at the peak speed measured and must then be reset before taking the next speed. On other units, however, the pointer does not stop at the peak and must be read quickly, using the beginning of the return motion of the pointer as a cue. This sort of readout, unlike the first type, requires some practice on the part of the operator. It should be noted that most of the newer radar units provide a digital readout rather than a pointer and scale, thus resolving this problem.

One final problem is the increasing use of radar jamming devices, i.e., the so called "Fuzz Busters". While there is no good estimate of the percentage of drivers using such devices, it is probably not high. However, the user knows when there is a radar in the vicinity and can inform other drivers via CB radio. Since a high percentage of automobile drivers and virtually all truckers have CB units, it is hard to use radar in an unobtrusive fashion. Thus, in diagnosing a speed problem or evaluating an improvement where speed is an MOE, it is not advisable to use radar if there is evidence of frequent use of "Fuzz Busters". See the material on "Obtrusiveness Checks" in Part 1 for a further discussion on monitoring radar detection.

Film Method to Collect Speed Data

While film would generally never be used solely as a means of collecting speed data, it is sometimes desirable to obtain speeds in conjunction with other types of data, e.g., erratic maneuvers, volumes, etc. However, the use of film for speed data requires that the camera be operated at a minimum of 8 frames per second, rather than the 2 frames per second which is generally used for other MOE's. The disadvantage of this is that the film must be changed more frequently. However, if field personnel must be kept at a minimum the use of film for speeds plus other measures may not be particularly disadvantageous if the operator can make additional observations from the camera location. Given a vantage point of adequate height and a location orthogonal to the roadway, speeds have been measured with a 2-mile per hour accuracy from film. It should be noted that this accuracy was obtained using roadway marker spacing 5 to 10 feet. While it is not always necessary to use markers spaced this closely, long traps should not be used because of parallax problems. It should be noted that pavement seams, guardrail posts, and the like can frequently be used as reference markers, thus the need to provide artificial reference is not usually necessary. It is only necessary to accurately measure the distance between references and to construct a frame/time/speed chart to be used in the data reduction process.

Data Reduction and Analysis

Radar speeds, since they are in miles per hour, require no data reduction. Other means of automatic collection must simply be converted from time to speed, with the conversion factor depending upon the sensor deployment.

Manual Speed Measurement

For manual speed measurement, the field sheet presented in Figure 2-34 should be used. The sample field sheet is set up for two different lengths of speed course. In addition, a blank column is provided to permit the correlation of time with speed for a course length that is different from the two distances indicated.

The equation is used to determine the speed column for any chosen length of study course has been given as: $V = \frac{D}{1.47T}$

The analyst should indicate the appropriate column for the selected length of speed course. Spearate field sheets or separate columns should be used for each direction of travel.

The sample field sheet is divided into vehicle classifications of passenger cars, trucks, and buses. This distinction may be important in the analysis of high-accident locations, the consideration of selective enforcement measures, and the application of traffic control devices. However, the total column allows for the summation of speeds for all vehicles.

The number of passenger cars, trucks, or buses traveling at the same speed is determined by adding horizontally the number of tally marks. This subtotal is then entered in the column headed "No. Veh." for each vehicle category. A summation of the number of passenger cars, trucks, and buses provides the total number of all vehicles traveling at the same speed. Also, a vertical summation of any vehicle category (passenger car, truck, bus, or all vehicles) accounts for the total number of observations in the spot speed study for that particular category.

Speed Measurement From Film

It should be noted that a disadvantage of using film for collection of speed data is the significant increase in data reduction time compared to other data collection methods. This is one of the many tradeoffs between field time, crew size, and data reduction time that must be made in developing the Data Collection Plan.

If film is chosen for the collection of speed data and the camera vantage point is not ideal, i.e., high and orthogonal to the roadway, it is advisable to perform a pre-data collection check by filming cars (driver by staff members) traveling at several known levels of speed and determining the relationship between actual speed and measured. These data provide the basis for a correction factor in the film-reduced data when necessary. If time and resources permit, this same procedure can be used during selected periods of data collection and the known speeds can be used as a quality control check on data reduction personnel. Since the data reduction task is rather tedious, there may be a tendency toward laxity after long periods. Knowledge, on the part of data reduction personnel, that "test" speed vehicles were used and/or feedback regarding errors committed may help to avoid such problems.

INTERSECTION DELAY

Overview

The material in this section has been adopted from Report No. FHWA-RD-76-137, A Technique for Measurement of Delay at Intersections by W. R. Reilly, C. C. Gardner, and J. H. Kell (September 1976).

This section contains compete instructions for the application of two methods which lead to estimates of vehicle delay and stops on approaches to signalized intersections. It is recommended that the two methods be applied simultaneously in the field, with a minimum of one observer used for each method.

The field method which yields an estimate of delay is termed the "Intersection Delay Study." This technique gives an estimate of the total stopped delay in vehicle-seconds, incurred by vehicles passing through an intersection. The study is based on a point sample of stopped vehicles.

The field method which gives a measure of stops and also an estimate of total volume is termed the "Percent Stopping" Study. This study leads to an estimate of the number of vehicles having to make at least one stop on the intersection approach, as a percentage of the total number of vehicles entering the intersection. The same study also gives an estimate of total volume.

Two delay types are recommended for use in traffic analyses. Approach delay per vehicle is a measure of the total time lost on an intersection approach when compared with free flow operation. Stopped delay per vehicle is a measure of the time lost while a vehicle is completely stopped. In addition to these delay types, "percent of vehicles stopping" is a useful measure of performance to complement the delay measures.

In calculations of road-user costs and benefits it is necessary to estimate both delay and stops. For example, approach delay will give the total amount of time which is lost by motorists on an intersection approach due to traffic congestion and signal operation. If a monetary value is assigned to time, a calculation can be made of the value of time savings resulting from a proposed improvement. Another example of the application of the recommended performance measures relates to the caculation of costs of tire wear, fuel consumption, and general motor wear. This calculation depends on good estimates of stopped delay and the percent of vehicles stopping.

Definitions

The following list gives definitions for terms that are used in the application of the Intersection Delay Study and the Percent Stopping Study.

Approach Delay - the total amount of time, in vehicle-seconds, lost by vehicles due to traffic conditions on the approach to a signalized intersection. For an individual vehicle, approach delay is the amount of time used to pass through the approach minus the amount of time used by an unimpeded vehicle moving at free flow speed to pass through the approach.

Approach Delay Per Vehicle - approach delay divided by the total number of vehicles passing through the intersection approach during a period of time, in vehicle-seconds per vehicle.

Approach Volume - the total number of motorized vehicles crossing the STOP line and passing into the intersection in a given period of time.

Intersection Approach - the portion of a roadway which carries traffic toward an intersection.

Interval Between Samples - the time, in seconds, between each successive point sample of stopped vehicles taken in the Intersection Delay Study.

Lane - a portion of the intersection approach used by a single line of moving traffic.

Lane By Lane - a breakdown of data by individual lane on the intersection approach. The numbering scheme used to identify lanes assigns "1" to the far right lane. Moving left each lane is numbered sequentially, with the leftmost lane receiving the highest number. Auxillary lanes are numbered along with through lanes.

Not Stopping - a vehicle which proceeds along the intersection approach and enters the intersection without coming to a stop.

Percent of Vehicles Stopping - the proportion of approach volume expressed as a percent, which has stopped one or more times on the intersection approach.

Point Sample - a count of the number of vehicles stopped on the intersection approach or in designated lanes at a given instant in time.

Queue - a line of vehicles on the intersection approach, each vehicle having stopped at least once.

Sampling Point - the instant in time at which a point sample is taken.

STOP Line - a marked or imaginary transverse line at which vehicles stop, when necessary, at the intersection. The line is either a marked STOP line, the first marked crosswalk line, or an imaginary line located at the point where the front bumper of the first vehicle in a stopped queue would be situated.

Stopped Time - the time, in vehicle-seconds, during which a vehicle is stopped with locked wheels on the intersection approach. One exception to this definition deals with creeping vehicles.

Stopped Delay - the total amount of stopped time, in vehicle-seconds, for all vehicles using an intersection approach during a period of time, in vehicle-seconds per vehicle.

Stopping - a vehicle which comes to a stop one or more times on the intersection approach.

Vehicle - any motorized vehicle using the intersection approach. Motorcycles and motorbikes are included in this category but bicycles are not included.

Intersection Delay Study

Study Objectives

The principal objectives of the Intersectin Delay Study is to collect data on the approach to a signalized intersection such that an accurate estimate of approach delay per vehicle and stopped delay per vehicle can be made. The Percent Stopping Study (see next section for description) must be taken simultaneously with the delay study in order to calculate these two measures of performance on a "per vehicle" basis.

Study Requirements

A step-by-step approach should be followed in the design of an Intersection Delay Study. The following elements must be considered.

Select Intersection Approach To Be Studied - if all approaches to a single intersection are to be studied, it is best to do so on the same day to minimize personnel costs. However, it may be difficult to study all approaches under peak conditions if the peak period is relatively short.

Select Time Period To Be Studied - for most applications a peak traffic period and an off-peak period should be studied to give a balanced view of intersection operation.

Select Length of Study Period - a minimum of sixty point samples should be taken for each study. This represents a 15- or 13-minute period, depending on the interval between samples used. If an entire intersection is to be studied, it is recommended that each approach be observed for sixty point samples, with the field crew moving from approach to approach until all have been studied. This procedure can be repeated to obtain an additional sixty point samples on each approach if time permits. It is recommended that lengths of studies be either 60, 90, or 120 point samples. Availability of manpower will be the principal determinant of which length is used.

Determine Type of Traffic Signal Operation - for each study period a determination of the mode of operation of the traffic signal must be made. Modes include pretimed, actuated, and interconnected system control. For each proposed study period, the cycle length of pretimed or the background cycle of system control is determined. If the cycle length cannot be determined in advance of the study, a short investigation is made in the field just prior to performing the work.

Determine Interval Between Samples* - if a signal is operating in a pretimed or system mode, use a 13-second interval for cycle lengths of 45, 60, 75, 90, 105, 120, 135, or 150 seconds. For all other cycle lengths in a pretimed or system mode, use a 15-second interval between samples. For all traffic actuated signals not operating in a system, use a 15-second interval.

Determine Means for Obtaining Volume Count - a volume count must be taken simultaneously with the Intersection Delay Study if measures of performance are to be calculated on a "per vehicle" basis. It is recommended that the Percent Stopping Study (see next section) be used to obtain this volume count. However, a simple count of total volume using either one observer or some type of mechanical counter could be used in lieu of the Percent Stopping Study.

---

* For traffic signals operating on a fixed cycle length, the interval between samples should not be an even divisor of the cycle length. This restriction is not important when the cycle length is greater than 150 seconds.

Select Observation Point - if possible, this should be done prior to the day of the study. Usually the best location is on the right-hand side of the approach, in the shoulder or sidewalk area, however, if the site is hilly, other locations may be better. Figure 2-41 shows possible locations. If inclement weather is probable, the use of a vehicle is recommended and the observation point must accommodate a parked vehicle. If a vehicle is used it must be positioned so as not to be conspicuous or hazardous to traffic using the intersection. Rooftops or buildings offer good locations.

Manpower Requirements

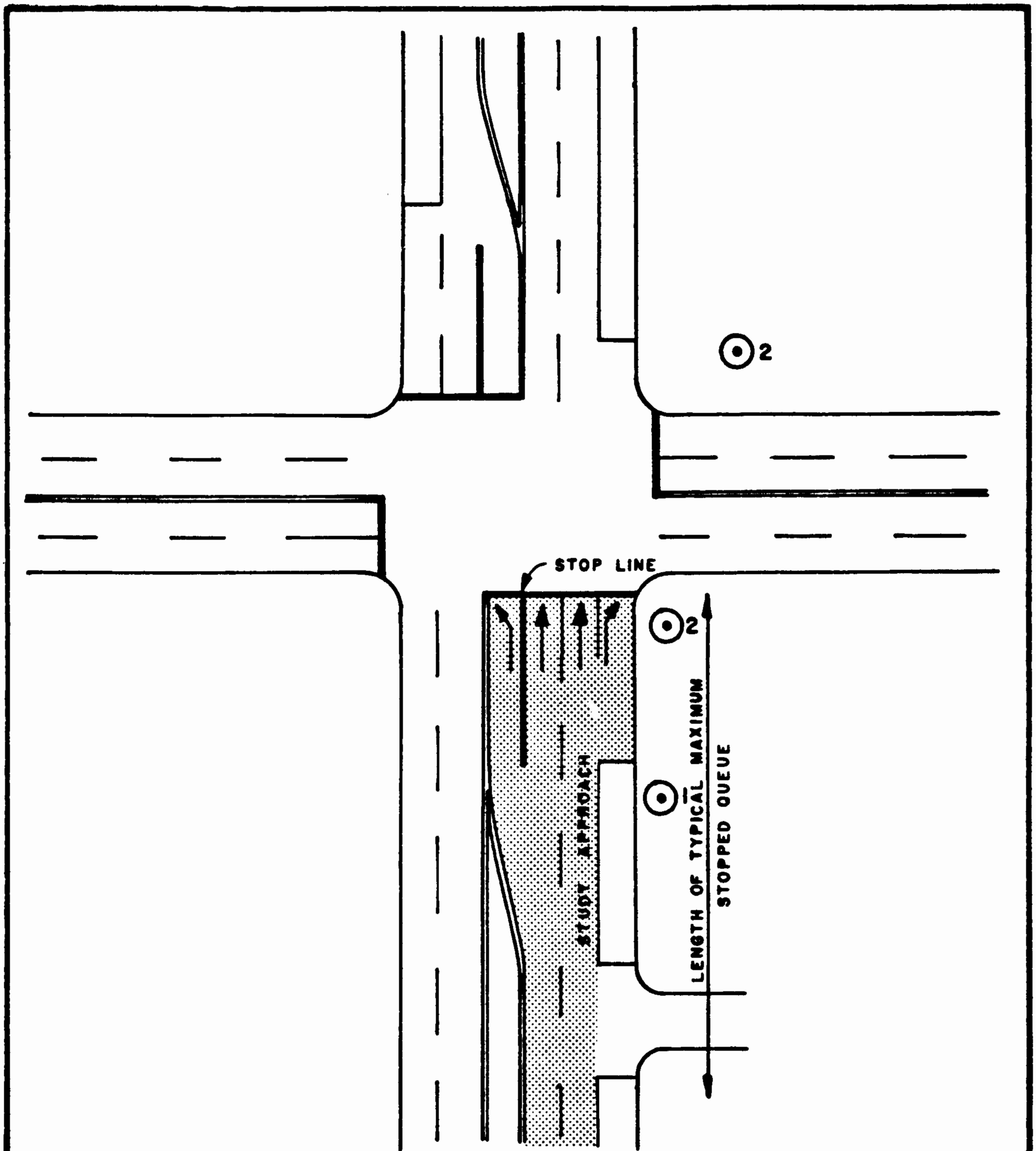
Elements related to manpower training and assignments are described below for the Intersection Delay Study. A complete summary of manpower requirements for both the Intersection Delay Study and the Percent Stopping Study is given in the section on Manpower Requirements.

Estimate Manpower Requirements - from local knowledge of flow conditions at the study site, estimate the number of persons needed as follows. Use one person for approaches with one lane, regardless of traffic volume. For two-lane approaches, use one person if most stopped queues do not exceed 25 vehicles, or 500 feet in each lane. For approaches with three or more lanes, use one person if most stopped queues do not exceed 10 vehicles, or 200 feet in each lane. For all other traffic conditions, use a two-person team.

If no information on queue length exists, a rough estimate can be made by the following calculation.

$$\text{Average Maximum Queue (in vehicles per lane per cycle)} = \frac{\text{Cycle Length}}{3600} \times \frac{(.5)\ (\text{Volume Per Hour})}{(\text{No. of Lanes})}$$

Assign Responsibilities - for each Intersection Delay Study a "crew chief" is assigned and is responsible for all aspects of the field work, including the Percent Stopping Study if performed at the same time. For the Intersection Delay Study, the crew chief serves as one of the "delay observers." If traffic conditions warrant, a second person is also assigned as a delay observer. The delay study team is thus comprised of the crew chief and one additional delay observer if necessary.



Legend: 1 = Recommended observation point for Intersection Delay Study, midway along length of average maximum stopped queue to be observed.
2 = Preferred observation points for Percent Stopping Study.

Figure 2-41.
Location of Field Observation Points

Equipment Requirement

The following items will be needed in the performance of an Intersection Delay Study.

Timing Device for Sampling Points (1 per team) - it is recommended that a small battery powered cassette recorder or other audio device be used to provide an audible cue at each sampling point. The tape should start with the word "begin" to signify the zero point of the study. Then, a cue (the word "now" is suggested) is given at each sampling point. It is recommended that the tape have a total of 120 cues to cover the longest possible study length. Following cue nos. 30, 60, 90, and 120 the number of the sampling point should be given audibly.

It is recommended that the user agency prepare one tape for studies with a 13-second interval between samples and one tape with 15-second intervals. Prior to each field study, it is essential that the power source of the recorder be fully charged and that a check be made of the playback speed and the audible cues to insure that an accurate time interval will be produced in the field. The most convenient types of recorder are those which either fit into a pocket or which have a strap for suspension from a belt.

If a cassett recorder is not available, a stopwatch with a "fly-back" feature and a sweep of 60 seconds is used. The stopwatch should be calibrated from time to time to ensure accurate results. Either one of two techniques can be used in the field. First, a small card with stopwatch readings for all sampling points for the study period is prepared and the field crew takes a point sample at each reading. Second, the flyback feature of the stopwatch is used if the interval between samples is 13-seconds, with the cue chief calling out a cue at 13, 26, 39, 52, 05, 18, 31, 44, 57, and 10 seconds as read on the sweep hand. Approximately one-half second before reaching the last of these points, the second hand is brought back to zero using the flyback feature, and the stopwatch continues in motion from zero. This latter technique eliminates the need to look at a list of readings but does require that the crew chief memorize the 10 readings and that the stopwatch be carefully used so that time is not "lost" in resetting the sweep hand.

In summary, either a stopwatch or a cassette recorder should be used for the interval timing device, although the latter is preferred.

Timer for Study Period (1 per team) - the crew chief will use an accurate wrist watch or a stopwatch with which the length of study will be timed. This watch will be read at zero or an even minute at the beginning of the study and a reading will be taken at the final sampling point to determine the total elapsed time of the study.

Other Equipment - each team member needs a clipboard, pencils, and enough data sheets for the periods to be studied. Each data sheet accommodates 120 point samples. A blank sheet is found at the end of this manual.

Field Procedures

The step-by-step procedure for performing the Intersection Delay Study is as follows.

Step 1 - upon arrival at the site the crew chief checks the suggested point to ensure that a good view of stopped queues is available. If blockage of view occurs due to parked vehicles, sidewalk activity, etc., an alternative observation point is selected.

Step 2 - if a doubt exists as to traffic signal timing, the crew chief performs a check by using a stopwatch to time three signal cycles, from end of green on the main street to the next end of green on the main street. If all three cycles conform to a cycle length of 45, 60, 75, 90, 105, 120, 135, or 150 seconds, a 13-second interval between samples is used. If not, a 15-second interval is used.

Step 3 - if more than one person is used for the Intersection Delay Study, the crew chief assigns specific lanes of the approach to each person. Then, at each sampling point, each delay observer (the crew chief is one of the delay observers) records the number of stopped vehicles in those lanes for which he or she is responsible.

Step 4 - each delay observer fills out the general information at the top of the data sheet, making sure that the interval between samples which is to be used is noted. Figure 2-42 shows a typical set of data on the Intersection Delay Study field data sheet.

Step 5 - at the proper time of day, the crew chief begins the study by setting both the "timing device for sampling points" (either a stopwatch or a cassette recorder) and the "timer for study period" in motion. At the same instant, the crew chief signals to all other persons, including those performing the Percent Stopping Study, that the study period has begun.

Step 6 - at time zero of the study no point sample is taken. At the first cue, which occurs at either 13 or 15 seconds, each observer notes the number of vehicles stopped at that instant and records this number on the data sheet. Each successive sampling point is identical in operation in that the delay observer notes and records the number of vehicles stopped at the instant the cue is given.

Step 7 - at the end of each 30th sampling interval a message on the cassette will indicate the number of sampling points (either 30, 60, 90, or 120) which have passed since time zero. If an observer has not yet reached the shaded box (see Figure 2-42) on the data sheet, one or more samples has been missed. At the next sampling point, such as the 31st, the sample is entered in the 31st box, leaving one or more boxes blank for later adjustment in the office. Observers are instructed not to try to guess what the missing value might be but rather to leave the box(es) blank.

Step 8 - at the end of the required number of samples, the crew chief signals to all others that the study has ended and reads the study timer to obtain the total elapsed time of the study. This time is noted on the data sheet under "Comments." It is important that the signal at the beginning and at the end of the study be given exactly at the zero point and the final sampling point, respectively, so that observers performing the Percent Study can begin and end their count at the proper time.

Instructions to obsevers as to which vehicles are included in the sample of stopped vehicles at each sampling point are as follows:

(a) A vehicle with locked wheels (no motion) is counted.

(b) A vehicle that had previously come to a stop and is creeping (at the instant a point sample is taken) in a stopped queue which is not discharging from the intersection is classified in the following manner: It is considered as "stopped" if a gap of less than or equal to 50 feet or about three car lengths, exists between it and the vehicle in front of it; it is considered to be "moving" (and thus is not counted in the point sample of stopped vehicles) if the gap to the next vehicle is greater than 50 feet.

Two additional points are important. First, when two persons are used to perform the Intersection Delay Study it is recommended that they stand relatively close together so that an audible cue, either from a cassette or from the crew chief, can be heard by both. If it

INTERSECTION DELAY STUDY
POINT SAMPLE, STOPPED DELAY METHOD

Intersection *Tucson Blvd/22nd St* Study Traffic On *Tucson Blvd.*

City and State *Tucson, Az.* Agency *City of Tucson, Traffic Engineering Div.*

Day, Date *Mon., Aug. 2, 1976* Study Period *1340-1353* Observer *L. Wiles*

Traffic Approaching From *N* (N,S,E,W) Weather *Clear and Hot*

If more than one person is studying same approach, explain division of responsibilities. ______

INTERVAL BETWEEN SAMPLES = *13* SECS.

START	2	6	7	4	0	0	0	1	4	6
	0	0	0	0	2	7	11	6	1	0
	0	0	0	3	4	6	2	0	0	0 (30)
	1	7	13	12	4	1	0	0	4	9
	11	8	2	0	0	0	3	7	7	4
	0	0	0	4	11	4	1	0	2	(60)
										(90)
										(120)

NOTE: ONE SAMPLE MISSING

OBSERVED TOTAL, ALL SAMPLES *187*

[30] DENOTES 30TH SAMPLE

COMMENTS: *At last sample, stopwatch reading was 13 minutes, 02 seconds.*
One sample missed in second group of 30 samples.

Figure 2-42.
Intersection Delay Study, Field Data Sheet

becomes absolutely necessary for one delay observer to move away from the other, a prearranged system of audible or visual cues is used to signal each sampling point. One problem encountered with audible cues is that they can be missed if traffic noise becomes intense.

Second, the delay observers should be made aware of the fact that the most difficult point to sample is just after the traffic signal has turned green and the front end of a stopped queue is moving. The observer should make a mental note of all vehicles which are stopped at the instant of the sampling point. Then the observer can take a few seconds to count all of these vehicles.

Data Reduction

In the office, a data reduction form is filled out for each study period. This form, an example of which is given as Figure 2-43 contains space for reduction of data from both the Intersection Delay Study and the Percent Stopping Study.

Data reduction is performed in the following steps.

Step 1 - If the Percent Stopping Study (see the following section for description) was performed simultaneously with the Intersection Delay Study, the percent stopping data are entered on the data reduction form (lines i, ii) and a simple division yeilds the percent stopping figure.

Step 2 - A count of total volume during the study period is entered on line 7. The count is normally taken from the Percent Stopping Study (line iii) but may come from a simple manual or mechanical count.

Step 3 - If one or more point samples was missed in the field, a correcting procedure is used (lines a through f). The average value for all samples taken during each period of 30 samples is used as the estimate for any missing values during that same period.

DATA REDUCTION FORM

INTERSECTION DELAY AND PERCENT STOPPING STUDIES

Intersection TUCSON BLVD/22ND ST. City & State TUCSON, ARIZONA

Study Approach On TUCSON BLVD Traffic From N (N, S, E, W)

Day, Date, Time MON., AUG. 2, 1976 1340-1353

PERCENT STOPPING STUDY

(i)	Total no. of vehicles "stopping"	79 vehs.
(ii)	Total no. of vehicles "not stopping"	15 vehs.
(iii)	Total volume = (i) + (ii)	94 vehs.
(iv)	Observed Percent Stopping = [(i) ÷ (iii)] x 100	84%
(v)	Actual Percent of Vehicles Stopping = (iv) x 0.96	81%

CORRECTION PROCEDURE FOR MISSED SAMPLES IN DELAY STUDY

		Corr.* No. 1	Corr.* No. 2
(a)	Total no. of point samples taken in field during 30-sample period	29	
(b)	30 - (a)	1	
(c)	Sum of point sample values for 30-sample period on field data sheet	115	
(d)	Value of each missing sample = (c) ÷ (a), round to nearest whole number	4	
(e)	Total value for all missing samples in 30-sample period = (b) x (d)	4	

(f) Total value for all missing samples in study period = sum of (e) for all corrections 4

* Use one correction factor for each 30-sample period in which the field data sheet has one or more missing values.

INTERSECTION DELAY STUDY

(1)	Total no. of point samples taken in field	59
(2)	Total no. of point samples missed, from (b) above	1
(3)	Total no. of point samples used in calculations = (1) + (2)	60
(4)	Interval between samples	13 secs.
(5)	Sum of observed point sample values	187 vehs.
(6)	Sum of calculated "corrected" point sample values, from (f), above	4 vehs.
(7)	Sum of all point sample values = (5) + (6)	191 vehs.
(8)	Total Stopped Time = (4) x (7)	2483 veh.-secs.
(9)	Stopped Delay = (8) x 0.92[5]	2284 veh.-secs.
(10)	Approach Delay = (9) x 1.3[5]	2969 veh.-secs.
(11)	Total Volume = (iii)	94 vehs.
(12)	Stopped Delay Per Vehicle = (9) ÷ (11)	24 veh.-secs./veh.
(13)	Approach Delay Per Vehicle = (10) ÷ (11)	32 veh.-secs./veh.

Figure 2-43.
Data Reduction Form

Step 4 - A check is made of the elapsed time of the study as noted by the crew chief under "Comments" on the field sheet. If the elapsed time is not within 30 seconds of the product of the interval between samples and the total number of samples (including those missed) it is recommended that the study be repeated or that a correction factor be applied to the value for interval between samples (line 4). The corrrected interval, in seconds, is the total elapsed study time divided by the number of sampling points (60, 90, or 120). If no correction is indicated, the value found at the top of the field data sheet is entered on line 4 of the data reduction form.

Step 5 - On the field data sheet, all observed samples are summed and the total is placed at the bottom of the sheet.

Step 6 - Using data from the field sheet, lines 1 and 5 are filled in on the data reduction form. If two observers were used for the Intersection Delay Study it will be necessary to add the values from each of their field sheets to arrive at a total for the entire study approach.

Step 7 - Lines 6 through 13 are completed as per instructions on the reduction form itself.

Presentation of Results

The measures which can be estimated from the Intersection Delay Study are (note that "line" numbers refer to data reduction form):

- Stopped Delay, in vehicle-seconds (line 9)
- Approach Delay, in vehicle-seconds (line 10)
- Stopped Delay Per Vehicle, in vehicle-seconds per vehicle (line 12). Approach Delay Per Vehicle, in vehicle-seconds per vehicle (line 13)

The latter two measures require a volume count for their computation. This volume count will normally be obtained by using the Percent Stopping Study.

In general, the best measure to use in comparing efficiency of intersection operation or for setting priorities for improvement project is approach delay per vehicle. However, for some uses related to idling costs, the stopped delay per vehicle figure might be more applicable.

In presenting results, an explicit identification of the delay type is essential and the above-mentioned terms, rather than the vague term "delay" should be used.

Percent Stopping Study

Study Objectives

The objectives of the Percent Stopping Study are: To develop an estimate of the "percent of vehicles stopping" on approaches to signalized intersections; and, to develop an estimate of total volume on these approaches. The volume estimate is used with values derived from the Intersection Delay Study (see the previous section) to report delay on a "per vehicle" basis.

Study Requirements

Because the Percent Stopping Study will almost always be performed in conjunction with the Intersection Delay Study, much of the study design will be accomplished as part of the delay study.

Selected Length of Study Period - if the Percent Stopping Study is to be conducted independently of the delay study, it is recommended that a study period of 15 to 30 minutes be used.

Select Observation Point - if possible, this should be done prior to the day of the study. Figure 2-41 shows two possible locations, both of which normally provide a good vantage point.

Manpower Requirements

A complete summary of manpower requirements for both the Percent Stopping Study and the Intersection Delay Study is given in the following section.

Estimate Manpower Requirements - for locations with flow rates greater than 500 vehicles per 15 minutes, two observers may be required for the Percent Stopping Study. Each observer will be responsible for counting vehicles departing the approach in those lanes assigned to him or her. For locations with flow rates below 500 vehicles per 15 minutes, a one-person team is adequate.

Assign Responsibilities - the crew chief of the Intersection Delay Study is also in charge of the Percent Stopping Study. The study team for the Percent Stopping Study is comprised of one or two observers, in addition to the crew chief who merely serves to supervise the study.

Equipment Requirements

The following items will be needed in the performance of a Percent Stopping Study.

Timer for Study Period - if the Percent Stopping Study is not performed at the same time as an Intersection Delay Study, one of the percent stopping observers will need a stopwatch to time the study. This observer will be serve as crew chief and will call out the beginning and end of the study.

Hand Counters - each percent stopping observer may be equipped with two hand counters (i.e., a unit with two separate buttons). The counter is used to register two categories of count: Stopping and not stopping. If such counters are not available, the observers simply use tally marks to record the count on the field data sheet.

Other equipment - each team member needs a clipboard, pencils, and enough data sheets for the periods to be studied. A blank data sheet for the Percent Stopping Study is included at the end of this volume.

Field Procedure

The step-by-step procedure for performing the Percent Stopping Study is as follows:

Step 1 - Upon arrival at the site, the observer checks the suggested observation point to ensure that a good view of all vehicles using the approach is available.

Step 2 - The percent stopping observer fills in the top of the field data sheet with general information. Figure 2-44 shows a data sheet with typical information and data. The observer then awaits the start of the study as signalled by the crew chief of the Intersection Delay Study.

Step 3 - At time zero the observer begins counting each vehicle which crosses the STOP line. If a vehicle has stopped one or more times on the study approach, it is counted in the "stopping" category. Each vehicle is counted only once, regardless of the number of stops it may have made. A vehicle which edges past the STOP line but continues waiting is not included in the count until such time as it makes a final move to clear the intersection.

Step 4 - The observer ends the count upon the signal at the end of the study period. Any vehicle which has not yet crossed the STOP line is not included in the count at the end of the study.

Step 5 - At the end of the study the observer notes the totals for each of the two categories on the data sheet. If a hand counter is used the two values are taken directly from the counter. If tally marks are used the observer will sum the tallies to arrive at the totals.

Data Reduction

In the office, a data reduction form is filled out for each study period. Figure 2-43 is an example of the form used. Data reduction of the Percent Stopping data is performed in the following steps.

Step 1 - The values for stopping and not stopping are taken from the field data sheets and entered on lines i and ii. If two observers were used to perform the Percent Stopping Study the sum of the values from both observers are used. Lines i and ii are summed to give a value for total volume (line iii).

Step 2 - The value for "stopping" is divided by total volume to give a measure of pecent stopping (line iv).

Step 3 - Line iv is multiplied by 0.96 to give an estimate of percent of vehicles stopping (line v).

Step 4 - The total volume on line iii is entered on line 7 of the data reduction form so that delay can be computed on a "per vehicle" basis.

PERCENT STOPPING STUDY

Intersection *Tucson Blvd/22nd St.* Study Traffic On *Tucson Blvd.*

City and State *Tucson, Az.* Agency *City of Tucson, Traffic Engineering Div.*

Day, Date *Mon. Aug. 2, 1976* Study Period *1340-1353* Observer *L. Burke*

Traffic Approaching From *N* (N,E,S,W) Weather *Hot*

If more than one person is studying same approach, explain division of responsibilities. ______

STOPPING *	NOT STOPPING *
卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 ////	卌 卌 卌

* IF TALLY MARK IS USED, 卌 DENOTES A COUNT OF "5"

TOTAL STOPPING *79* TOTAL NOT STOPPING *15*

COMMENTS: ______

Figure 2-44.

Percent Stopping Study, Field Data Sheet

Presentation of Results

The measure "Percent of Vehicles Stopping" is usually presented with a measure of vehicle delay. The percent stopping figure is particularly important in analyses which relate to costs associated with the number of vehicle stops.

Manpower Requirements

Table 2-3 illustrates the number of persons needed for the field studies described in this volume. Although each of the two studies can be performed independently, it is recommended that the Percent Stopping Study be performed concurrently with the Intersection Delay Study.

Table 2-3.
Summary of Manpower Requirements

Study	Description of Conditions	No. Persons Needed for Field Study	Name of Persons Needed
Intersection Delay*	One-lane approach, all lengths of queues	1	Crew Chief
	Two-lane approach, stopped queues up to 25 vehicles per lane	1	Crew Chief
	Two-lane approach, stopped queues exceed 25 vehicles per lane	2	Crew Chief Delay Observer
	Approaches with three or more lanes, stopped queues up to 10 vehicles per lane	1	Crew Chief
	Approaches with three or more lanes, stopped queues exceed 10 vehicles per lane	2	Crew Chief Delay Observer
Percent Stopping	Flow rate from 0 to 500 vehicles per 15 minutes, for any number of lanes	1	Percent Stopping Observer
	Flow rate greater than 500 vehicles per 15 minutes, for any number of lanes	2	Percent Stopping Observer Percent Stopping Observer
Volume Count, in lieu of Percent Stopping Study	Any volume level, for any number of lanes	1	Volume Observer
Combination	Any combination of two of the above studies will require the sum of the persons needed for each study		

* A Crew Chief is assigned to supervise the study and is in charge of all field studies performed simultaneously.

Intersection Delay Study, Lane by Lane Data

If an agency desires to study one or more specific lanes on an intersection approach, the Intersection Delay Study is easily adapted to this end. The field data sheet which would be used is found on Figure 2-45. All calculations of delay are identical to those described for the overall approach.

Manpower requirements will be increased somewhat and the following guidelines should be followed if lane by lane studies are performed.

- use one person for one-lane approaches, for any traffic volume.
- for two-lane approaches use one person if most stopped queues do not exceed 25 vehicles. If stopped queues do exceed 25 vehicles per lane use two persons.
- for all approaches with three or more lanes use a two-person team for all volume levels.
- for approaches with five or more lanes, more than one data sheet per observer will be necessary.

In performing the field work on a per lane basis it becomes very important for the crew chief to fully define the responsibilities of each observer so that each lane is counted, and is counted by only one observer. The crew chief should also define when a vehicle is considered to be in one lane or the other. The best definition to use is "a vehicle is in a lane when more than 50 percent of the area of the vehicle is in the lane."

INTERSECTION DELAY STUDY

POINT SAMPLE, STOPPED DELAY METHOD

Intersection ____________________ Study Traffic On ________________________

City and State __________________ Agency _________________________________

Day, Date ________________ Study Period _____________ Observer _____________

Traffic Approaching From _________ Weather ________________________________
N,S,E,W

If more than one person is studying same approach, explain division of responsibilities. ________________________________

INTERVAL BETWEEN SAMPLES = ___ SECS.

FOR LANE * ______________

									30
									60
									90
									120

OBSERVED TOTAL, ALL SAMPLES ____

FOR LANE * ______________

									30
									60
									90
									120

OBSERVED TOTAL, ALL SAMPLES ____

[30] DENOTES 30TH SAMPLE

* RIGHT HAND LANE IS "NO. 1", LEFT MOST LANE HAS HIGHEST DESIGNATED NUMBER

COMMENTS: ____

Figure 2-45.
Intersection Delay Study, Field Data Sheet, Lane By Lane

In reporting results on a per lane basis, the user is cautioned that the delay values are based on a single physical lane and on the occurrences within that lane. The volume used to place the delay value on a "per vehicle" basis is related to the vehicles which have departed the intersection from the lane in question. Thus, the bases for the numerator and demoninator are dissimilar and unrealistic results may be found in some cases. (This caution also applies to the Percent Stopping Study, lane by lane.)

If results are to be presented on a per lane basis, the Percent Stopping Study must also be performed on individual lanes.

Percent Stopping Study, Lane by Lane

The study is performed and analyzed exactly in the manner described in the section on Percent Stopping Study, except that the data are recorded on a different data sheet, which is displayed on Figure 2-46.

Manpower requirements may be slightly increased and the following guidelines should be followed if lane by lane studies are performed.

- use one person for one-lane and two-lane approaches, for any volume level.
- use two persons for approaches with three or more lanes, for any volume level.
- for approaches with five or more lanes, more than one data sheet per observer will be needed.

Each observer should be equipped with the appropriate number of hand counters, two counters needed for each lane being observed. If hand counters are not available, tally marks are used.

PERCENT STOPPING STUDY

Intersection ____________ Study Traffic On ____________

City and State ____________ Agency ____________

Day, Date ____________ Study Period ____________ Observer ____________

Traffic Approaching From ____________ Weather ____________
N,E,S,W

If more than one person is studying same approach, explain division of responsibilities. ____________

FOR LANE* ______		FOR LANE* ______	
STOPPING	NOT STOPPING	STOPPING	NOT STOPPING

* IF TALLY MARK IS USED, 卌 DENOTES A COUNT OF "5"

TOTAL STOPPING ____ TOTAL NOT STOPPING ____ TOTAL STOPPING ____ TOTAL NOT STOPPING ____

COMMENTS: ____________

Figure 2-46.
Percent Stopping Study, Field Data Sheet, Lane By Lane

TRAVEL TIME AND DELAY

Overview

The information in this section is adapted from the Manual of Traffic Engineering Studies for measuring travel time and delay. The method described is the test car (floating car) technique using the "maximum-car" technique. This method can also be used to collect data on fuel usage if the test car is equipped with a fuel meter.

Travel time and delay studies are used to evaluate the quality of traffic movement along a route and to determine the locations, types, and extent of traffic delays. The efficiency of flow is measured by travel and running speeds. In the actual study, total travel and running times are observed and then converted into speed measures.

Delay information is recorded when the traffic flow is stopped or greatly impeded. The duration of traffic delay is measured in units of time along with notations of the corresponding location, cause, and frequency of delay to travel. Route delays are determined for travel along a specified route during a particular day(s) of the week and time(s) of day.

Study Details

Study Routes

The engineer usually specifies the routes where travel time and delay studies are to be conducted. In general, the section should be a minimum of 1 mile in length to ensure the collection of meaningful data. The routes may encompass a known problem location, may be an arterial where a traffic operations review is being conducted, or may consist of links and nodes representative of a CBD or other network of interests.

Area-wide travel time and delay surveys are generally made on the major routes that carry heavy traffic volumes and connect to and from the central business district. Studies of this nature permit the development of time contour maps that graphically summarize the efficiencies of the major routes in the urban area.

Time of Study

Studies are often designed to reflect travel conditions during the peak hours and in the directions of heaviest traffic movements. Travel may also be compared between periods of peak and non-peak conditions. The following times are suggested for the conduct of travel time and delay studies to reflect the range of travel conditions for both peak and non-peak periods, although all of these time intervals are not required:

1. 0700 to 0900 (peak)
2. 0930 to 1130 (non-peak)
3. 1330 to 1530 (non-peak)
4. 1600 to 1800 (peak)
5. 1900 to 2200 (non-peak)

The shift times at major industrial or commerical locations may require adjustments to the suggested time periods. Travel time and delay studies are usually made in reasonable good weather. However, bad weather checks are taken when it is desirable to obtain information on such operations. For a before-and-after evaluation, similar conditions must exist at the times of data collection, if the results are to be comparable.

Personnel and Equipment

A study car (or cars) are needed to collect the travel time and delay data. Manual operation requires a driver, a recorder, and two stopwatches for each test car in operation.

If any automatic recording device is used in the test car, then only the driver is needed.* One person is generally able both to drive the vehicle and operate the various control buttons that code the travel and delay information for the automatic recording device. Automatic recording devices are available for recording travel distance, travel time, and locations of delay or other significant points by a system of coded numbers that are imprinted on the continuous paper readout.

Sample Size Requirements

The sample size for a travel time and delay study is based on the specific need for the information. The following suggested ranges of permitted errors in the estimate of the mean travel speed are related to the survey purpose:

---

*In some instances, manual back-up data collection may be used to augment automatic recording, and to assure data collection in the care of equipment failure.

1. Transportation planning and highway needs study -- ± 3.0 to ± 5.0 mph.

2. Traffic operations, trend analysis, and economic evaluations -- ± 2.0 to ± 4.0 mph.

3. Before-and-after studies -- ± 1.0 to ± 3.0 mph.

Other uses for travel time and delay results can be correlated with the above criteria.

Although the determination of sample size requirements is difficult for travel times or travel speeds, the information given in Table 2-4 provides an approximate value for designing travel time and delay studies. A sample size is determined for each direction of travel, and for each set of traffic and environmental conditions. The desired permitted error is first determined in accordance with the purpose of the study.

Table 2-4
Approximate Minimum Sample Size Requirements For Travel Time and Delay Studies With Confidence Level of 95.0 Percent

Average Range in Travel Speed (mph)	Minimum Number of Runs for Specified Permitted Error				
	±1.0 mph	±2.0 mph	±3.0 mph	±4.0 mph	±5.0 mph
2.5	4	2	2	2	2
5.0	8	4	3	2	2
10.0	21	8	5	4	3
15.0	38	14	8	6	5
20.0	59	21	12	8	6

Although both overall and running speeds may be determined from the corresponding travel times, the selection of sample size is more conveniently based on using the running speed values. This procedure avoids the consideration of any erratic overall travel times that may result from several unusual delay situations. Running speeds are more stable than overall speeds in describing the travel conditions along a given route, because delay time is eliminated in the calculation of running speed. Variable delays are encountered during successive test runs even under relatively similar traffic and environmental conditions.

The average range in running speed is calculated by the use of the following equation after the first set of these speed values has been determined by the test car technique.

$$R = \frac{\Sigma S}{N-1}$$

where R = average range in travel speed (mph)
ΣS = sum of values for all speed differences
N = number of completed test runs

The minimum sample size is approximated from Table 2-4 for the calculated average range in running speed and the desired permitted error. If the required sample size is greater than the initial number of test runs, then additional test runs, that are numerically equal to the difference between the required sample size and the initial number of test runs, must be performed under similar conditions.

Study Procedure

The test car technique of collecting travel time and delay data affords considerable flexibility in evaluating the quality of traffic flow. A test vehicle is driven along the study route at the posted speed limit unless impeded by actual traffic conditions. In the maximum-car technique, a safe level of vehicular operation is maintained by observing proper following and passing distances and by changing speed at reasonable rates of acceleration and deceleration.

Before the test runs are begun, the beginning and ending points are identified so that the test car may be driven past these locations in accordance with the selected operating condition. In addition, major intersections or other control points are selected along the study route as reference locations. Time readings are taken at these locations to permit the development of travel speeds by sections along the traveled route. The selection of the near or far curb line or the center of the intersection provides a consistent point for all time readings.

The test car is driven to a point that is located a little in advance of the start of the study route. At this point, the recorder fills in the identifying information on the field sheet. A typical field sheet is shown in Figure 2-47.

As the test car is driven past the beginning point, the recorder, in a manual procedure, starts one stopwatch. If the vehicle is equipped

TRAVEL TIME AND DELAY STUDY
TEST CAR TECHNIQUE
FIELD SHEET

DATE ____________ WEATHER ____________________ TRIP NO. __________

ROUTE ____________________________ DIRECTION ________________________

TRIP STARTED AT ____________ AT __________________ ______________
(LOCATION) (MILEAGE)

TRIP ENDED AT ______________ AT __________________ ______________
(LOCATION) (MILEAGE)

CONTROL POINTS	
LOCATION	TIME

STOPS OR SLOWS		
LOCATION	SEC DELAY	CAUSE

TRIP LENGTH __________ TRIP TIME __________ TRAVEL SPEED __________

RUNNING TIME ________ STOPPED TIME ________ RUNNING SPEED ________

SYMBOLS OF DELAY CAUSE S—TRAFFIC SIGNALS SS—STOP SIGN LT—LEFT TURNS
PK—PARKED CARS DP—DOUBLE PARKING T—GENERAL
PED—PEDESTRIANS BP—BUS PASSENGERS LOADING OR UNLOADING

COMMENTS ____

RECORDER ____________________________

Figure 2-47.
Sample Travel Time and Delay Study Field Sheet

with a fuel flow meter and if data on fuel usage is being collected, the recorder also records the fuel at the start of the run. If the vehicle is equipped with an automatic recording device, then this equipment is activated to indicate the start of the test run. The vehicle is driven the length of the study route according to the selected operating criterion. Time readings are taken at the predetermined control points, or the automatic recording device is actuated to indicate the passing of these points.

When the test car is stopped or forced to travel slowly, the recorder uses the second stopwatch to measure the duration of each delay. The location, duration, and cause of each delay are recorded in the appropriate places on the field sheet. If the test car is equipped with an automatic recording device, the driver operates the proper control buttons to record the start and end of each traffic delay. A numerical code or other actuated identification procedure is used to indicate the type of delay.

As the test car passes the end of the study route, the recorder stops the first stopwatch and notes the total time for the test run. Fuel data for the end of the run is recorded if applicable. If the vehicle is equipped with an automatic recording device, the proper actuation is made to record the passing of the terminal point.

If an automatic sound recorder is employed, the observer announces the various pieces of identifying information and the time at which the vehicle passes the beginning and the ending of the study route as well as the location and the time of passing for each control point.

In addition, the duration, and cause of each traffic delay are announced as the test car proceeds along the study route.

The length of the study route and the distnces between the selected control points must be determined so that time measures can be converted into speed values. Distance is obtained from the odometer reading of the test vehicle or scaling of a reliable map. Some automatic recording devices are connected to the speedometer-odometer cable so that distance is continuously indicated on the automatic recording device. However, the actual data collected depend upon the type of device that is installed in the test vehicle.

Data Analysis and Summary Statistics

The test car technique procedure provides considerable flexibility in the determination of travel speeds and delays. Summary statistics can be developed for various street intersections between selected control points as well as for the entire study route. The discussion is equally applicable to running speeds, and this transfer is accomplished by replacing "travel" with "running" in the statements and equation. Travel and running speeds are calculated from total travel and running times, respectively, by application of the following equation.

Travel Speed

Travel speed for each vehicle is computed from travel time using the following formula:

$$S = \frac{60D}{T}$$

where S = travel speed (mph)
D = length of study route or section (mile)
T = travel time (min)

Values calculated in this manner are shown in Table 2-5.

Table 2-5.

RESULTS OF TRAVEL TIME AND DELAY STUDY

Test Run (12.5 miles)	Travel Time (min)	Travel Speed (mph)
1	28.4	26.4
2	33.8	22.2
3	36.2	20.7
4	21.1	35.5
5	30.2	24.8
6	27.6	27.2
7	32.7	22.9
8	38.1	19.7
9	29.9	25.1
10	25.3	29.6

Computation of mean travel time:

$$\bar{T} = \frac{\Sigma T}{N} = \frac{303.3}{10} = 30.3 \text{ min.}$$

Computation of standard deviation of travel time:

$$s = \sqrt{\frac{\Sigma(T - \bar{T})^2}{N - 1}} = \sqrt{\frac{234.37}{9}} = \sqrt{26.0411} = 5.10 \text{ min.}$$

Computation of mean travel speed:

$$\bar{S} = \frac{60\ ND}{\Sigma T} = \frac{60 \times 10 \times 12.5}{303.3} = 24.7 \text{ mph.}$$

Computation of average range in travel speed:

$$\bar{R} = \frac{\Sigma S}{N - 1} = \frac{51.0}{9} = 5.7 \text{ mph.}$$

Mean travel speeds or space-mean can be calculated by the following equation:

$$\bar{S} = \frac{60\ ND}{\Sigma T}$$

where $\bar{S}$ = mean travel speed (mph)
D = length of study route or section (mile)
ΣT = sum of travel time for all test runs (min.)
N = number of test runs.

Types of dalay are determined for each test run in accordance with the appropriate descriptions that are provided in the following definitions.

- Delay -- time lost to travel because of traffic frictions and traffic control devices, usually expressed in minutes.
- Fixed delay -- component of delay which is caused by traffic control devices, regardless of the traffic volume and interference present.
- Operational delay -- component of delay which is caused by the presence and interference of other traffic, whether these interferences occur as side frictions or internal frictions.
- Stopped-time delay -- component of delay during whch the vehicle is actually standing still.
- Travel-time delay -- difference between the total travel time and the calculated time that is based on traversing the study route at an average speed corresponding to uncongested traffic flow on the route.

Mean delay time is usually the only summary statistic that is calculated for each delay category of interest.

Graphic Summaries

Graphical summaries are useful in describing the quality of traffic movement along a route or within an urban area. Plots of both average overall travel speeds by street sections and cumulative travel times and average intersection delays along the study route are shown in Figure 2-48 for an urban major street.

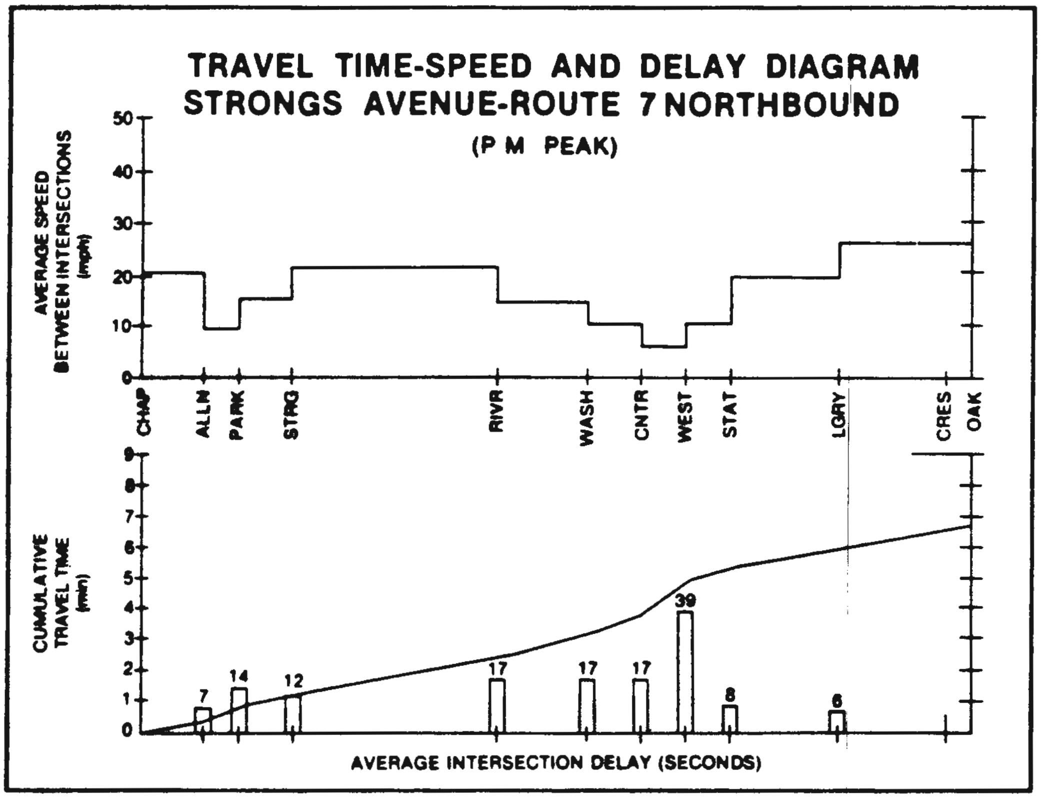


Fig. 2-48. Graphical Summary of Travel Speeds and Travel Times Along a Major Street

FORMS

ACCIDENT SUMMARY

PROJECT: ______________________________

PROJECT NO.: ______________________________

PREPARED BY: ______________________________ DATE ____________

DATA SOURCE: ____________	AADT	Exposure Veh. _____ or Veh. Mi. _____
TIME PERIOD: ____ TO ____		

Circumstance	Accident Category					
	Head-On	Side-swipe	Fixed Object	Rear End	Single Vehicle	Total
Total Accidents						
Direction						
Severity Fatal (#K)						
Injury (# Inj.)						
Prop. Damage Only						
Speed Safe						
Too Fast						
Vehicle Type Passenger Car						
Truck						
Motorcycle						
Other						
Road Surface Dry						
Wet						
Icy-Snow						
Other						
Light Conditions Daylight						
Darkness						
Season Spring						
Summer						
Fall						
Winter						

ACCIDENT SUMMARY

DAY AND TIME

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
A.M.								
12:01 – 1:00								
1:01 – 2:00								
2:01 – 3:00								
3:01 – 4:00								
4:01 – 5:00								
5:01 – 6:00								
6:01 – 7:00								
7:01 – 8:00								
8:01 – 9:00								
9:01 – 10:00								
10:01 – 11:00								
11:01 – 12:00								
P.M.								
12:01 – 1:00								
1:01 – 2:00								
2:01 – 3:00								
3:01 – 4:00								
4:01 – 5:00								
5:01 – 6:00								
6:01 – 7:00								
7:01 – 8:00								
8:01 – 9:00								
9:01 – 10:00								
10:01 – 11:00								
11:01 – 12:00								
TOTAL								

ERRATIC MANEUVER DATA SHEET

PROJECT: ____

PROJECT NO.: ____

PREPARED BY: ______________________________ DATE: ______________

DAY: ____________________ TIME: ______________________

WEATHER: ____

SKETCH:

EM'S:

VEHICLE TRACE DATA SHEET

PROJECT: ____

PROJECT NO.: ____

PREPARED BY: ______________________________ DATE: ______________

DAY: ______________________ TIME: ______________________

WEATHER: ____

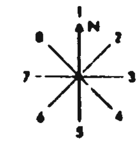
NOTES: ____

____

TRACES:

INTERSECTION CONFLICTS

Location ______________________ Leg Number ____________



Day ____________ Date ______________ Observer ______________

Conflict – C, Secondary Conflict – SC

COUNT START TIME (MILITARY)	TOTAL APPROACH VOLUME	Left Turn Same Direction		Slow Vehicle		Right Turn Same Direction		Opposing Left Turn		Left Turn from Left		Cross Traffic from Left		Left Turn from Right		Cross Traffic from Right		Right Turn from Right							
		C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC	C	SC
TOTAL																									

Severe Conflicts:

Possible Causes of Slow Vehicle Conflicts:

Other Notes and Comments:

INTERSECTION CONFLICT SUMMARY

Location ______________________________ Leg Number ______________

Day ______________ Date ______________________ Observer ______________________

COUNT START TIME (MILITARY)	Left Turn Same Direction	Slow Vehicle	Right Turn Same Direction	Opposing Left Turn	Left Turn from Left	Cross Traffic from Left	Left Turn from Right	Cross Traffic from Right	Right Turn from Right	All Same Direction	All Cross Traffic from Left	All Cross Traffic from Right	All Cross Traffic
TOTAL													
RATE													

Comments:

VEHICLE TURNING MOVEMENT COUNT

FOUR-APPROACH FIELD SHEET

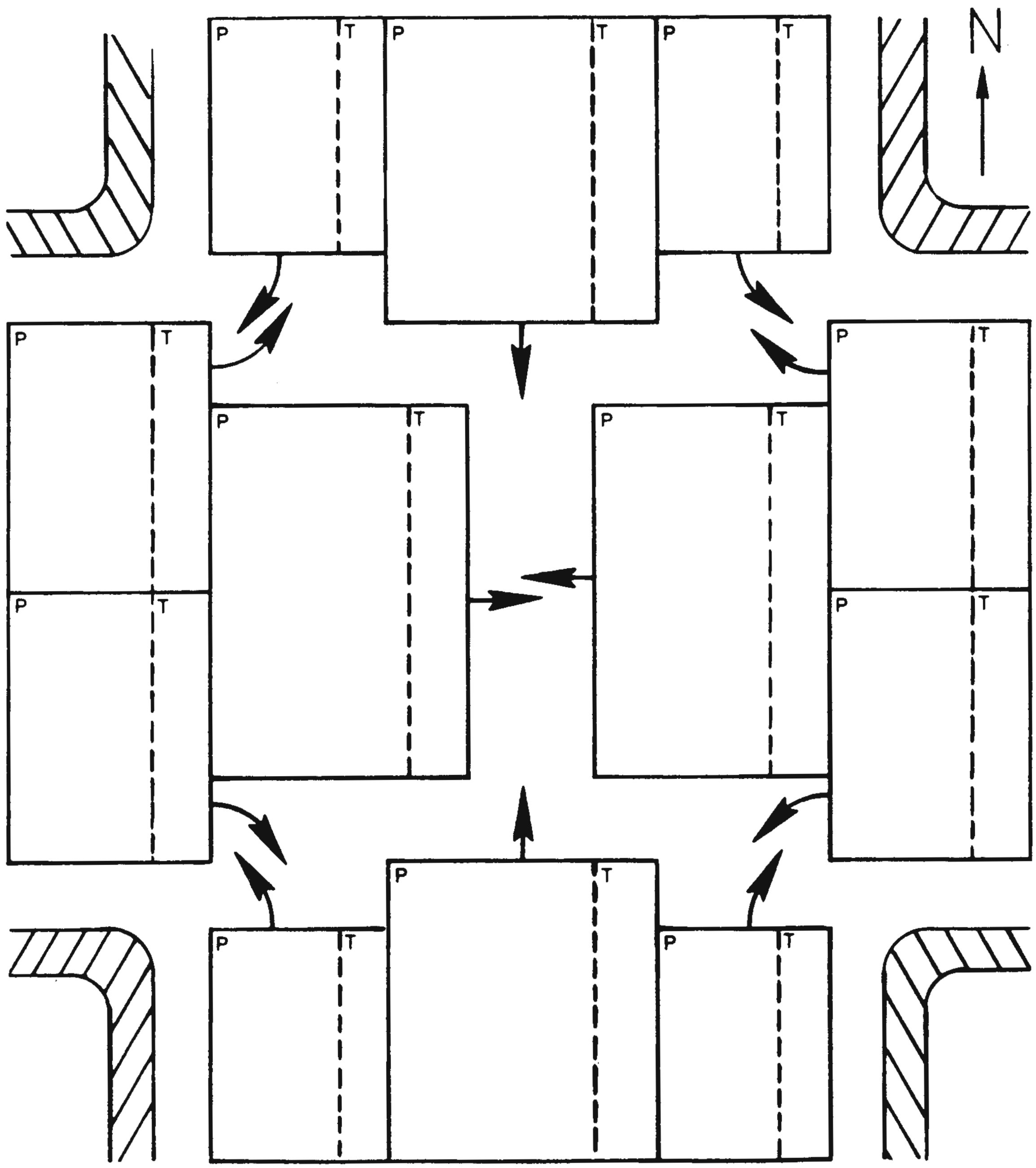
Time ____________ to ____________

N/S Street ______________________________ Date ____________________ Day ____________

E/W Street ______________________________ Weather ______________________________________

P = passenger cars, stationwagons, motorcycles, pick-up trucks. Observer ______________________________________

T = other trucks. (Record any school bus as SB; other buses as B).



VEHICLE TURNING MOVEMENT COUNT
TWO-APPROACH FIELD SHEET

N ↑

Hold sheet with arrow pointing NORTH

Time: __________ to ______________

Date: ______________

From NORTH SOUTH
on

From EAST WEST
on ______________

Truck	Passenger
	LEFT ↗
	STRAIGHT →
	RIGHT ↘

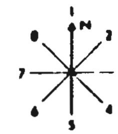
Truck / Passenger		
RIGHT ↙	STRAIGHT ↓	LEFT ↘

TRAFFIC VOLUME COUNTS

Location ____

Day ____________ Date ______________ Time Period ______________

Observer ____



COUNT START TIME (MILITARY)	Leg No. ______			Leg No. ______			Leg No. ______			Leg No. ______		
	⤴	→	⤵	↰	↑	↱	↲	↓	↳	↖	←	↙
TOTAL												

NOTES AND COMMENTS:

____

____

____

____

DRIVEWAY COUNT FIELD SHEET

Time__________ to__________

Street______________________________ Date__________________ Day____________

Driveway Loc.______________________________ Weather____________________________

Indicate North By Arrow

Observer____________________________

Notes:____

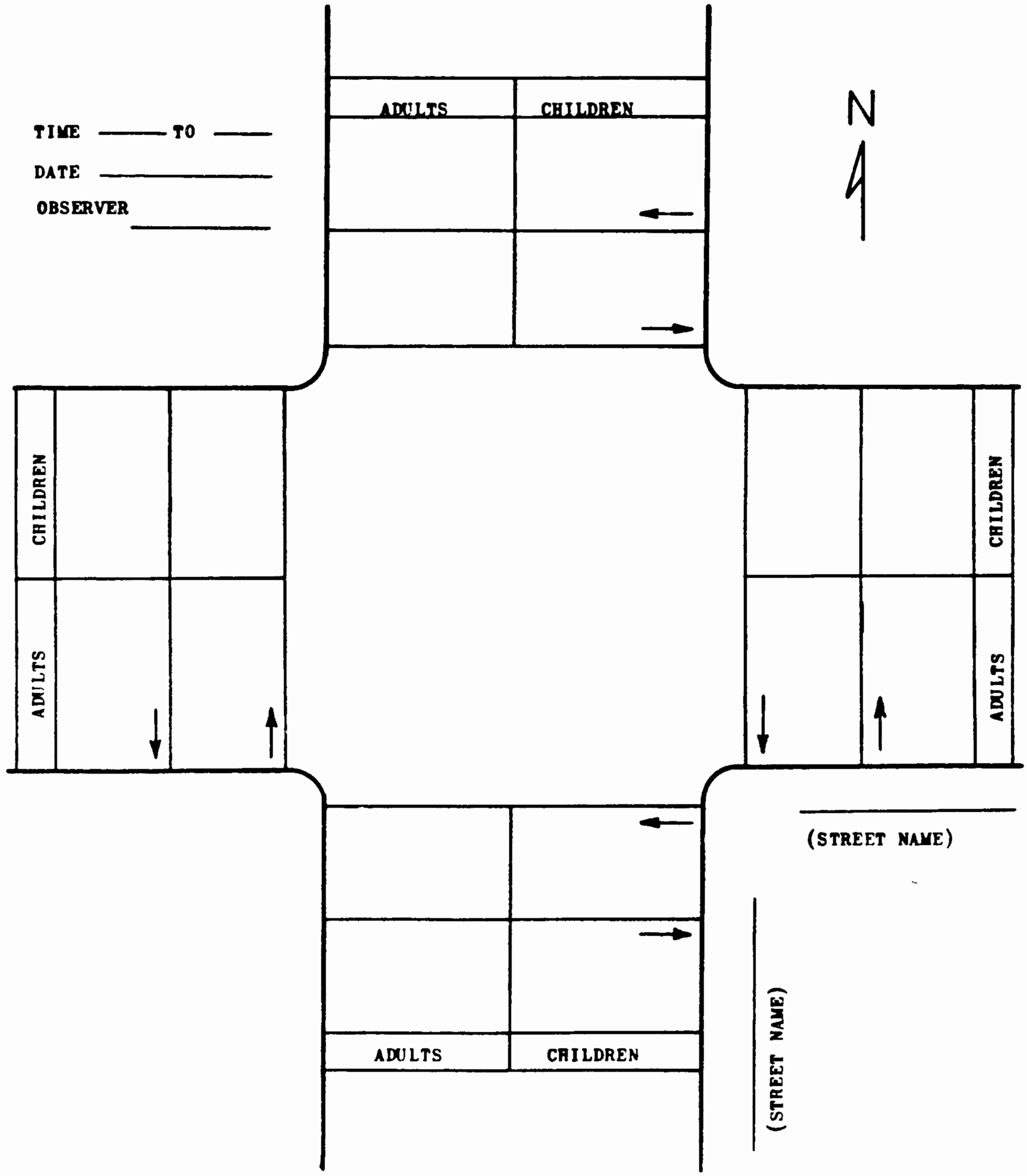
Right Turn IN		Straight		Left Turn IN	
Car	Tk.	Car	Tk.	Car	Tk.

Foot / Bike	Adults	Children
Foot		
Bike		

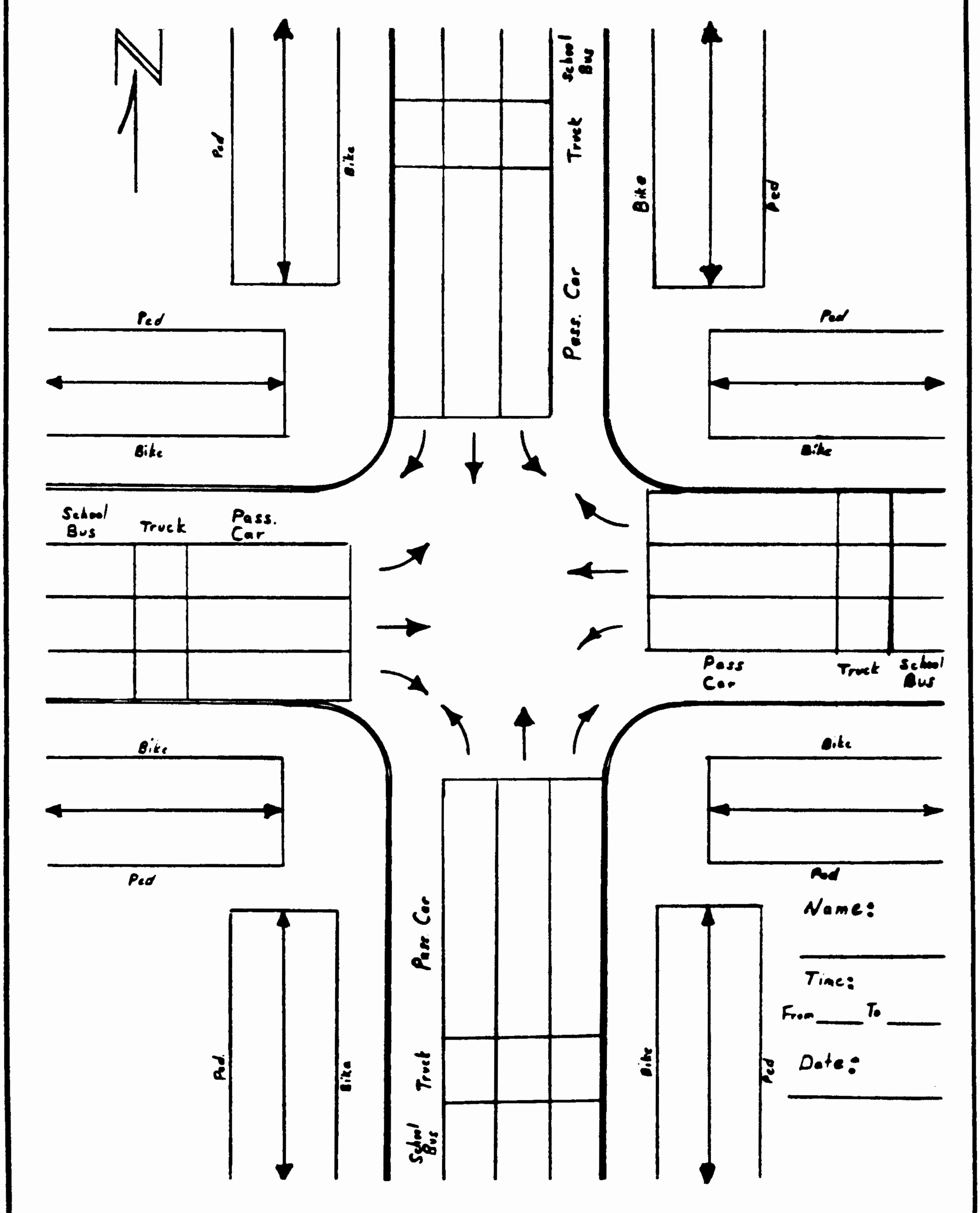
Foot / Bike	Adults	Children
Foot		
Bike		

Left turn OUT		Straight		Right turn OUT	
Car	Tk.	Car	Tk.	Car	Tk.

CROSSWALK FIELD SHEET
PEDESTRIAN COUNT



BICYCLE, PEDESTRIAN and VEHICLE VOLUME



TABULAR SUMMARY OF VEHICLE COUNTS

Observer ______________________ Date __________ Day __________ City ______________________

INTERSECTION OF ______________________ AND ______________________

R = Right turn
S = Straight
L = Left turn

TIME BEGINS	______ from NORTH				______ from SOUTH				TOTAL North South	______ from EAST				______ from WEST				TOTAL East West	TOTAL ALL
	R	S	L	Total	R	S	L	Total		R	S	L	Total	R	S	L	Total		

CONTINUOUS COUNTING
WEEKLY SUMMARY

Sta.No.________ Route____________________ Direction_______ Year______

Date: Hour Begin	Mon.	Tues.	Wed.	Thurs.	Fri.	Weekday Sub-total	Sat.	Sun.	Total for Week
AM									
00 00									
01 00									
02 00									
03 00									
04 00									
05 00									
06 00									
07 00									
08 00									
09 00									
10 00									
11 00									
12 00									
PM									
13 00									
14 00									
15 00									
16 00									
17 00									
18 00									
19 00									
20 00									
21 00									
22 00									
23 00									
TOTAL									
				Av. Weekday Vol.			Av.Day Vol.		
% Av.Weekday						100			X
% Av.Day of Week						X			100
Weather*						X			X

*C = Clear, R = Rain, S = Snow, I = Ice

Remarks____

____

________________________ Compiled by__________________

Date____________________

GRAPHIC SUMMARY OF VEHICLE MOVEMENTS

Intersection ____

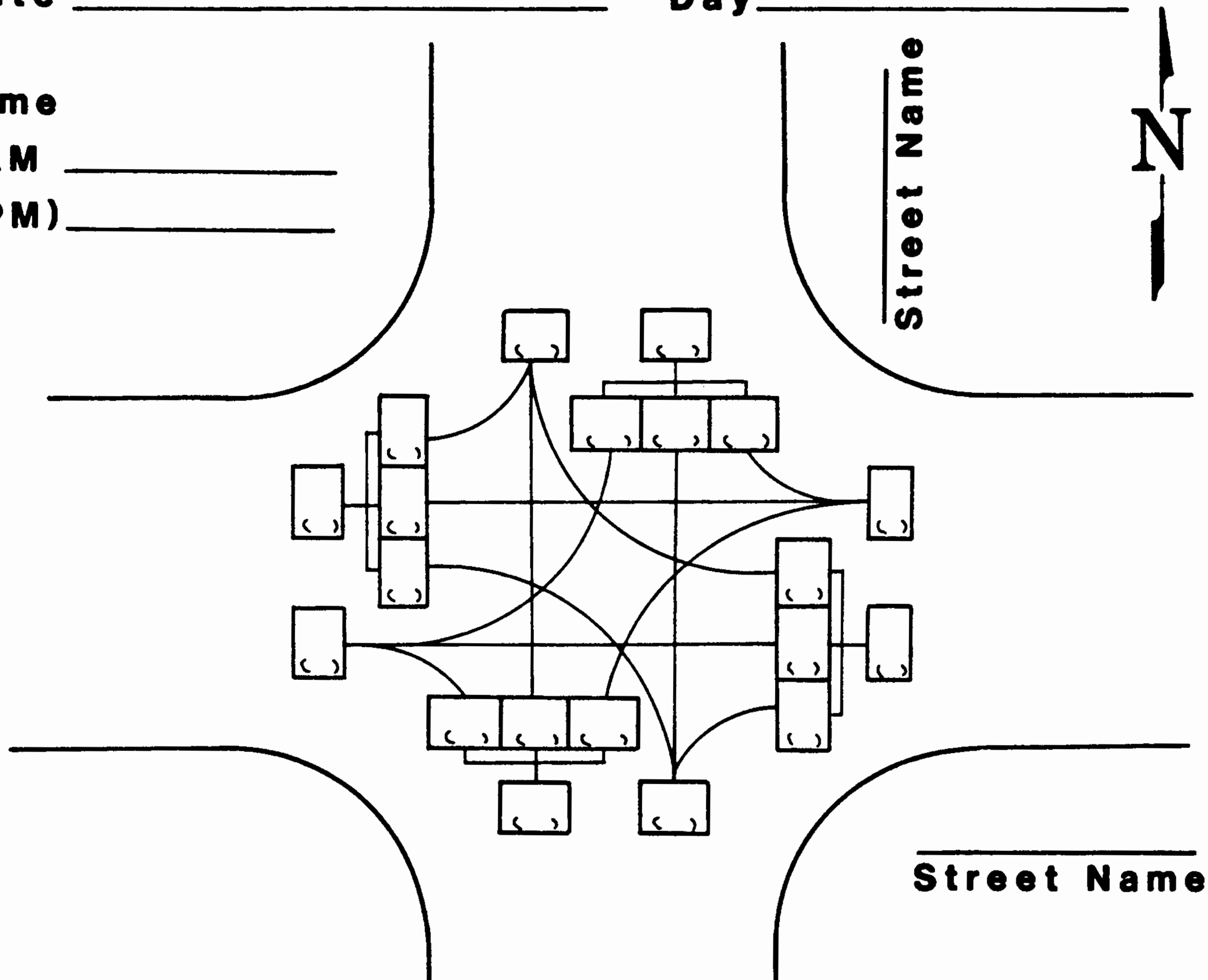
Observer ______________________ City __________________

Date __________________________ Day ___________________

Time

AM ______________

(PM) ______________



TOTAL ENTERING		
	AM	(PM)
N/S		
E/W		
Total		

SUMMARY
CLASSIFICATION SHEET FOR VEHICULAR TRAFFIC

Hour ____ to ____

Location ______________________________ Date ____________

______ Leg of Intersection

Hour Beginning	Passenger Cars		Single-unit Trucks			Bus		Tractor-truck Semitrailer			Full Trailer Combination		Total	Extra Axles	Machine Counts
	Local	Out-of-State	4 Tired	6 Tired	3 Axle	School	Other	3 Axle	4 Axle	5 or more Axles	4 Axle	5 Axle			
Total															

______ Leg of Intersection

Total															

______ Leg of Intersection

Total															

______ Leg of Intersection

Total															

TRAFFIC COUNT

FIELD SHEET

DATE _________

RECORDER_______

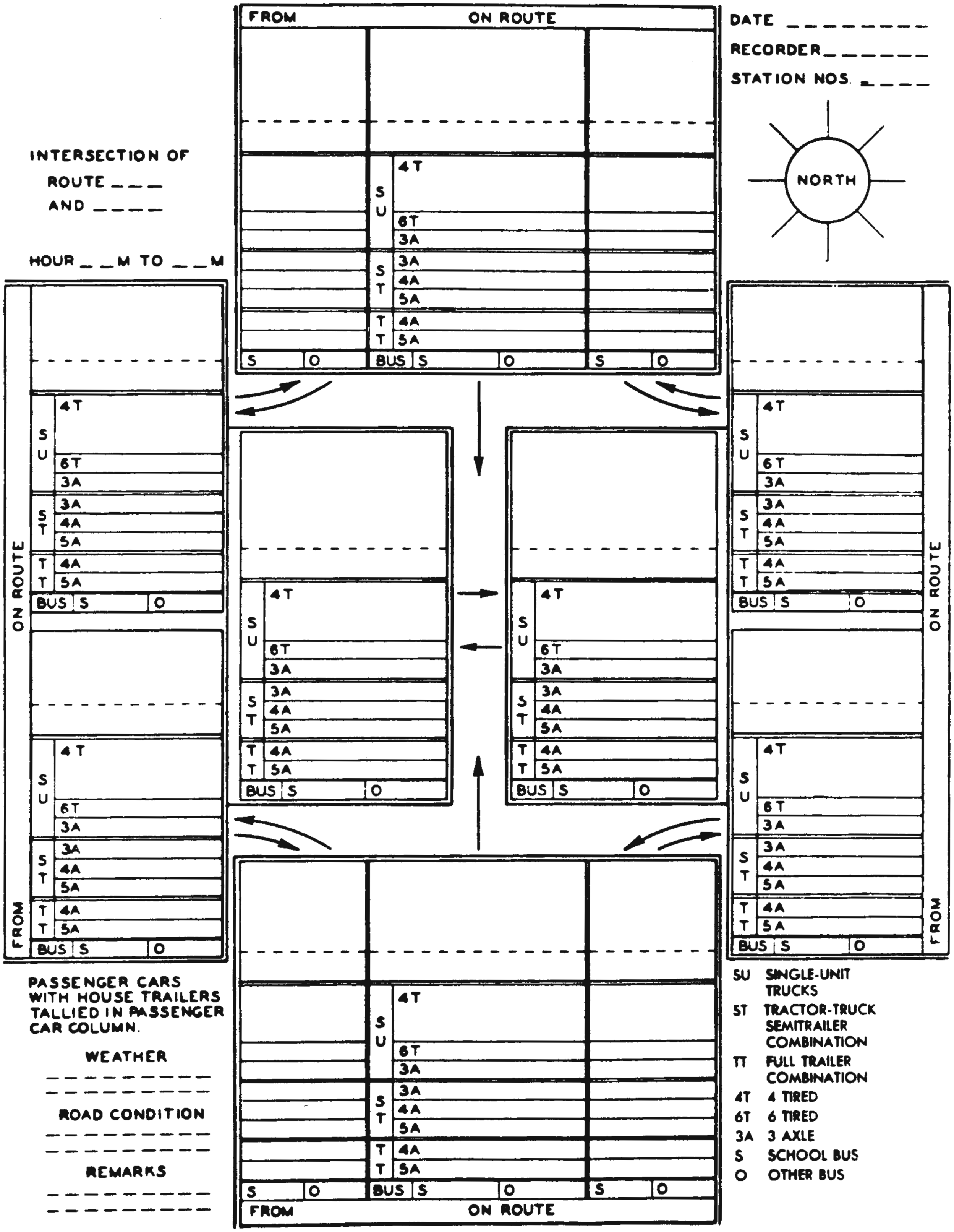
STATION NOS. _____

INTERSECTION OF

ROUTE ____

AND _____

HOUR __ __M TO __ __M



PASSENGER CARS WITH HOUSE TRAILERS TALLIED IN PASSENGER CAR COLUMN.

WEATHER

____

ROAD CONDITION

____

REMARKS

____

SU SINGLE-UNIT TRUCKS
ST TRACTOR-TRUCK SEMITRAILER COMBINATION
TT FULL TRAILER COMBINATION
4T 4 TIRED
6T 6 TIRED
3A 3 AXLE
S SCHOOL BUS
O OTHER BUS

SPOT SPEED STUDY
FIELD SHEET

Date ____________________ Location ______________________________ Direction __________________________

Time ____________________ Weather ____________________ Road Surface Condition __________________________

SECONDS	mph for 88 ft	mph for 176 ft		PASSENGER VEHICLES		BUSES		TRUCKS		TOTAL
					No Veh		No Veh		No Veh	
1	60.0	120.0								
1-1/5	50.0	100.0								
1-2/5	42.8	85.7								
1-3/5	37.5	75.5								
1-4/5	33.3	66.6								
2	30.0	60.0								
2-1/5	27.2	54.5								
2-2/5	25.0	50.0								
2-3/5	23.0	46.1								
2-4/5	21.4	42.8								
3	20.0	40.0								
3-1/5	18.7	37.5								
3-2/5	17.6	35.2								
3-3/5	16.6	33.3								
3-4/5	15.7	31.5								
4	15.0	30.0								
4-1/5	14.2	28.9								
4-2/5	13.6	27.2								
4-3/5	13.0	26.1								
4-4/5	12.5	25.0								
5	12.0	24.0								
5-1/5	11.5	23.0								
5-2/5	11.1	22.2								
5-3/5	10.7	21.4								
5-4/5	10.3	20.6								
6	10.0	20.0								
6-1/5	9.6	19.3								
6-2/5	9.3	18.7								
6-3/5	9.0	18.1								
6-4/5	8.7	17.6								
7	8.5	17.1								
7-1/5	8.3	16.6								
7-2/5	8.1	16.2								
7-3/5	7.8	15.7								
7-4/5	7.6	15.3								
8	7.5	15.0								
8-1/2	7.0	14.1								
9	6.6	13.3								
9-1/2	6.3	12.6								
10	6.0	12.0								
11	5.4	10.9								
12	5.0	10.0								
13	4.6	9.2								
14	4.2	8.5								
15	4.0	8.0								
			TOTAL VEHICLES							

INTERSECTION DELAY STUDY

POINT SAMPLE, STOPPED DELAY METHOD

Intersection ______________________ Study Traffic On ____________________________

City and State ____________________ Agency ______________________________________

Day, Date ______________ Study Period _______________ Observer __________________

Traffic Approaching From __________ Weather _____________________________________
N,S,E,W

If more than one person is studying same approach, explain division of responsibilities. ____
____
____

INTERVAL BETWEEN SAMPLES = ____ SECS.

START										
										30
										60
										90
										120

OBSERVED TOTAL, ALL SAMPLES _____

[30] DENOTES 30TH SAMPLE

COMMENTS: ____
____
____

DATA REDUCTION FORM

INTERSECTION DELAY AND PERCENT STOPPING STUDIES

Intersection ______________________ City & State ______________________

Study Approach On ______________________ Traffic From ______________________ N, S, E, W

Day, Date, Time ______________________

PERCENT STOPPING STUDY

(i) Total no. of vehicles "stopping" . . . . ______ vehs.

(ii) Total no. of vehicles "not stopping" . . . . ______ vehs.

(iii) Total volume = (i) + (ii) . . . . ______ vehs.

(iv) Observed Percent Stopping = [(i) ÷ (iii)] x 100 . . . . ______

(v) Actual Percent of Vehicles Stopping = (iv) x 0.96 . . . . ______

CORRECTION PROCEDURE FOR MISSED SAMPLES IN DELAY STUDY

	Corr. * No. 1	Corr. * No. 2
(a) Total no. of point samples taken in field during 30-sample period	____	____
(b) 30 - (a)	____	____
(c) Sum of point sample values for 30-sample period on field data sheet	____	____
(d) Value of each missing sample = (c) ÷ (a), round to nearest whole number	____	____
(e) Total value for all missing samples in 30-sample period = (b) x (d)	____	____

(f) Total value for all missing samples in study period = sum of (e) for all corrections . . . . ____

* Use one correction factor for each 30-sample period in which the field data sheet has one or more missing values.

INTERSECTION DELAY STUDY

(1) Total no. of point samples taken in field . . . . ______

(2) Total no. of point samples missed, from (b) above . . . . ______

(3) Total no. of point samples used in calculations = (1) + (2) . . . . ______

(4) Interval between samples . . . . ______ secs.

(5) Sum of observed point sample values . . . . ______ vehs.

(6) Sum of calculated "corrected" point sample values, from (f), above . . . . ______ vehs.

(7) Sum of all point sample values = (5) + (6) . . . . ______ vehs.

(8) Total Stopped Time = (4) x (7) . . . . ______ veh.-secs.

(9) Stopped Delay = (8) x 0.92 . . . . ______ veh.-secs.

(10) Approach Delay = (9) x 1.3 . . . . ______ veh.-secs.

(11) Total Volume = (iii) . . . . ______ vehs.

(12) Stopped Delay Per Vehicle = (9) ÷ (11) . . . . ______ veh.-secs./veh.

(13) Approach Delay Per Vehicle = (10) ÷ (11) . . . . ______ veh.-secs./veh.

PERCENT STOPPING STUDY

Intersection ______________ Study Traffic On ______________

City and State ______________ Agency ______________

Day, Date ______________ Study Period ______________ Observer ______________

Traffic Approaching From ______________ Weather ______________
N,E,S,W

If more than one person is studying same approach, explain division of responsibilities. ______________

STOPPING *	NOT STOPPING *

* IF TALLY MARK IS USED, ~~THL~~ DENOTES A COUNT OF "5"

TOTAL STOPPING ____ TOTAL NOT STOPPING ____

COMMENTS: ______________

INTERSECTION DELAY STUDY

POINT SAMPLE, STOPPED DELAY METHOD

Intersection ______________________ Study Traffic On ______________________

City and State ____________________ Agency ______________________

Day, Date ________________ Study Period ______________ Observer ______________

Traffic Approaching From __________ Weather ______________________
N,S,E,W

If more than one person is studying same approach, explain division of responsibilities. ______________________

INTERVAL BETWEEN SAMPLES = ____ SECS.

FOR LANE * ____________

									30
									60
									90
									120

OBSERVED TOTAL, ALL SAMPLES ____

FOR LANE * ____________

									30
									60
									90
									120

OBSERVED TOTAL, ALL SAMPLES ____

[30] DENOTES 30TH SAMPLE

* RIGHT HAND LANE IS "NO. 1", LEFT MOST LANE HAS HIGHEST DESIGNATED NUMBER

COMMENTS: ____

____

____

PERCENT STOPPING STUDY

Intersection ______________________ Study Traffic On ____________________________

City and State ____________________ Agency ______________________________________

Day, Date ________________ Study Period _______________ Observer ________________

Traffic Approaching From __________ Weather ____________________________________
N,E,S,W

If more than one person is studying same approach, explain division of responsibilities. ____

FOR LANE* ____________________

STOPPING	NOT STOPPING

FOR LANE* ____________________

STOPPING	NOT STOPPING

* IF TALLY MARK IS USED, ~~IIII~~ DENOTES A COUNT OF "5"

TOTAL STOPPING _____ TOTAL NOT STOPPING _____ TOTAL STOPPING _____ TOTAL NOT STOPPING _____

COMMENTS: ____

TRAVEL TIME AND DELAY STUDY
TEST CAR TECHNIQUE
FIELD SHEET

DATE ____________ WEATHER ____________________ TRIP NO. ____________

ROUTE ____________________________ DIRECTION ____________________

TRIP STARTED AT ____________ AT ________________ ____________
(LOCATION) (MILEAGE)

TRIP ENDED AT ______________ AT ________________ ____________
(LOCATION) (MILEAGE)

CONTROL POINTS	
LOCATION	TIME

STOPS OR SLOWS		
LOCATION	SEC DELAY	CAUSE

TRIP LENGTH ________ TRIP TIME ________ TRAVEL SPEED ________

RUNNING TIME ______ STOPPED TIME ______ RUNNING SPEED ______

SYMBOLS OF DELAY CAUSE: S—TRAFFIC SIGNALS SS—STOP SIGN LT—LEFT TURNS
PK—PARKED CARS DP—DOUBLE PARKING T—GENERAL
PED—PEDESTRIANS BP—BUS PASSENGERS LOADING OR UNLOADING

COMMENTS ____

RECORDER ______________________

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983 - 381-018 - 814/3445