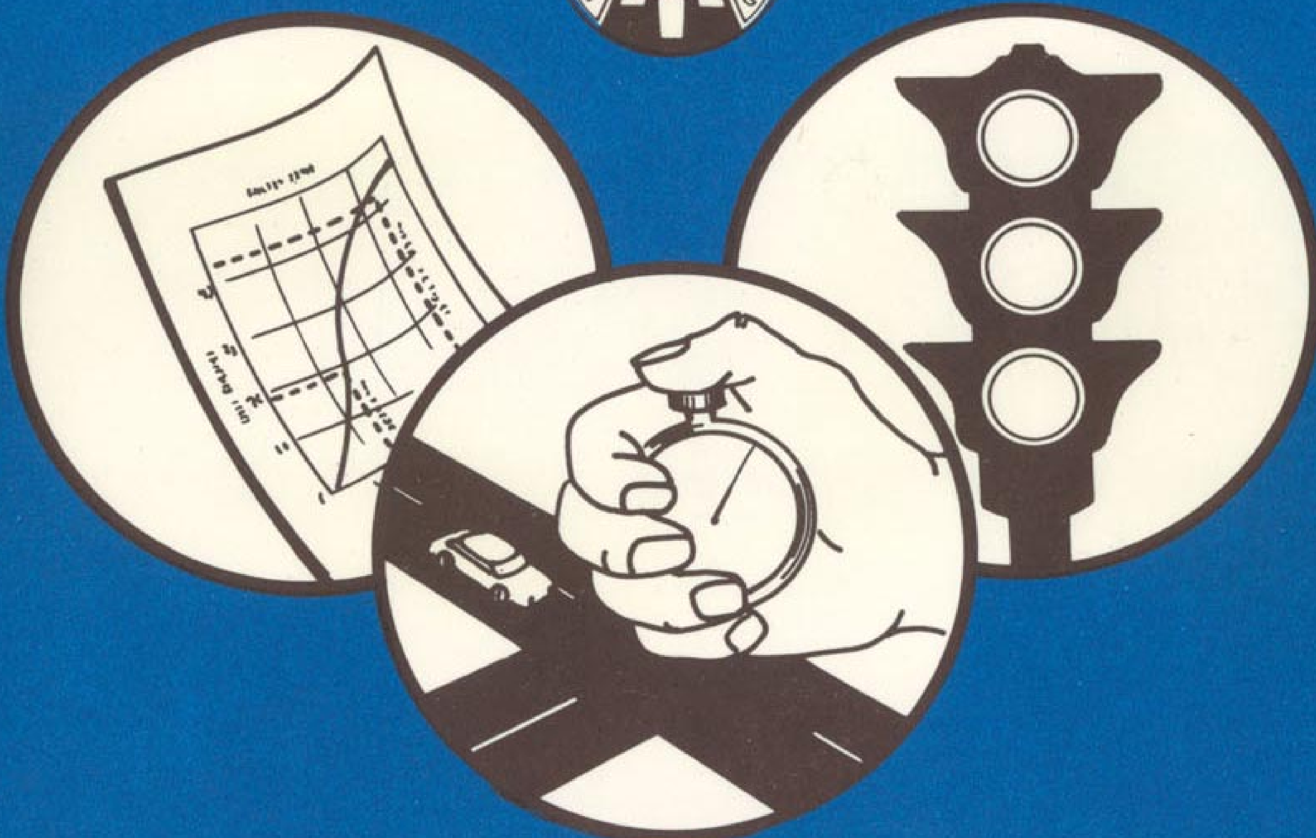
MTMCTEA PAMPHLET NO. 55-8

TRAFFIC ENGINEERING STUDY REFERENCE



MILITARY TRAFFIC MANAGEMENT COMMAND
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Washington, D C 20315

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TRANSPORTATION AND TRAVEL
TRAFFIC ENGINEERING STUDY REFERENCE

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PART ONE. GENERAL

SECTION I

INTRODUCTION

1. Background.

a. The revolution in highway transportation as evidenced by sweeping changes in motor vehicles, roadway construction, and traffic controls has provided immeasurable benefits to the individual and to those organizations such as the Department of Defense where mobility and mission are inseparable. However, this new flexibility of movement poses many problems, most involving congestion, accidents, energy loss, and environmental pollution. The need to minimize these problems was a great stimulus to the development of the traffic engineering profession, but demands for this expertise generated by tremendous growth in travel have continually exceeded capability.

b. Military installations are unique in that their physical size and operating budgets limit the magnitude and speed with which transportation problems can be treated. Trained personnel cannot be readily employed, and restricted funds and space frequently prevent the implementation of proper corrective action, particularly since general motor vehicle operation is considered secondary to the mission. This pamphlet recognizes current needs and is designed for technical and nontechnical persons who have been tasked to provide early remedy to the more basic traffic oriented problems, or to provide assistance to others who are so assigned. It is the first of a series of publications that is being prepared to aid installation personnel in handling problems or obtaining information relating to the design, use, or maintenance of transportation facilities and systems.

2. Purpose.

a. This pamphlet is intended for use by personnel responsible for vehicular traffic engineering analyses and control at Department of Defense (DOD) installations. It is not intended to replace published manuals and criteria or to be used as a substitute for formal training, but to provide supplemental assistance to those who have need for immediate guidance on the basic considerations in analysis and remedy of traffic-related problems. It indicates what information is important, how it can be assembled, what its significance is, and what are some of the more widely used methods for alleviation of traffic problems.

b. In accordance with DOD Directive 5160.60 and AR 55-80, the Military Traffic Management Command (MTMC) is the designated DOD executive agent in public highway matters. The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) an MTMC field command, is delegated traffic engineering support responsibilities for DOD. The information in the pamphlet will also assist local personnel in the coordination and assembly of data for the more complex studies conducted by MTMCTEA, and will enable them to deal directly with many of the day-to-day traffic problems.

c. Solutions resulting from use of this reference are not intended to replace the more direct and economical solutions of "spreading the vehicular demand" to eliminate problems by staggering the duty hours, use of preferential parking to enhance group riding, and/or coordination of land use to preclude undesirable vehicle concentrations.

3. Scope.

a. This pamphlet identifies the more common problems experienced in connection with traffic operation on military installations, the types of studies most frequently used in determining solutions to the problems, and those aspects of each study type that concern data collection, analysis, and interpretation. It includes sufficient illustrations of formats, diagrams, and calculations to insure a logical process in the conduct of the studies and the presentation of related analyses and findings.

b. This manual is designed for use by installation personnel in the treatment of the day-to-day problems that cause traffic accidents and congestion. The primary variances in study scope will be as dictated by the size of the installation, the length and use of its roadways, the volume of its activities, and the nature and magnitude of its transportation problems. More definitive investigative procedures, analyses, interpretations, criteria, and applications of remedial measures may be obtained from the publications in the selected bibliography and by contacting MTMCTEA.

4. Application. This pamphlet is intended to assist local personnel in the assembly of traffic data, in recognizing the type and magnitude of traffic-related problems, in determining practical solutions, and in providing support to those engaged in the more complex traffic engineering studies. A common sense approach, however, must be applied in the use of this material. Onsite observation of traffic operations and review of previously recorded accident data will usually indicate if the problem is localized and relatively minor. In these cases, the guidance furnished

herein should facilitate determination of a satisfactory conclusion. When questions arise during initial observations or analyses, or when the problem evidences more than ordinary involvement, contact with MTMCTEA should be made to determine appropriate action. Incorrect or unnecessary data collection and analysis can result in considerable waste of effort.

5. Training. The activities on the installation that closely relate to traffic engineering matters include those involved with facility engineering, construction, security, safety, and law enforcement. Responsibilities vary between installations, but, in any case, those persons who are directly accountable for traffic engineering should be given opportunity to develop proper expertise. This is best accomplished by attendance at one or more of the many special courses available at colleges and universities throughout the country. For example, Northwestern University, Georgia Institute of Technology, and the University of Southern California offer 1- to 4-week courses especially designed to educate technicians and engineers in specific areas of traffic engineering, or to present a complete overview of the more common traffic problems and the techniques employed in their solution.

6. Changes and revisions. Recommended changes or comments related to this pamphlet should be keyed to the specific page, paragraph, and line of the text to which it applies, and sufficient detail provided to assist in a thorough evaluation of each. Comments should be forwarded to the Commander, Military Traffic Management Command Transportation Engineering Agency, ATTN: MTT-TE, PO Box 6276, Newport News, Virginia 23606-0276.

SECTION II

HOW TO USE THIS GUIDE

7. General. This guide is intended for use as an aid in both the selection and conduct of the type of study required to provide information to solve a localized problem or to clarify for installation personnel the type and degree of assistance required by professionals in the study of the more complex situations. It is a primary need to limit study effort to the minimum by selection of appropriate study type. In some cases this may mean only a sampling of data whereas in others it may result in the conduct of more than one study type. It is unlikely that an installation would have a need to perform every study listed in this guide, particularly, since the

more complex problems should be solved by professional traffic engineering personnel. As an example, the design of a modern traffic-signal system requires professional expertise.

8. Study selection. The user of this pamphlet should first determine the scope and magnitude of the problem and the apparent involvements. The cross-reference guide presented in table 1 combines the more common problems and symptoms under the heading of "Study Generator". It is used to determine which study(ies) will provide the information required to permit analysis of the problem and determination of appropriate remedial action. Review is made of the details provided in part two for the study before actual study conduct is initiated.

9. Public roads. Installation officials are encouraged to cultivate and maintain contact with representatives of the state and local highway authorities. In addition, installation officials should be aware that they may call upon the local Federal Highway Administration (FHWA) division office for advice and/or assistance in regard to local public highway matters, when necessary. Need for more formal action should be transmitted to the Commander, MTMC, the designated agent of the Secretary of Defense to support the Department of Defense Highways for National Defense Program. (Ref: DOD Directive 5160.60, Highways for National Defense, Appendix B. This has been expanded in the joint regulation, AR 55-80/OPNAVINST 11210.1/AFR 75-88/MCO 11210.2A/DSAR 4500.19, Highways for National Defense, 2 August 1974 (Appendix B). In any access road problem, these documents should be acquired.)

10. Organization. The information in this pamphlet is arranged to present traffic study techniques throughout part two. Specific types of studies are discussed in separate sections. Appendix A contains definitions of technical terms used in this text. Appendix B provides a list of pertinent publications applicable to this guide, with the names of institutes that have an interest in traffic. Appendixes C and D provide sample forms for inventorying traffic-control devices, and appendix E provides guidance in establishing priorities for alleviating traffic problems.

TABLE 1
TRAFFIC-STUDY REFERENCE

STUDY GENERATOR	Traffic Studies Required													
	1 Traffic-Volume Studies	2 Street Classification Study	3 Highway-Capacity Study	4 Vehicle-Occupancy Study	5 Personnel and Duty-Hour Study	6 Traffic-Accident Study	7 Traffic-Control Devices Inventory	8 Travel-Time and Delay Studies	9 Spot-Speed Studies	10 Origin and Destination Studies	11 Traffic-Control-Device Observance Studies	12 Transit Studies	13 Parking Studies	14 <u>Highway Safety Program Standard 13</u>
Accidents	P					P	P		P		P			S
Bicycles	P					S								
Building Program	P		P		P									
Bus Service					P							P		
Capacity, Traffic	P		P					S						
Car Pooling	P		S		P									
Classification, Street	S	P							S					
Congestion	P			S	S			P		S				
Construction Projects	P				P					P				
Control, Traffic	P						P		S		P			
Counts, Counters	P						S					S		
Delays, Traffic	S			S				P						
Driver Confusion						S	P							
Duty Hours					P									
Energy Conservation				P	P									
Entrance Gates	P		P	S	S					P				
Flow, Traffic	P													
Generators, Traffic	P			P	P					P		S	S	
<u>Highway Safety Program Standard 13</u>						P	P		P					P
Intersection	S					P	P							
Land Use	S			P	P					P				
Law Enforcement						P	S		S		P			
Mode, Transportation	P			S							S	P		
<u>Manual on Uniform Traffic Control Devices for Streets and Highways</u>							P							P
Origin and Destination				S						P	S			
Parking Congestion	P		S	S	S					S			P	
Pavement Marking						S	P							S
Pedestrians	P					P							S	
Personnel	S				P									
Planning, Master	P	P	S		P					P				
Population Changes	P			S	P					P				
Public Approach Roads (see text)	P		P	S	S	S				P				
Regulations, DOD							P							P
Safety	P					P	S		S		P			P
Signals						S	P							S
Signs						S	P							S
Speed, Spot Speed						P			P					
Through Traffic	P									P				
Traffic Control							P				S			
Transit Service					P							P		
Travel Desires	S				S					P				
Travel Time			S					P				S		
Trucks	P	P	S											
Turning Movements	P		S											
Vehicle Occupancy				P	S									
Volume, Traffic	P		S	S	S									

Legend: P = Primary Importance.
S = Secondary Importance.

SECTION III

CONDUCTING A TRAFFIC STUDY

11. General. Traffic engineering studies are conducted to develop factual information necessary to effect intelligent solutions to traffic problems, to provide guidance for the planning of transportation systems and facilities, and to assist authorities in developing the most desirable land-use patterns. Accurate knowledge of travel desires, constraints, and operational problems is a primary element in any decision involving transportation. Information obtained by application of procedures contained in this reference will assist personnel in correcting many of the more frequently experienced traffic problems and will prove invaluable when assisting MTMCTEA in the conduct of the more complex studies that require professional expertise. (See AR 55-80/OPNAVINST 11210. 1/AFR 75-88/MCO 11210. 2A/DSAR 4500. 19.)

12. Use of traffic studies. Each section of part two relates to the conduct of a particular type of study and provides detailed explanations of basic purpose and application. Sufficient guidance and illustrations are included to insure adequacy in the conduct of each type of study. Questions concerning the conduct or application of any study contained herein should be directed to MTMCTEA.

13. Study requirements of Highway Safety Program Standard 13 (HSPS). Requirements set forth in HSPS 13 were established to insure full and proper application of modern traffic engineering principles and uniform standards to reduce the likelihood and severity of traffic accidents. The Highway Safety Program Manual, Volume 13 (HSPM 13), Traffic Engineering Services is a guide for implementation of HSPS 13 (section 14) and requires certain studies as contained in this pamphlet, particularly part two, section 2, "Street Classification Study"; section 6, "Traffic Accident Study"; and section 7, "Traffic-Control-Devices Inventory".

14. Format. Each section of this pamphlet deals with an individual type of study and is organized as follows:

a. Purpose of study.

b. Data needed.

c. Methods of data collection.

d. Analysis of raw data.

e. Interpretation of processed data.

f. Application of study results.

15. Planning a traffic study. Planning a traffic study is as important as the study itself. Improper techniques, excessive data collection, or even unnecessary study conduct can cause waste of manpower and/or make it difficult to determine the correct solution to a problem. It is essential that the engineer/technician has sufficient information to conduct the analysis, but frequently this can be obtained by no more than sample observation or survey of traffic movements and desires. Compliance with the following procedure will make it easier to conduct a study and will help to preclude excessive use of personnel time:

a. Examine records and assemble available related data.

b. Determine how much additional data are required.

c. Select location(s) and time(s) for data collection.

d. Review study procedure as in part two of this pamphlet.

e. Establish personnel and equipment needs.

f. Prepare survey forms.

g. Arrange for and brief survey personnel on study procedures.

h. Collect field data.

i. Perform analyses and interpret data.

j. Determine alternate solutions.

k. Select solutions that best fit the dictates of effectiveness, economy, and ease of implementation.

PART TWO. TRAFFIC ENGINEERING STUDIES

SECTION I

TRAFFIC-VOLUME STUDIES

16. Purpose. The purpose is to count the number of persons or vehicles passing along a given facility. The amount of traffic in vehicles per unit of time is called the traffic volume. A count may be classified by the time of day, direction of travel, types of vehicles, and number of vehicle occupants. The scope of a count may range from a comprehensive survey of traffic flow on all major roadways of an installation to a count of the number of cars passing through an intersection in a single hour. Typical types of traffic-volume data and their usage are:

a. ADT. Average daily traffic (ADT) is an average of 24-hour volumes over a stated period of time. Unless otherwise stated, the period is for a year, or annual average daily traffic (AADT). These data are used to estimate growth trends, to calculate accident rates, to decide construction priorities, to plan roadway maintenance, and to design future street networks.

b. Peak-hour volumes. Peak-hour volumes are needed to determine when the peak traffic movements occur during the day and the number and direction of these movements at a given point or area. These are used to determine what additional traffic-control devices, such as traffic signals, should be modified. These data are also used to determine the number of lanes necessary to accommodate known or projected demands, to allocate right-of-way to appropriate traffic flows, and to design and locate streets and gates.

c. Vehicle classification. Vehicle classification is used to identify a road in terms of the traffic it serves. The classes typically include passenger cars, various types of trucks and buses, motorcycles, and bicycles. Vehicle-classification data are used primarily in the design of pavement thickness and in calculating highway capacities.

17. Information needed. The types of traffic-volume counts needed will be determined by the ultimate usage of the data. Use of too much manpower and time to collect too much data is as improper as not collecting enough data. In any volume-counting program, you must determine: (1) the locations where counts will be taken; (2) the overall length of time the data collection will last; (3) the intervals at which information will be recorded (for example, every 15 minutes, hourly, or daily); and (4) what

will be counted (for example, total vehicles, trucks, pedestrians, or a combination of these and other categories).

18. Methods. The methods used will be determined by the purpose of the traffic count.

a. Techniques. The two basic techniques for obtaining traffic-volume data involve either the use of an automatic (mechanical) counter or a manual count (hand tally).

(1) Automatic counters. These portable devices are generally battery-powered, but some of the smaller units operate by windup springs. They usually employ a pneumatic road tube to detect a passing vehicle, and it provides an impulse to advance the counter mechanism. Some counters employ a wire road loop or other electronic detector on or imbedded in the pavement to indicate vehicle passage. Most counters using a road tube are designed to register one vehicle for every two (axle) impulses. An adjustment multiplier may be needed if traffic consists of over 5 percent tractor-trailers or other multiple-axle vehicles. The road tube may be installed across half the road to obtain a directional count, or may be stretched across the entire road to indicate total volume. To obtain accurate counts, the road tube must be carefully installed according to the manufacturer's instructions.

The more complex counters print the volume count on a paper tape at 15-minute intervals, cumulatively up to 1 hour, when the counter resets to zero. Thus, when a counter is left at one location for 24 hours or more, a record of hourly volumes is obtained; and 15-minute peaks can be obtained by subtracting the consecutive cumulative printouts. The simpler counters contain only a cumulative counter dial, which must be read on location at the intervals for which the counts are desired.

(2) Manual counts. These require field personnel to hand tally each vehicle as it passes the checkpoint. They must have a pencil, wristwatch, clipboard, and a sufficient supply of appropriate field data sheets unless use is made of push-button manual-counting registers. The latter may be board mounted to simulate an intersection. Manual registers greatly increase the total number of vehicles that one person can count in a given period, since he only has to indicate the passing of a vehicle by depressing a key and record the counts at the end of each count interval.

Sufficient personnel must be available to obtain accurate data. At very busy intersections, it may be necessary to provide one man for each approach. Less busy intersections can be counted by two men; or even one, if he has an intersection board of manual registers. When all-day counts are undertaken, it will be necessary to provide extra men so that the workers may have periodic breaks. It is suggested that several of the more capable workers be appointed as overseers and made responsible for the collection of field sheets at the day's end. Different persons performing manual counts will always obtain slightly different numbers. The overseer should apply a data check system of the count with other intersections along the same street, a comparison of manual counts with those of automatic recorders, and a spot manual count of his own.

b. Length of count. Traffic counts are made over a time period long enough to provide the data desired. For example, a peak-period count should include sufficient time to insure the peak hour is covered. Normally it is desirable to include a minimum of 15 minutes at each side of the peak hour. Traffic signals are timed using data collected during the morning-peak, evening-peak, noon-peak, and/or off-peak periods. To satisfy the warrants for a traffic signal, data should be collected during the 10 busiest hours of the day. Twenty-four-hour counts may be used as estimates of the average daily traffic. Automatic counters can be left in place for extended periods or even be permanently installed to determine daily, weekly, or seasonal variation in traffic volumes. Intersectional traffic volumes are usually recorded in terms of 15-minute intervals to permit identification of peaking within the hour.

Short counts can be obtained of less than the total periods under study to permit coverage of a number of locations when total time available for counting is limited. In these, to estimate peak-hour volumes, the observer would count 6 minutes at each location, preferably for at least three times during the hour. The three short counts at each location are averaged, and an estimate of the hourly volume is obtained by multiplying this average by 10.

c. Types of studies. The major types of volume studies performed at military installations are the turning-movement count, traffic-volume count, vehicle-classification count, and special counts.

(1) Turning-movement count. This type of manual count should be performed at every major intersection in the overall study area. The counts are made during morning- and evening-peak periods, and if possible, during noon-peak and several off-peak periods. Personnel are assigned to specific corners of the intersection being counted and are instructed to place a tally mark for each passing vehicle according to its movement, either left, straight, or right. A sample field-data sheet is shown in figure 1. Four of these forms would be used at a four-way

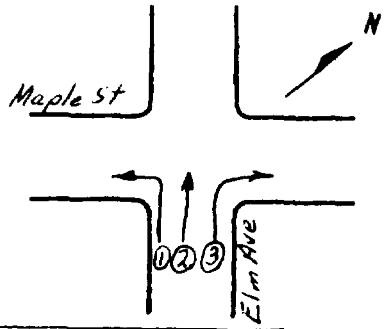
TURNING MOVEMENT COUNT FIELD SHEET

LOCATION Maple St. & Elm Ave

DATE July 21, 1975

TIME 0645 TO 0815

OBSERVER L.R. Smith



TIME	①	②	③
0645 to 0700	15	7	22
0700 to 0715	21	9	29
0715 to 0730	30	18	46
0730 to 0745	41	27	88
0745 to 0800	42	28	173
0800 to 0815	22	11	38

SAMPLE

Figure 1. Typical turning-movement-count field sheet.

intersection, but some individuals may be counting on more than one form. Space is available for writing times down the left side of the sheet. The counting period should be divided in 15-minute subperiods. An alternate field-data sheet such as figure 2 may be used when two or more low-volume approaches are counted by one person.

(2) Traffic-volume count. This type is usually performed at midblock locations along a street. The count may be done manually on a simple tally sheet or may be performed using automatic traffic counters. The count may include one or two directions of traffic. The total duration of the count is often 24 hours, which includes the morning- and evening-peak hours. An automatic traffic counter can be installed at the same location for 1 week or more. This provides a profile of day-to-day variations during the week, which may then be averaged to calculate the average daily traffic. When counts have been averaged over a period of 1 year, the result is termed the annual average daily traffic. A major artery having traffic that is typical of the entire installation may be selected as the location for a long-term master counter. By means of calculated adjustment factors, readings from the master counter are used to adjust those of local counters. The locations for local counters should be selected to permit traffic-flow analysis of the entire arterial street network and to include problem areas on collector and local streets.

(3) Vehicle-classification counts. These manual counts may be performed during any period of interest but should attempt to sample typical traffic conditions with representative percentages of trucks. By drawing more lines on the suggested field counting sheet, a classification count may be performed as an integral part of other traffic-volume counts (fig 3). Vehicles are usually grouped according to size and number of axles as follows:

Group 1--Passenger cars and panel and pickup trucks.
Group 2--Two-axle trucks and buses.
Group 3--Three-, four-, and five-axle trucks.

Record should also be made of any tracked vehicles or forklifts that pass the checkpoint.

(4) Pedestrian counts. These are performed whenever there is a question about pedestrian flow. Problems could arise where there is a conflict between pedestrian and vehicle traffic, such as at a midblock school crossing or at a circulation road within a large parking lot. Pedestrian counts are also used to provide design data for pedestrian facilities and traffic-control devices. For example, the required width of sidewalk

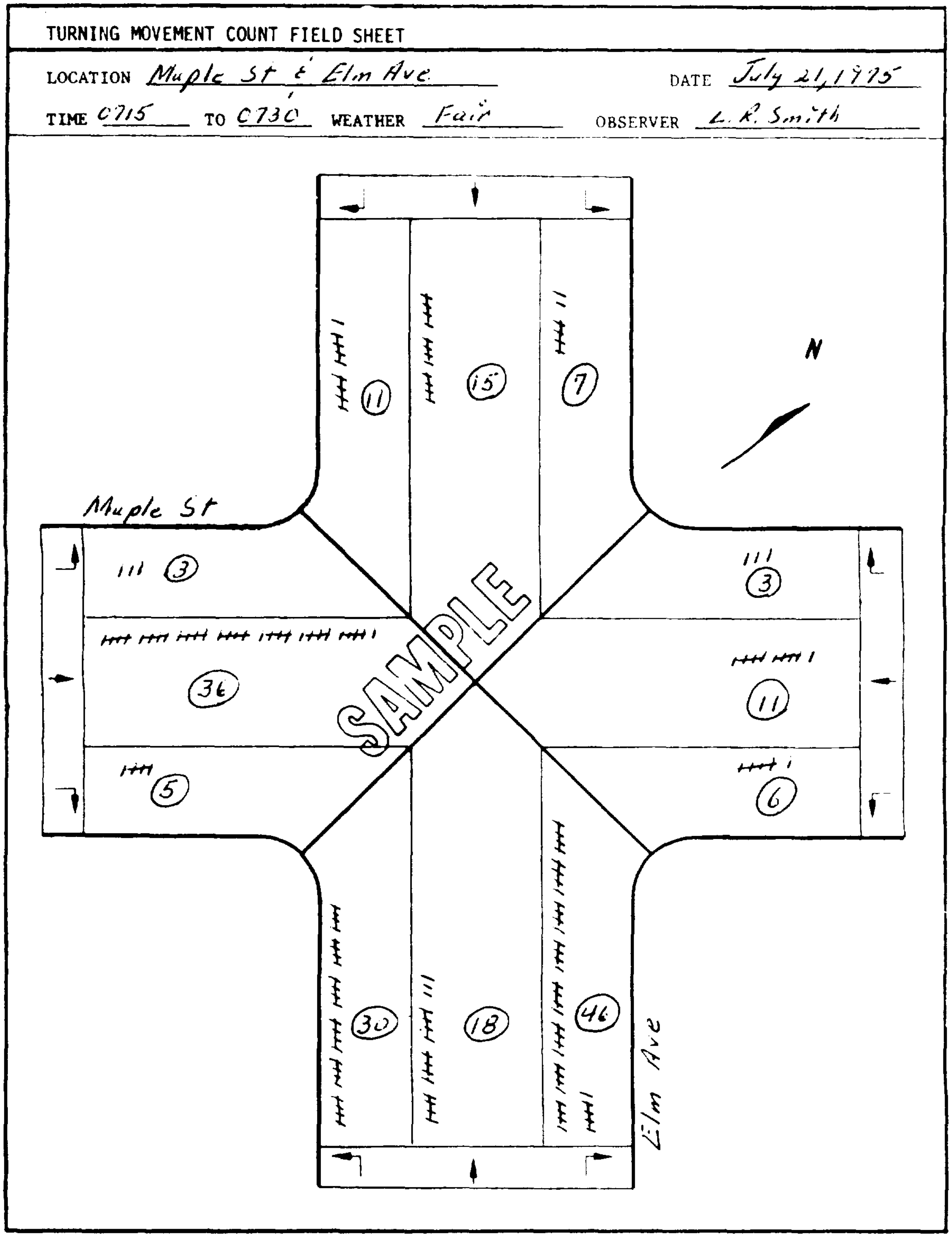


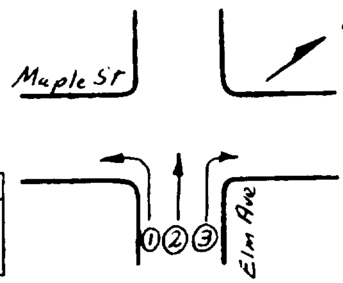
Figure 2. Typical abbreviated-turning-movement-count field sheet.

TURNING MOVEMENT/VEHICLE CLASSIFICATION COUNT FIELD SHEET

LOCATION Maple St & Elm Ave

DATE July 21, 1975 TIME 0645 TO 0815

OBSERVER L. R. Smith



LEGEND

GROUP	VEHICLE TYPE
1	CAR, PANEL & PICKUP TRUCK
2	TWO AXLE TRUCK (ABOVE 1½TON) & BUSES
3	THREE OR MORE AXLE TRUCK

TIME	① (left)			② (through)			③ (right)		
	1	2	3	1	2	3	1	2	3
0645 to 0700	11	3	0	5	2	0	15	5	2
0700 to 0715	15	4	2	7	2	0	23	4	2
0715 to 0730	26	3	0	16	0	0	42	3	0
0730 to 0745	33	6	2	25	0	0	80	6	2
0745 to 0800	38	3	0	26	0	0	158	10	5
0800 to 0815	20	0	0	9	0	0	34	3	0

Figure 3. Typical turning-movement-vehicle-classification-count field sheet.

pavement is determined by pedestrian flow rates, and the warrants for a pedestrian overpass are determined by potential pedestrian/vehicle conflicts.

(5) Special counts. There are many possibilities for counts of a special nature; for example, counts of vehicles parking, U-turning, weaving, or turning right on red signal (when permitted). Other special counts are covered in part two, sections IV and XI of this pamphlet.

19. Analysis. This will consist of initial refining of raw data, summarizing counts, cross-checking volumes, and multiplying by adjustment factors as presented in the following paragraphs.

a. Data reduction.

(1) The first step is to convert the raw data to a more convenient form. The turning movements for an entire intersection are summarized on a suggested data sheet such as the one shown in figure 4. The movements for the various time periods are then studied to find the highest hour (four consecutive 15-minute periods) and the highest 15-minute volume within that hour for each approach. The movements may be added and summarized on a form similar to the one shown in figure 5. This figure can also show pedestrian, bicycle, or other classification data relevant to solution of any problem.

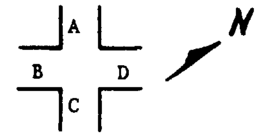
(2) Traffic-volume counts are transferred from either the automatic counter printed paper tape or from the rough field-data sheets to a summary form such as shown in figure 6. Counts taken along the same street should be compared to determine a logical flow of traffic. For example, if 500 more vehicles were counted at one intersection than at another a block away, there should be an intermediate driveway that caused the variance. If that is not the case, suspect either a counter malfunction or the credibility of the manual count. A recount should be made unless corroborative data can be found.

b. Adjustment factors. The purpose of an adjustment factor is to modify a volume count to reflect average daily traffic movement for the site in question. Traffic volumes usually exhibit a predictable day-to-day variation. Traffic volumes on Sunday, Monday, Friday, and Saturday normally are unique and should be adjusted to agree with the more stable midweek day counts. When a master counter has been left in one location for an entire week, the results can be used to adjust a local counter according to the particular weekday it was in place. First, determine the average daily traffic for the master; then the day factor; and finally, the ADT for the local counter.

TURNING MOVEMENT SUMMARY

INSTALLATION *Ft Battle*

DATE *July 21, 1975* LOCATION *Maple St & Elm Ave*



TIME	A *Elm Ave*				B *Maple St*				C *Elm Ave*				D *Maple St*				TOTAL
	↰	↑	↱	TOTAL	↰	↑	↱	TOTAL	↰	↑	↱	TOTAL	↰	↑	↱	TOTAL	
0700	7	15	11	33	3	36	5	44	15	7	22	44	7	15	2	24	145
0715	4	10	1	15	4	40	6	50	21	9	29	59	10	13	3	26	150
0730	6	9	3	18	3	36	5	44	30	18	46	94	11	15	1	27	183
0745	8	12	9	29	1	42	8	51	41	27	88	156	8	20	4	32	268
0800	4	20	6	30	3	54	13	70	42	28	173	243	7	18	3	28	371
0815	3	21	8	32	2	62	12	76	22	11	38	71	9	12	2	23	202
TOTAL	32	87	38	157	16	270	49	335	171	100	396	667	52	93	15	160	1319

SAMPLE

Figure 4. Typical turning-movement summary sheet.

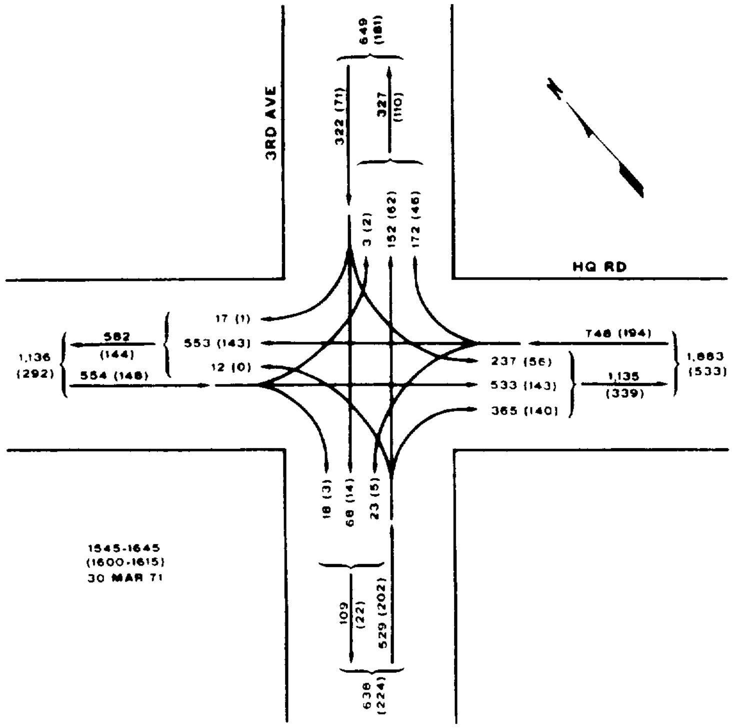


Figure 5. Typical turning-movement diagram.

$$\text{ADT master} = \frac{\text{Sum of daily 24-hour master counts (for 1-week period)}}{7}$$

$$\text{Day factor} = \frac{\text{ADT master}}{\text{24-hour master count for that day}}$$

Adjusted ADT local count = day factor x 24-hour local count

It should be noted that weekly, monthly, seasonal, or employment level adjustment factors can also be computed.

20. Interpretation.

a. Convenient graphic displays of the results should be prepared to assist interpretation. One such display is shown in the traffic-volume flow map (fig 7) where the band width for each street is proportional to the traffic volume. It is thus easy to determine which are the more important travel routes. A flow map may be prepared showing 24-hour or peak-hour volumes. A simpler method of preparing a flow map is to draw a composite

MECHANICAL RECORDINGS SUMMARY SHEET			
STREET & LOCATION	Adam Ave Between Apple Ave & Eve St		
LOCATION NO. A	DATE 7/22/75	WEATHER Fair	
TIME		AM PEAK 15-MINUTE PERIODS	
0100/1A	155	0600	
0200/2A	106	0615	149
0300/3A	54	0630	227
0400/4A	50	0645	378
0500/5A	63	0700	584
0600/6A	200	0715	728
0700/7A	1358	0730	691
0800/8A	2454	0745	553
0900/9A	504	0800	482
1000/10A	581	0815	173
1100/11A	662	0830	111
1200/12A	645		
1300/1P	1263	PM PEAK 15-MINUTE PERIODS	
1400/2P	531	1600	
1500/3P	722	1615	447
1600/4P	705	1630	422
1700/5P	1676	1645	405
1800/6P	1600	1700	402
1900/7P	615	1715	386
2000/8P	600	1730	420
2100/9P	470	1745	401
2200/10P	436	1800	393
2300/11P	336	1815	117
2400/12P	255	1830	180
24-HOUR TOTAL (16,121)	FACTORED TOTAL (16,100)		

Figure 6. Typical mechanical recordings summary sheet.

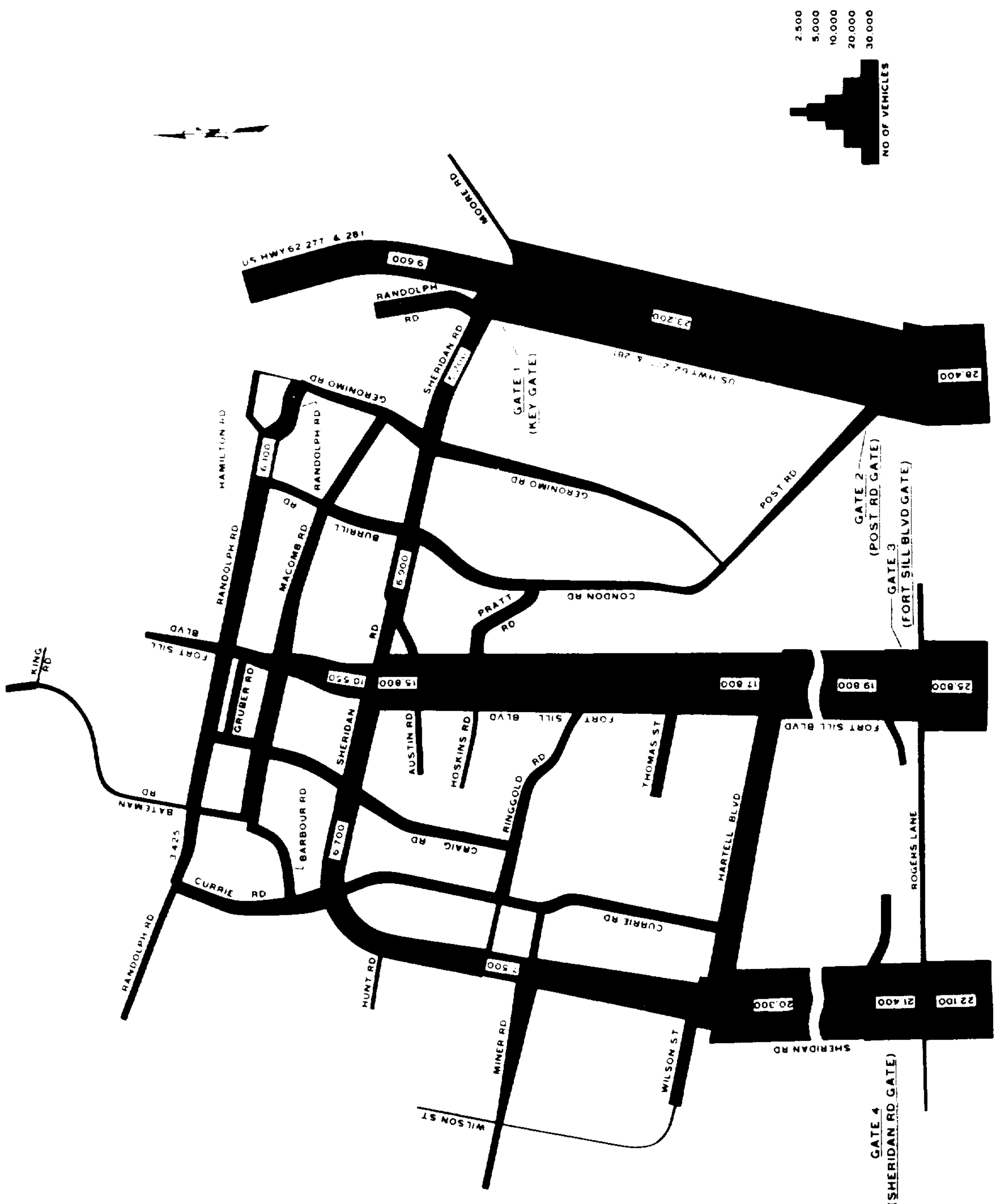


Figure 7. Typical flow map.

turning-movement diagram (fig 8). This form lacks the visual emphasis of the flow map but provides the convenience of showing the turning movements at every intersection.

b. It is also helpful to plot the hourly traffic variations on major streets of the installation (fig 9). Usually peak hours carry about 10 to 15 percent of the day's total traffic. When a higher percentage is observed, it may be an indication that staggered duty hours are needed to help spread the traffic load (part two, sec V).

c. Every road facility has a theoretical capacity for traffic that is seldom exceeded (part two, sec III). When traffic volumes approach the theoretical roadway capacity, travel times increase, and delays and/or congestion occur. It is thus useful to compute the ratio of volume/capacity (V/C). The closer the V/C ratio is to 1.0, the more burdened is the roadway and the greater the probability of congestion, delay, and accidents.

21. Application. Volumes are basic traffic data and are used in conjunction with other types of data to support all traffic-improvement decisions. The following are typical uses for traffic volumes:

a. To justify installation (or removal) of a traffic signal by comparison with the volume warrants stated in the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD); also, to time the traffic-signal cycle correctly and to determine the type of signal equipment required.

b. To indicate the need for traffic-control signs according to the requirements stated in the MUTCD.

c. To evaluate accident data and study the relationship of turning movements to accidents and congestion.

d. To compare day and night traffic volumes with their associated accident rates to determine the need for street lighting.

e. To help in the development of a street-classification system such as primary, secondary, and tertiary streets.

f. To evaluate the need for greater street width to handle high traffic volumes.

g. To facilitate assignment of traffic-control police for intersection duty during certain time periods.

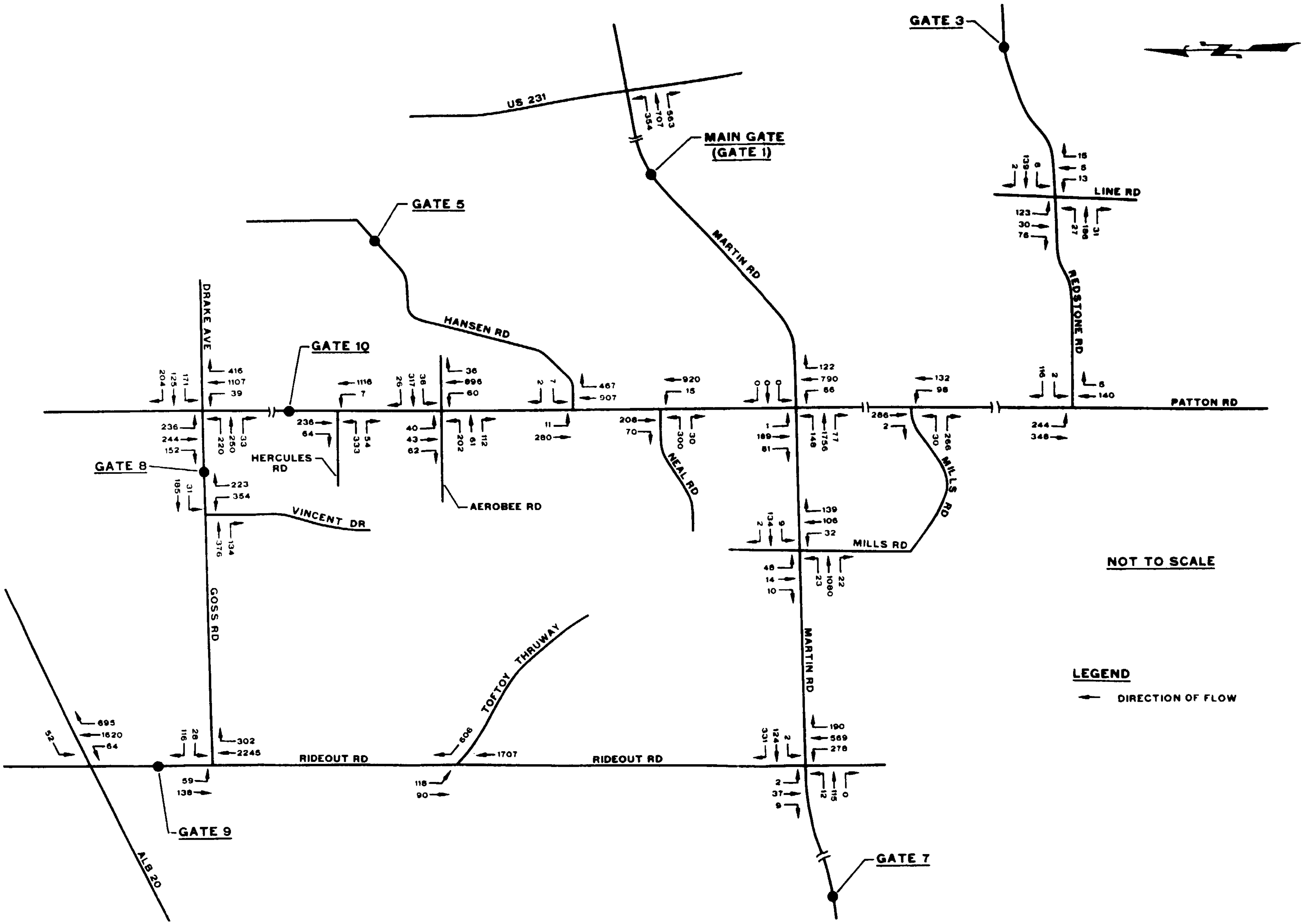


Figure 8. Typical composite-turning-movement diagram.

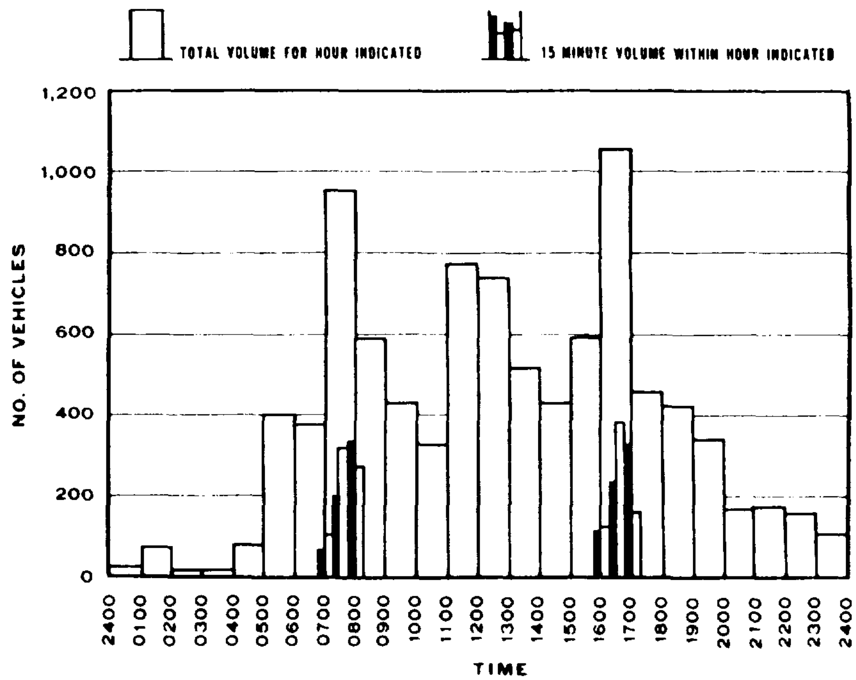


Figure 9. Typical hourly-traffic-variation chart.

h. To indicate long-term growth trends for vehicle usage and for traffic volumes in general.

i. To help establish construction and maintenance priorities.

j. To help establish the road pavement markings, and to determine the required frequency for repainting traffic-worn lines.

k. To help with the analysis of parking demands and to assess the impact of new traffic generators on the surrounding streets.

l. To determine the ideal locations for commercial facilities whose business is influenced by passing traffic (service stations, banks, or retail stores).

SECTION II

STREET-CLASSIFICATION STUDY

22. Purpose. The purpose is to classify installation roads according to their functional importance. The importance of a road is determined by the service it supplies to adjacent land areas and by the traffic that uses it. The system of classification to be described is specified by Department of Army Technical Manuals (TM) 5-822-2 and 5-822-5 (app B).

23. Information needed. A street inventory, maps, an adjacent land-usage survey, a compilation of street-traffic volumes, and a traffic-classification breakdown are required.

a. Maps. Obtain the following Master Plan maps from the installation facilities engineering office: (1) Basic Information, General Site; (2) Basic Information, Reservation; (3) Basic Information, General Road and Railroad; and (4) Plans for Future Development, General Site Plan.

b. Land Use. Prepare a land-use map from either the reservation map or from personal observation. Indicate, by color coding, areas used for family housing, commercial services, troop training, and the like. Shade in major traffic generators such as hospitals, office buildings, and shopping areas.

c. Traffic Volumes. Prepare a map showing the traffic volumes on every primary and most secondary streets of the installation (see part two, sec I). It also will be necessary to indicate the traffic classification by vehicle type on the arterial streets.

24. Method. Several steps are involved in the process of determining the street classification: (1) by importance, (2) by traffic volumes, and (3) by traffic-composition category.

a. By importance. Each street should be classified by its importance to the overall installation street plan: P--primary street (1st), S--secondary street (2d), T--tertiary street (3d).

A measure of importance is indicated by the service that a street supplies to adjacent land uses:

(1) Primary. These are main arteries and provide access to, through, and between the various sections of the installation.

(2) Secondary. These streets collect traffic from local activity areas and provide access between and within the various sections of the installation.

(3) Tertiary. These are local streets and connect more important streets with individual buildings and other land uses.

b. By traffic volumes. Each street should also be classified according to the traffic volume that it typically serves. A letter grade from A to F is determined by comparing the measured traffic volume with table 2 of TM 5-822-2 (app B). To use that table, select the lowest letter-grade road class that has capacity enough to handle both the design hourly volume (DHV) and the average daily traffic (ADT). The design hourly volume will usually correspond to the evening-peak-hour traffic. Presented in table 2 is information extracted from TM 5-822-2, table 2, for the special case of category I, flat terrain, and built-up area.

TABLE 2
TRAFFIC CAPACITY FOR VARIOUS CLASSES OF INSTALLATION ROADS[a/]

Road Class	Traffic Capacity of the Road[b/]: Average Daily Traffic (ADT) (Veh per Day)	Design Hourly Volume (DHV) (Veh per Hour)
A (four-lane)	10,000[c/]	1,200[c/]
B (two-lane)	8,400-10,000[d/]	1,000-1,200[d/]
C (two-lane)	6,300- 8,400[d/]	750-1,000[d/]
D (two-lane)	2,100- 6,300[d/]	250- 750[d/]
E (two-lane)	210- 2,100[d/]	25- 250[d/]
F (two-lane)	Under 210[d/]	Under 25[d/]

[a/]Assumed conditions: Category I, flat terrain, and built-up area.
[b/]At intersections, the capacity shown is in terms of flow during the time percentage of green signal indication.
[c/]Vehicles per lane in heavier direction of flow.
[d/]Total vehicles for all lanes, in both directions.

c. By traffic composition. A category should be determined for each street according to the types of traffic served. Vehicle classification counts are performed on all major streets, and the vehicles are grouped according to size and number of axles (see para 18c(3)).

Having determined the percentage composition of traffic, each road is assigned a category. The category information in table 3 is extracted from TM 5-822-5.

TABLE 3
INSTALLATION ROAD CATEGORY FOR VARIOUS COMPOSITIONS OF TRAFFIC

	Road Traffic By Groups		
Road Category	Group 1 (Pct)	Group 2 (Pct)	Group 3 (Pct)
I	99	1	0
II	90	10	0
III	85	14	1
IV	75	15	10
V, VI, VII	Contains tracked vehicles and forklifts		

25. Analysis. This will consist of preparing an updated street map similar to the general road and railroad map. The map should clearly present the street classification by importance, the measured traffic volumes, and the road category. A table of streets may be prepared instead of a map.

26. Interpretation. This will consist of a comparison of the updated street classifications with those currently existing. There are two aspects to the comparison: (1) adequacy of traffic capacity, and (2) adequacy of pavement design.

a. Traffic capacity. Inadequate roadway capacity is indicated when it would be necessary to change the road class to handle the existing traffic volumes. For example, if it were necessary to change from Road Class B to Class A, widening to four lanes would be indicated. Traffic capacity should be compared on both open-road portions and at controlled intersections. When inadequate roadway capacity has been determined, the situation should be further investigated using the more detailed techniques listed in part two, section III.

b. Pavement design. The ability of roadway pavement to carry heavy vehicles depends, in general, upon the pavement thickness, strength of the paving materials, and the pavement foundation. A pavement design index is used to indicate the required strength of road surface. The design index is a number from 1 to 6, with the higher design index indicating a stronger pavement. It is a function of both street classification and traffic composition. The design index should be determined from the information in table 4, which has been extracted from TM 5-822-5 (app B).

TABLE 4
REQUIRED DESIGN INDEX*

	Traffic Composition			
Road Class	Category I	Category II	Category III	Category IV
A	3	4	5	6
B	3	4	5	6
C	3	4	4	6
D	2	3	4	5
E	1	2	3	4
F	1	1	2	3

*Refer to TM 5-822-5 for road classification.

27. Application.

a. Practical application of street-classification results can be made to the street system by determining where operational improvements are required. The results may also be used to provide pavement design criteria to help establish a road-maintenance program and to determine priorities for construction funding.

b. Another application is the classification of streets according to traffic conditions that will exist in some future design year. For example, if traffic volumes and compositions have been projected for a design year of 1990, it is possible to determine the required future street classifications and the required pavement design standards. A table of future street design parameters should be prepared using table 5 as a guide.

SECTION III

HIGHWAY-CAPACITY STUDY

28. Purpose.

a. The comparison of counted traffic volumes with calculated highway capacity is an important input to the study of needed improvement

TABLE 5
FUTURE STREET DESIGN PARAMETERS[a]

Roadway	1982 Projections on Proposed Thoroughfare Plan: 24-Hour Traffic Volume (ADT) (All Lanes)[b] Low High	Design Hourly Volume (DHV) (All Lanes)[b] Low High	Traffic Composition Category	Importance to Viability of Thoroughfare Plan	Resultant Design Parameters: Class of Street Needed	Pavement Design Index
New Braunfels Ave	12,500-21,000	1,350-1,740	II	Primary	A	4
Stanley Rd	3,000-13,000	250-1,615	III	Primary	A	5
Wilson St	7,500-15,000	350-1,580	III	Primary	A	5
Artillery Post Rd	2,200- 7,500	30- 645	II	Secondary	C	4
Harney Rd	1,000- 3,000	250- 420	I	Tertiary	D	2

[a] Volumes shown are the future year, as assigned to thoroughfare plan.

[b] Low and high volumes occur on different sections of the same street and thus show the range of traffic volumes expected.

projects. Highway capacity, very broadly, is a measure of the effectiveness of various roadways to serve traffic.[1] Study of highway capacity is needed for:

(1) Identification of points of congestion and their relative severity.

(2) Determination of the need for and effectiveness of specific improvements to increase capacity.

(3) Establishment of priorities for street improvements based upon capacity considerations.

(4) Derivation of criteria for the planning and design of new streets and the modification of existing streets to meet future needs.

b. The subject of highway capacity is complex and has been the subject of continuing study and research by traffic engineers for many years. The authoritative reference source is the Highway Capacity Manual (app B). This section is based upon material from that manual, that has been reduced for general use in the more common types of traffic studies at military installations. As simplified as this section may be in comparison to the Highway Capacity Manual contents, this type of study is relatively complex and should be performed only when substantial need is evident.

[1] The terms highway, street, and roadway have the same meaning as used in this section.

29. Information needed. The basic concepts and information involved in the computation of highway capacity are discussed below:

a. Types of flow. Traffic flow may be divided into two general groupings:

(1) Uninterrupted. A condition in which a vehicle traversing a section of road is not required to stop by any cause external to the traffic stream. This type of flow might be found on freeway or expressway facilities, on roads through essentially rural areas, or on roads to ranges and maneuver areas.

(2) Interrupted. A condition in which a vehicle traversing a section of roadway is required to stop by a cause outside the traffic stream such as signs and signals or pedestrians. This condition usually occurs at or near intersections. Although midblock interruptions and interferences may become so significant that they control traffic flow and capacity, intersections are the usual cause of interruption on most roadways.

b. Factors affecting capacity. The factors that affect capacity the most are:

(1) Physical features of the roadway.

(a) Lane width and total approach width.

(b) Lateral (side) clearance and width of shoulder.

(c) Auxiliary lanes used for parking, speed change, turning, bus stops, and storage.

(d) Surface conditions.

(e) Alignment.

(f) Grades.

(2) Traffic conditions.

(a) Percentage of trucks and buses in the traffic stream.

(b) Turning movements, particularly left turn.

(c) Variations in traffic flow during peak hours.

(d) Control measures such as one-way operation, parking restrictions, and turning-movement controls.

(e) Traffic interruptions, such as:

1. Traffic signals, military-police control, and STOP and YIELD signs.

2. Volume of cross traffic at intersections.

3. Entrance/exit gates.

(f) Weaving and merging of traffic flows.

(3) Environmental conditions.

(a) Metropolitan area population.

(b) Characteristics of the study location such as near central business district or in fringe, residential, suburban, or rural areas.

(c) Load factor, which is the ratio of the number of green intervals that are fully utilized by traffic during the peak hour to the total of green intervals for that approach during the same period.

30. Methods. Study guidelines have been separated into the two general areas of concern: roadway capacity and intersectional capacity.

a. Roadway capacity. The Highway Capacity Manual contains material to be used for determining the effect (individually or collectively) of the above-mentioned factors on the capacity of a given roadway. The information in this section has been simplified, and many factors have been reduced to typical conditions that generally prevail on a military installation. Thus, this material presents a relatively simple method for determining highway capacity, which is of sufficient accuracy for use in traffic studies that require this type of analysis.

(1) Capacity computation. The Highway Capacity Manual gives values shown in table 6 for ideal conditions of uninterrupted flow. In actual practice these values represent ideal conditions of 12-foot-wide lanes with no lateral restrictions and on level terrain. They must be

adjusted downward to take into account actual roadway and traffic factors. Specific adjustment factors are listed in the Highway Capacity Manual. After applying factors to reflect actual roadway conditions, such as narrow lane width, lateral restrictions, and high turning volumes, the actual capacity will be approximately 70 to 80 percent of the ideal capacity; that is, the ideal values as shown in table 6 should be reduced by 20 to 30 percent to give reasonably accurate capacities for uninterrupted flows.

TABLE 6
ROADWAY CAPACITY UNDER IDEAL CONDITIONS

Highway Type	Capacity (Passenger Vehicles/Hour)
Two-lane, two-way traffic	2,000 total, both directions
Three-lane, two-way traffic	4,000 total, both directions
Multilane (four or more)	2,000 per lane, one direction

(2) Level of service. There are many factors and combinations of conditions that may occur on a given roadway. Level of service is a descriptive measure of the effect that these factors and conditions have on the flow of traffic. The different levels of service reflect the relative differences in traffic interruptions, speed and travel time, freedom to maneuver, safety, driving comfort and convenience, and operating costs that may occur on a given highway under given conditions. As shown in table 7, six levels of service have been defined and designated by letters A (free flow) through F (forced flow and very unstable).

TABLE 7
LEVELS OF SERVICE AS DEFINED BY HIGHWAY CAPACITY MANUAL

Level of Service	Description
A	Free flow. Low volumes and high speeds, no delays.
B	Stable flow. Speeds restricted by travel conditions, minor delay.
C	Stable flow. Speeds and maneuverability closely controlled by higher volumes.
D	Unstable flow. Speeds considerably affected by change in operating conditions.
E	Unstable flow. Low speeds, volume at or near capacity.
F	Forced flow. Very low speeds, volumes are below capacity, long delays.

A highway will provide different levels of service at different times depending upon the volume and composition of traffic and speeds attained. The higher the traffic volume, the lower the level of service. The worst condition or service level represents stagnant or congested traffic. At this time, the volumes carried are unpredictable or practically nil, since speeds are minimal.

b. Intersection capacity.

(1) General. One of the most important elements limiting and often interrupting the flow of highway traffic is the at-grade intersection. To a large extent, intersections control the capacity of the installation arterial streets. They also seriously affect the ability of installation access roads to perform at maximum efficiency.

The capacity of an intersection approach street is the number of vehicles per hour that it can handle under existing physical design conditions, traffic characteristics, controls, and assumed level of service. In this section, specific procedures are outlined for computing capacity under a range of intersection conditions. Where field observations have been made of a fully loaded intersection and the resulting figure is in disagreement with this guide, the observed value should be used as the capacity of that particular location.

(2) Peak-hour factor. The peak-hour factor (PHF) represents the peaking of traffic volumes during the hour of peak traffic. In order to calculate the peak-hour factor, it is necessary to compare the highest 15-minute count with the total volume for the hour by using the formula below.

$$PHF = \frac{\text{Total peak-hour volume}}{4 \times \text{Highest 15-minute count}}$$

For example, if the peak-hour volume was 900 vehicles per hour and the highest 15-minute count within that hour was 300, the PHF is equal to 0.75. The lower the PHF, the more severe is the peaking within the hour. A PHF of 1.00 represents an even flow of traffic throughout the peak hour.

(3) Fundamental capacity charts. Figures 10 and 11 are used to determine the approach capacity of each leg of an intersection per hour of green time, given the width of the approach street. One hour of green time would be available if traffic signals for that approach were always green. The approach width is the total width of the approach pavement

(one direction of movement only) including any parking lanes but excluding lanes reserved exclusively for turns. In addition to approach width, other elements such as the presence or absence of parking and one-way or two-way operations must be known. For all other factors conditions considered typical or average for military installations have been assumed such as percent of turns, trucks, and buses. Effects of significantly more or less turns and commercial traffic can be computed.

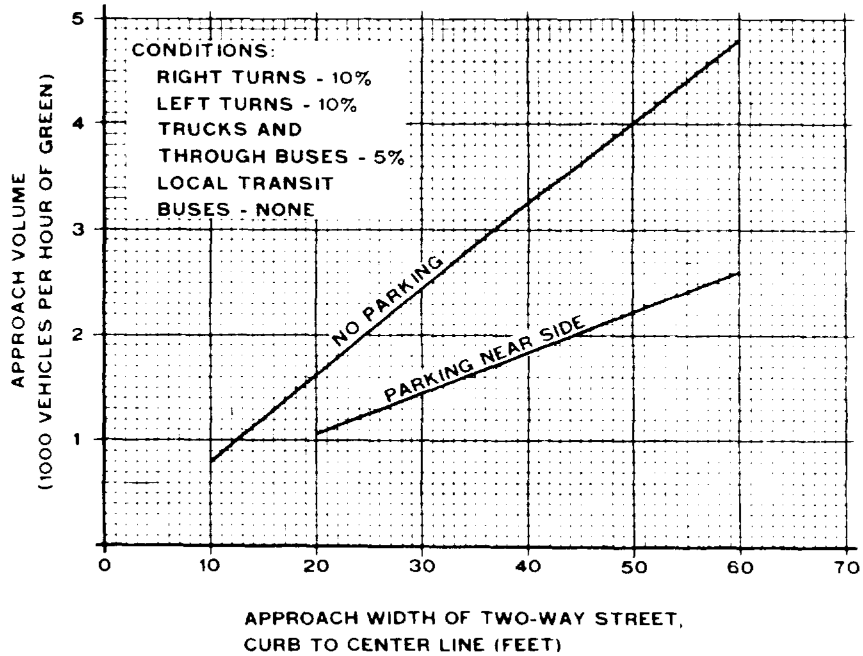


Figure 10. Urban intersection approach service volumes in vehicles per hour of green for two-way streets.

(4) Green-time-to-cycle-length (G/C) ratio.

(a) Since the volume read from the chart is in terms of per-hour-of-green, a further computation must be made to adjust for the actual amount of green, or "go", time available for the approach street during each hour of traffic-signal operation. If the intersection is signalized with pretimed signals (signals that alternate green, yellow, and red indications in accordance with a fixed pattern), the actual vehicle-per-hour capacity is computed as follows: First, divide the number of seconds of green indication, G, by the total number of seconds in a signal cycle, C; then, multiply the per-hour-of-green capacity by this G/C ratio. For example, if a given intersection approach has 30 seconds of green out of a

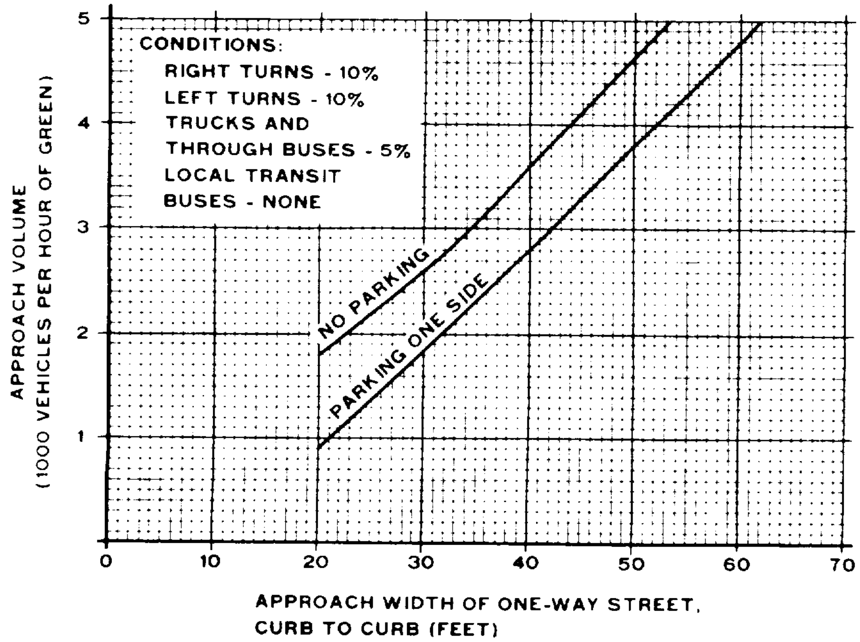


Figure 11. Urban intersection approach service volumes in vehicles per hour of green for one-way streets.

total traffic signal cycle of 60 seconds and a capacity of 1,500 vehicles per hour of green (taken from chart, figures 10 or 11), the calculation would be 30/60 x 1,500 = 750 vehicles per hour. This amount is called the service volume. In the case of traffic-actuated signals or military-police control, the G/C ratio must be obtained by field studies to determine average ratios during peak conditions.

(b) Where traffic signals do not exist but will be installed in the future, capacity may be estimated by assuming signalized intersection parameters. First, assume a cycle length; then, assume that the green, or go, time on each street is directly in proportion to the relative traffic volumes on the intersecting streets and inversely proportional to the respective street widths. The formula stating this procedure is:

$$\frac{\text{Relative time, Street A}}{\text{Relative time, Street B}} = \frac{\text{Volume, Street A}}{\text{Volume, Street B}} \times \frac{\text{Width, Street B}}{\text{Width, Street A}}$$

or

$$\frac{T_A}{T_B} = \frac{V_A}{V_B} \times \frac{W_B}{W_A}$$

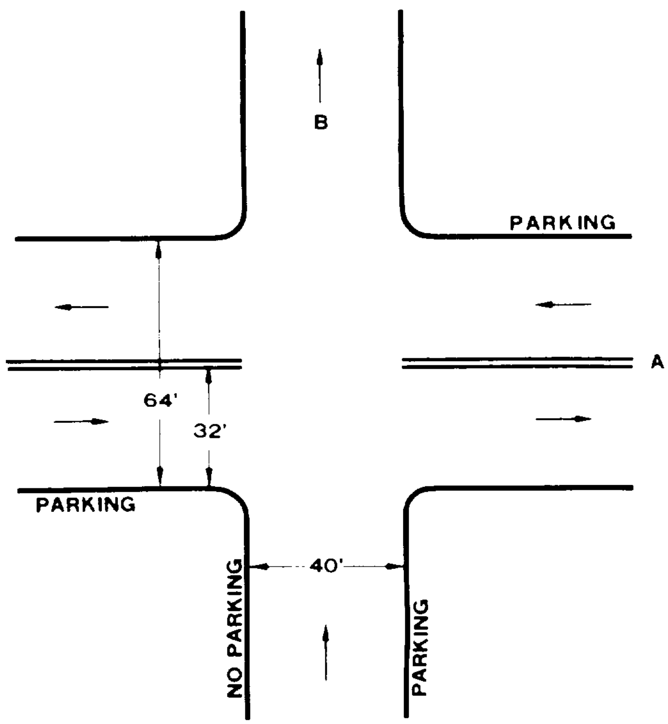
Then the G/C ratio for Street A approach is:

$$T_A = \frac{T_A}{T_A + T_B}$$

31. Analysis. Examples of analysis are found in the following sample problems:

a. Signalized intersection.

(1) Given: An intersection with dimensions, flow directions, parking, and traffic signals, as shown:



Signal Timing

Green time - Street A	= 32 sec
Street B	= 22 sec
Yellow time (2 at 3 sec)	= 6 sec
Total cycle	= 60 sec

(2) Problem: Find the capacities of Streets A and B.

(3) Solution: Figure 10 is the applicable chart for two-way streets, and figure 11 for one-way streets.

For Street A, enter the lower scale of figure 10 at an approach width of 32 feet, and project upward to the line designated Parking Two Sides. Using this intercept as a turning point, project horizontally to the left-side-volume scale. Read volume of 1,500 vehicles per hour of green.

$$\text{Signal ratio} = \frac{\text{Green time}}{\text{Total cycle}} = \frac{32 \text{ Sec}}{60 \text{ Sec}} = 0.53$$

Street A capacity (one approach) (actual vehicles per hour) = 1,500 x 0.53 = 795

For Street B, using figure 11, enter lower scale at 40-foot width, project upward to Parking-One-Side line; then, similarly, read left-side-volume scale, 2,800 vehicles per hour of green.

$$\text{Signal ratio} = \frac{22 \text{ Sec}}{60 \text{ Sec}} = 0.37$$

Street B capacity (one approach) (actual vehicles per hour) = 2,800 x 0.37 = 1,036

b. No intersection control.

(1) Given: Same conditions as in a(1) above, except no traffic signals.

Traffic volumes - Street A - 20,000 vehicles per day
Street B - 10,000 vehicles per day

(2) Problem: Find the capacities of Streets A and B.

(3) Solution: In the same manner as described in 3a(3) above, the per hour of green volumes are found to be:

Street A approach - 1,500
Street B approach - 2,800

The relationships between ADT and street widths yield the T_A and T_B values as follows:

$$T_A = V_A \times W_B = 20,000 \times 40 = 800,000$$

$$T_B = V_B \times W_A = 10,000 \times 64 = 640,000$$

$$\text{Street A green time ratio} = \frac{T_A}{T_A + T_B} = \frac{800,000}{800,000 + 640,000} = 0.56$$

$$\text{Street B green time ratio} = \frac{T_B}{T_A + T_B} = 0.44$$

Optimums:

Street A capacity (actual vehicles per hour) = 1,500 x 0.56 = 840

Street B capacity (actual vehicles per hour) = 2,800 x 0.44 = 1,232

32. Application. Several important practical applications of capacity studies are presented below:

a. Increased capacity. Methods of increasing capacity may be tested analytically. The methods include:

(1) Elimination of on-street parking.

(2) Prohibition of turning movements or the provision of special turning lanes and signal phases.

(3) Street widening, particularly at intersection approaches.

(4) Relocation of bus stops.

(5) Relocation of objects near the pavement edge.

(6) Changing from two-way to one-way-traffic movement.

(7) Use of reversible lanes.

(8) Improvements in traffic-signal timing and analysis regarding the potential benefits in revising signal phasing.

The determination of the amount of additional capacity to be obtained from each of the above improvements is indicated in the Highway Capacity Manual.

b. Future traffic. The traffic capacity of an existing highway may be compared with the traffic volumes projected for some future date. The comparison will provide the highway designer with information necessary to determine what improvements will be necessary. Capacity analysis of projected traffic volumes may also be used to determine the design standards for new highway construction.

c. Project comparison. Traffic improvement projects may be ranked according to the potential increase in capacity per dollar expended (app E).

SECTION IV

VEHICLE-OCCUPANCY STUDY

33. Purpose.

a. This study measures the amount of group riding by counting the number of occupants in each motor vehicle. Vehicle-occupancy (VO) studies have several useful purposes. These purposes can be classified into two general groups: first, those that have policy implications as found in AR 210-4, "Car Pooling and Parking Controls"; and second, those that are technical in nature. Policy implications will be discussed here, and the technical aspects will be discussed in paragraph 38 of this section.

b. The nation's increased ownership and usage of the automobile generates undesirable levels of traffic congestion, air pollution, and energy consumption. As a result, it is Federal policy to encourage the use of car pools and mass transportation. Note that AR 210-4 requires installation commanders to insure "to the extent practical, that regular arrival and departure times are maintained for all employees and adjustments in scheduled duty hours are permitted for individual employees to facilitate car pooling." Paragraph 7-2 of joint service regulation AR 55-80, Highways for National Defense, dated 2 August 1974, states "Requests for traffic engineering studies concerned with minor day-to-day problems created by peak-hour congestion or other short duration impacts should be made only after installation personnel have staggered duty hours or conducted programs to increase car pooling." Basically, it is MTMC policy that car and bus pooling will be actively promoted at all military installations to the extent that the net transportation effect is reduction in traffic congestion, air pollution, and energy consumption. A record of average vehicle occupancy over a period of time may, therefore, be used as a measure of compliance with national and DOD policy before MTMC commits resources for transportation engineering studies at military installations.

34. Information needed. This will consist of the number of persons occupying each vehicle that passes the checkpoint. Date, time, direction of traffic flow, and location of the study should also be recorded. Counts may be categorized by vehicle type: for example, passenger vehicles, buses, and trucks.

35. Method. A manual count is made of the number of persons (including the driver) riding in each vehicle. A tally mark is then recorded in the proper column of a data sheet such as figure 12. Other aspects of study are described below:

a. When. Usually data will be collected during the morning-peak period when most employees are arriving for duty. Other time periods could also be surveyed (such as evening, noon, or off peak), if some special problem were involved. Different time periods often exhibit a different average vehicle occupancy because of different trip purposes. However, it is the peak-period movements that generate the greatest concerns and are usually the only times these studies are made. Data are usually collected by 5-minute intervals. Typical workdays should be selected for the study. Care should be taken to avoid taking counts on or proximate to holidays.

b. Where. Counts are normally made at every major entrance to the installation but may also be performed at special subareas such as the entrance to the commissary or to the theater. For the purpose of constructing an origin-destination trip table, a vehicle-occupancy study could be performed on major interior arteries during off-peak travel periods.

c. What.

(1) Usually, all occupants of passenger vehicles are counted including those in sedans, pickup trucks, station wagons, vans, and

VEHICLE OCCUPANCY FIELD SHEET

INSTALLATION FT. BATTLE

LOCATION MAIN GATE

DATE 15 JULY 1975 TIME 0700 TO 0815 OBSERVER J. W. JONES

TIME	NUMBER OF OCCUPANTS						
	1	2	3	4	5	6	BUS
0700							
	卌 卌 卌 卌 卌 卌 卌 卌 II (42)	卌 III (8)	III (3)	II (2)	I (1)	0	I (1)
0715							
	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 (75)	卌 卌 卌 卌 III (23)	IIII (4)	II (2)	I (1)	I (1)	0
0730							
	卌 卌 卌 卌 卌 卌 III (33)	IIII (4)	II (2)	0	0	0	0
0745							
	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 III (53)	卌 卌 II (12)	I (1)	I (1)	0	0	0
0800							
	卌 卌 卌 IIII (19)	III (3)	0	0	0	0	0
0815							
	TOTALS						
	VEHICLES = 222	50	10	5	2	1	1
	PEOPLE = 222	100	30	20	10	6	
	TOTAL PEOPLE = 388	VEHICLE OCCUPANCY	= 388/290 = 1.3				
	TOTAL VEHICLES = 290						

Figure 12. Typical vehicle-occupancy field sheet.

campers. Commercial vehicles and trucks are not considered for the purpose of vehicle occupancy, but may be tallied separately if desired. Buses also are tallied separately, and the number of passengers may be counted during the course of a special transit study (part two, sec XII).

(2) One man will be required to count each entering traffic lane. When traffic volumes are high, a sampling procedure may be used. The unbiased sample should select every other vehicle or some other convenient multiple. Personnel should be equipped with field-data sheets, clipboards, pencils, and wrist watches.

d. Alternate. An origin-destination questionnaire (part two, sec X) can be used as an alternate method for collecting vehicle-occupancy data. However, this method is advisable only if the questionnaire is to be issued to gather other information and the vehicle-occupancy question is included as a supplement.

36. Analysis. This will consist of summarizing the raw data, determining the total number of occupants, and computing the average vehicle occupancy. Table 8, using typical data, demonstrates the procedure.

TABLE 8
VEHICLE-OCCUPANCY CALCULATIONS*

Persons per Vehicle		No. of Vehicles Counted		Total No. of Occupants
1	x	2,062	=	2,062
2	x	372	=	744
3	x	63	=	189
4	x	12	=	48
5	x	5	=	25
6+	x	0	=	0
Total		2,514		3,068

*Average vehicle occupancy = 3,068/2,514 = 1.2204
Rounded to equal 1.2 persons per vehicle.

The next step in the analysis is to tabulate the data and compute percentages. Typical vehicle-occupancy summary tables are shown in Figure 13.

TABLE X
VEHICLE OCCUPANCY BY ENTRANCE GATE

Entrance Gate	Total Vehicles	Vehicle Occupants	Vehicle-Occupancy Ratio
Bayshore	813	1,010	1.2
MacDill	412	509	1.2
Dale Mabry	568	723	1.3
Port Tampa	721	826	1.1
Total	2,514	3,068	1.2 (Avg)

TABLE X
VEHICLE-OCCUPANCY SUMMARY*

Occupants per Vehicle	Vehicle		Occupant	
	No.	Pct	No.	Pct
1	2,062	82.0	2,062	67.2
2	372	14.8	744	24.3
3	63	2.5	189	6.2
4	12	0.5	48	1.5
5	5	0.2	25	0.8
Total	2,514	100.0	3,068	100.0

*Average vehicle-occupancy (VO) ratio = 1.2.

Figure 13. Typical vehicle-occupancy tables.

37. Interpretation.

a. Since World War II, vehicle ownership in the United States has consistently increased. When a family owns more cars, it is more likely to use those cars for individual home-to-work trips. Morning-peak-hour traffic is composed largely of home-to-work trips. Thus the vehicle occupancy measured at installation entrance gates reflects the increased ownership and usage of the automobile.

b. This agency determined from previous studies that the overall DOD vehicle occupancy for 1973 is the following: Air Force, 1.3; Army, 1.4; Navy, 1.5 persons per vehicle. The higher ratios reflect use of fewer vehicles by equivalent numbers of personnel assigned to the more industrialized installations.

c. The results of a vehicle-occupancy study may be used to gauge the utilization of, need for, and success of car-pool and bus-pool programs. For example, a VO compared to the national averages presented in paragraph 37, with allowance for rural or urban conditions, can reflect the relative utilization of car and bus pools. A VO lower than the national average, with allowance for rural or urban conditions, can reflect the need or justification for active promotion of car- and bus-pooling programs. VO rates available over a period of years can reflect the degree of success an installation commander has had in instituting car- and bus-pool programs. Military installations should strive to attain VO ratios as high as possible.

38. Application. The results of a vehicle-occupancy study may be applied to determine entrance/exit-gate statistics, to calculate parking demand, to support an access road study, and to determine the need for car-pool formation.

a. Entrance/exit gates. Results of the vehicle-occupancy study may be used to estimate the number of persons (or vehicles) that daily enter or exit the installation. They may also be used to estimate person flow along a particular highway, which information is useful in certain highway economic and planning problems. To determine person flow, multiply the measured daily traffic volume (ADT from part two, sec I) by the previously determined average vehicle occupancy.

Persons per day = ADT x VO

b. Parking demand. The results of a vehicle-occupancy study may be used to estimate the demand for parking prior to the construction of new facilities. Estimated parking demand is equal to the expected number of people, divided by the vehicle-occupancy ratio.

Parking demand (spaces) = No. of persons/VO

For example, a new office building will employ 700 people. As the result of an isolated vehicle-occupancy study, it was determined that typical ridership was 1.5 persons per vehicle. The basic estimated parking demand is thus equal to 700/1.5, or 466 spaces. The estimate may be further refined in accuracy by determining a separate vehicle occupancy for visitors or service vehicles as opposed to employees. An allowance should be made for traffic circulation and future growth.

c. Access roads. Evidence that vehicle occupancy at the installation is not substantially below the applicable average may be used in some cases to support a need for additional road capacity (see part one, para 9 of this guide).

d. Car pools. The results of a vehicle-occupancy study may be used to indicate the potential reduction in traffic that could occur with increased use of car pools. When installation roads are jammed with peak-hour traffic, increased use of car pools is one of the most cost-effective solutions. Listed below are several methods of encouraging the formation of car pools:

(1) Advertise. Allow free advertising space in the local newspaper for persons seeking car-pool partners.

(2) Big board. In a prominent location, such as a cafeteria, display a large local map that has been zoned to show employee live areas. Provide information cards that may be filed nearby according to zone number. Persons seeking car-pool partners may then match up cards.

(3) Computer matching. The United States Department of Transportation, Federal Highway Administration, has available computer programs that can be used to match up employees and aid in the formation of car pools.

(4) Incentives. Provide close, free, reserved parking for car pools with four or more persons.

(5) Flexi-time. Flexible worktime schedules permit the employee to set his own arrival/departure time and thus participate in car pools that might arrive/depart at other than the employee's original duty-hour schedule.

(6) Mass transit. The use of mass transit should be supported. Employee bus organizations should be encouraged. Communication should be established with local commercial bus companies, particularly about new routes or schedule times, to improve ridership (part two, sec XII). Satellite (fringe) parking areas may be developed where employees may leave their cars and take a bus. For example, when many of the employees live in a nearby community, a cooperative shopping center could be used for parking, and special commercial bus runs could be established.

SECTION V

PERSONNEL AND DUTY-HOUR STUDY

39. Purpose. These studies determine employee strengths, locations, and duty hours. The study may also include the gathering of motor-vehicle registration data. The results of this study may be used to determine concentrations of personnel reporting/departure times and a consequent need to stagger duty hours. Staggering duty hours is an excellent method of producing a more even distribution of traffic and better utilization of the available street system. It is one of the first solutions that should be tried on a military installation when road congestion is a problem. However, care must be taken to see that staggering duty hours creates minimal loss of effectiveness of car-pooling programs.

40. Information needed. The basic data required by this study include: organization charts, personnel strengths, telephone directories, duty-hour lists, installation maps, and vehicle-registration data. The classes of information required are shown on the sample tables presented in the analysis section.

41. Method. The following will discuss the means of collecting the needed information.

a. Personnel strengths. The required personnel data will usually be found in the records kept at installation headquarters. Each major organization is required to maintain a table of distribution and allowances (TDA) that lists the authorized and actual personnel strengths. For purposes of traffic analysis, actual strengths should be used. Telephone directories and organizational charts are useful to verify that each and every organization, such as tenant organizations and contractors, has been included. Since the goal is to include all personnel who contribute to installation traffic, an average number should be used for workers who are hired on a daily basis. The installation master planner can provide the long-range planning strength that should be used to design future highway projects.

b. Duty hours. Duty hours can be obtained at installation headquarters or by contacting the individual activities on the installation. Duty-hour information also can be obtained by use of a questionnaire (part two, sec X).

c. Vehicle registration. These data are usually obtained from the installation provost marshal or security police. Unless the existing files have been recently purged, the information should be updated by special questionnaire.

42. Analysis and display of data. This will consist initially of preparing tables or graphic illustrations that summarize the data. The sample tables that follow indicate the classes of information that should be obtained from installation headquarters. Typical tabular personnel information (fig 14) has been broken down by organization and by personnel status: officer, enlisted, or civilian. This is appropriate in a traffic study because of the different vehicle-ownership rates exhibited by various organizations.

TABLE X
PERSONNEL INFORMATION

Organization	Officers	Enlisted Men	Civilians	Contractors	Total
US Army Missile Command (MICOM)	239	603	7,090	40	7,972
US Army Missile and Munitions Center and School (USAMMCS)	249	2,372	657	0	3,278
Marine Corps	9	29	0	0	38
SAM D Missile System	36	1	162	0	199
Lance Missile System	8	1	88	0	97
US Army Medical Department Activity (MEDDAC)	51	118	151	0	320
Marshall Space Flight Center (MSFC)	1	9	5,093	2,124	7,227
Nonappropriated Funds Activities	0	0	367	0	367
Thiokol Chemical Corps (Government Contract)	0	0	0	685	685
Lessee/Vendors	0	0	0	866	866
Miscellaneous Activities	0	0	402	0	402
Total	593	3,133	14,010	3,715	21,451

Figure 14. Typical personnel information table.

Vehicle-registration data (fig 15) should also include the vehicles registered by retired military persons, as they are frequent users of installation facilities. The typical duty-hour schedule shown in figure 16 has been broken down by 15-minute segments during the morning- and evening-peak periods. A bar chart could be plotted for this information to make it easier to identify concentrations of arrivals and departures. Duty hours could also be broken down by organization in order to determine which contribute most to traffic congestion.

TABLE X
VEHICLE REGISTRATION DATA

Registrant	No. of Registered Vehicles	Vehicle Ratio per Person*
Officer	1,580	1.6
Enlisted	8,380	1.4
Civilian	1,240	1.0
Retired Military	13,800	NVAL
Total	25,000	

*Excluding dependents.

Figure 15. Typical vehicle registration data table.

43. Interpretation. Most of the data collected for this section may be used as general information in the text that accompanies the final traffic report. Such data are essential so that analysis of existing traffic generation and accidents may be compared with future conditions when personnel and other data have changed. Interpretation of personnel information will consist of locating major organizations on the installation map and then noting the roads and entrance gates that provide access. Direct access to the organization is more favorable than a meandering path. Interpretation of vehicle-registration data is largely a matter of comparing records for past years to evaluate the effects of growth in vehicle ownership. The duty-hour schedule should be studied to find high concentrations (more than 25 percent) of arrival and departure times. These are of greatest significance when they correspond with peaks of roadway congestion.

44. Application. The results of personnel and duty-hour studies may be used for determining growth rates, for improving transit service, and for staggering duty hours.

TABLE X
DUTY HOUR REPORTING AND DEPARTURE SCHEDULE*

Time	No. of Persons	Pct of Work Force
Reporting		
2400-0059	93	0.8
0100-0159	96	0.8
0200-0559	120	1.0
0600-0659	169	1.4
0700-0714	3,081	26.1
0715-0729	2,931	24.8
0730-0744	1,122	9.5
0745-0759	2,129	18.1
0800-0859	725	6.2
0900-1459	208	1.8
1500-1559	477	4.0
1600-1659	560	4.7
1700-2359	89	0.8
Total	11,800	100.0
Departure		
2400-0059	921	7.8
0100-0259	31	0.3
0300-0359	385	3.3
0400-1159	408	3.5
1200-1459	288	2.4
1500-1514	195	1.7
1515-1529	257	2.2
1530-1544	2,786	23.6
1545-1559	2,362	20.0
1600-1614	908	7.7
1615-1629	784	6.6
1630-1644	1,797	15.2
1645-1659	28	0.2
1700-2359	650	5.5
Total	11,800	100.0

*Data derived from origin and destination questionnaire and based on assigned strength of 11,800 persons.

Figure 16. Typical duty-hour reporting and departure schedule table.

a. Growth rate. The history of personnel strengths at an installation may be studied to determine a growth rate. However, it will be noted that at most installations, population peaks during periods of mobilization. It is thus recommended that instead of the growth rate, the long-range planning strength be used for determining future needs.

b. Transit service. The results of a duty-hour study should be compared with existing mass transit route schedules to determine compatibility. Schedules should be established so that employees have sufficient time to walk between their office and the nearest bus stop.

c. Duty hours. When all personnel arrive or depart at the same time, installation roadways will be saturated with traffic. The results are traffic jams, congestion, delays, accidents, and increased air pollution. There are two basic ways of improving the situation: (1) by providing greater street capacity (which can be expensive); or (2) by spreading the duty hours over a longer period of time. Thus, the recommendation to stagger duty hours is the most cost-effective suggestion that can be made.

(1) Management. Many managers desire to have all their personnel report at the same time. It will thus be necessary to document the benefits to be obtained by staggered duty hours to sell the program to installation management. With the exception of a true production line, the impact of staggered duty hours upon organization capability can be minimized. This requires scheduling of mutually interdependent activities at the same or nearly the same duty hours.

(2) Scheduling. Correct planning of a duty-hour schedule will include consideration of travel times on the installation (part two, sec VIII). Each major block of traffic should be allowed time enough to clear the installation, or section thereof, before the next is released. Personnel of an organization with a long travel time to the gate(s) may arrive at the gate to find it jammed with traffic from a nearby organization that was released later. Accordingly, the departure times should be scheduled so that the first units released are those with the shorter travel time to the gate. The remaining units should be released in successive increments of 10 or 15 minutes, proceeding away from the gate. The morning arrival times would be staggered in a like manner unless the length of the workday or noon break were planned to be different. Coordination with organization directors is recommended to produce a workable schedule. Employee desires are often sampled using an origin and destination style questionnaire (part two, sec X). An example of a duty-hour schedule is shown in figure 17. Note that the table is presented by organization. This example indicates that there still remains much room for improvement, since 53 percent of the personnel would be required to report at the same time.

TABLE X
DUTY-HOUR SCHEDULE

Agency	Duty Hours 0730 to 1600	0745 to 1615	0800 to 1630	0815 to 1645	0830 to 1700	0845 to 1715	0900 to 1730	Total
Admin Ofc	27	6	5	2	2	2	1	45
Asst Secy of the Navy (Instl and Log)	20	10	11	3	9	1	10	64
Misc Navy	139	47	58	15	36	8	34	337
Naval Air	1,569	344	311	135	229	23	200	2,811
Naval Electronics	545	107	89	60	73	4	81	959
Naval Material	369	109	69	49	58	12	60	726
Naval Ordnance	1,007	215	178	91	123	8	92	1,714
Naval Ships	1,401	341	347	158	206	28	221	2,702
Naval Material Comd Spt Actv	298	70	84	23	30	5	35	545
Ofc of the General Counsel	0	4	4	0	7	3	0	18
ONR	212	78	50	42	68	5	26	481
Total	5,587	1,331	1,206	578	841	99	760	10,402
Pct of Total	53.7	12.8	11.6	5.6	8.1	0.9	7.3	100.0

Figure 17. Typical duty-hour schedule table.

SECTION VI

TRAFFIC-ACCIDENT STUDY

45. Purpose. Accidents are studied in an attempt to reduce the accident rate on the installation. The basic procedures in the accident study are: collection of accident data, identification of high-accident-frequency locations, analysis of available data, and application of remedial techniques. From a study of accident history, information may be gained that may be used to prevent future accidents. Information showing predominance of faulty vehicular equipment or automotive maintenance deficiencies can also be gained from accident studies. Accidents may be prevented by application of traffic-control devices, law enforcement, driver education, and safety-oriented traffic engineering. This section will cover the engineering analysis required and will develop techniques that may be used to reduce accidents. Order of severity should also be listed in terms of accidents per 100 million vehicle-miles or in terms of accidents per 100 million vehicles entering intersections, as discussed later in this section. The five basic steps necessary to perform a complete traffic-accident analysis are:

a. Accident reports. Accident reports should be collected and summarized in an orderly fashion. They are usually filed in the office of the provost marshal, security police, or installation safety office.

b. Selection. High-accident-frequency road sections and problem intersections should be selected in the order of accident occurrence.

c. Diagram. Collision diagrams should be prepared, and, if needed, condition diagrams for each selected problem location (terms are explained later in this section).

d. Field study. The accident data should be supplemented by field observations, particularly during the hours when most collisions have been reported. Special traffic-volume counts and photographs are helpful to aid in the analysis.

e. Analyze. All background facts and field data should be summarized and analyzed to select potential solutions that may be implemented. Normally, the percentage of accidents reported is higher on military installations than on civilian roads and highways. For this reason, direct comparison with civilian highway-accident statistics (accident rates and characteristics) should be made with caution.

46. Information needed. Since traffic accidents are relatively rare events considering the number of potential conflicts that could occur, the accident study should cover at least a 1-year period. The following data should be obtained:

a. Location. The provost marshal or security office normally will maintain an accident spot map. This is a large installation map showing all roadways, intersections, and major parking areas.

(1) Map pins are used to locate each accident. A color code is used to indicate the accident severity (typically: property damage only (PDO), blue; injury (I), red; and fatality (F), black). The time and date may be indicated by a flag on the map pin. The spot map may be photographed for use in reports.

(2) Instead of using pins to indicate each accident, it is possible to use a convenient legend, such as that shown in figure 18. A typical accident spot map is presented in figure 19. If the installation does not maintain an accident spot map, it will be necessary to prepare an accident listing by going through the accident report files.

SEVERITY	LIGHT CONDITION	
	DAY	NIGHT
PROPERTY DAMAGE ONLY (PDO)	○	●
INJURY (I)	△	▲
FATALITY (F)	□	■
IF VEHICLE-PEDESTRIAN ACCIDENT, ADD "P" ALONGSIDE THE SYMBOL. IF VEHICLE-BICYCLE ACCIDENT, ADD "B" ALONGSIDE THE SYMBOL.		

Figure 18. Accident spot-map legend.

(3) A separate listing should be prepared for on-street and off-street accidents. An identifying number should be assigned to each accident such as 75-1, 75-2, 75-3, which would represent the first three accidents of 1975.

b. Day of the week and time of day. Definite patterns of accident occurrence develop at most installations. The day and time are used to identify these patterns. Differentiating between daylight and darkness is a minimum requirement.

c. Severity. Note whether accidents involve fatalities (F), injuries (I), or property damage only (PDO).

d. Type of vehicle. Describe whether civilian vehicle, military vehicle, trucks, bus, bicycle, or other. If pedestrian, so indicate.

e. Movement. Describe the action of involved vehicles or persons. It is important to know what each was doing immediately prior to the accident to develop accident patterns (going straight, turning right or left, or stopped). The direction of travel is important also. The Standard symbols shown in figure 20 may be used to indicate the movement of each involved vehicle.

f. Probable cause. The cause of the accident noted on the accident report should be obtained, as well as any unusual circumstances (rain, snow, fog, road construction, or similar).

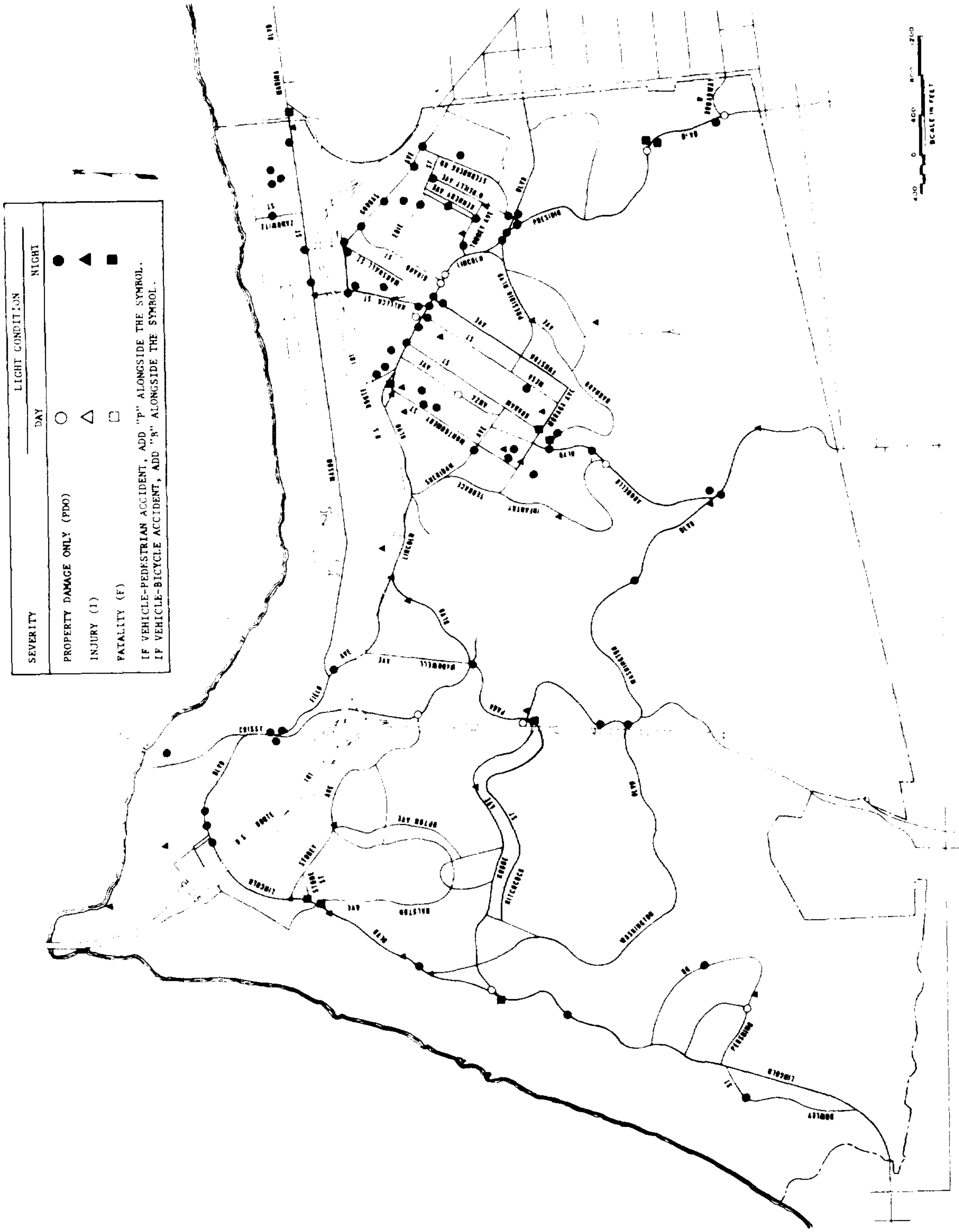


Figure 19. Typical accident spot map.

LEGEND FOR COLLISION DIAGRAMS

SYMBOLS		TYPES OF COLLISIONS	
	MOVING VEHICLE		REAR END
	PEDESTRIAN		HEAD ON
	PARKED VEHICLE		BACKING
	PARKING OR UNPARKING VEHICLE		RIGHT ANGLE
	BACKING VEHICLE		LEFT TURN
	FIXED OBJECT		SIDESWIPE
	FATAL ACCIDENT		OVERTURNED
	INJURY ACCIDENT		OUT OF CONTROL

Figure 20. Standard accident diagram symbols.

g. High-accident-frequency locations.

(1) Since each installation has a different pattern of development, it is difficult to set standards regarding "what is a high-accident-frequency location?" As a starting point, list all intersections with three or more accidents per year in descending order, placing the intersection with the highest number of accidents at the head of the list. Normally, intersections with four or more injury accidents per year deserve further study. If the listing indicates that 10 or less intersections fall into this category, use 4 or more accidents per year as the standard to designate high-accident-frequency intersections.

(2) To select high-accident-frequency sections of roadway for further study, use figure 21. Accidents at the intersection of two major streets are charged to both major street sections to check high-accident-frequency causes. This avoids the problem of how to divide the accidents between the adjacent street sections. As an example of use of the figure, if there are 20 accidents in a 1-mile section of roadway with a daily traffic volume of 10,000 vehicles per day, further study is justified since it exceeds the value of 18 shown in the figure; if the section were only 1/2-mile in length, 9 accidents or more would justify further study; similarly if the section were 2 miles in length, 36 accidents or more would warrant special

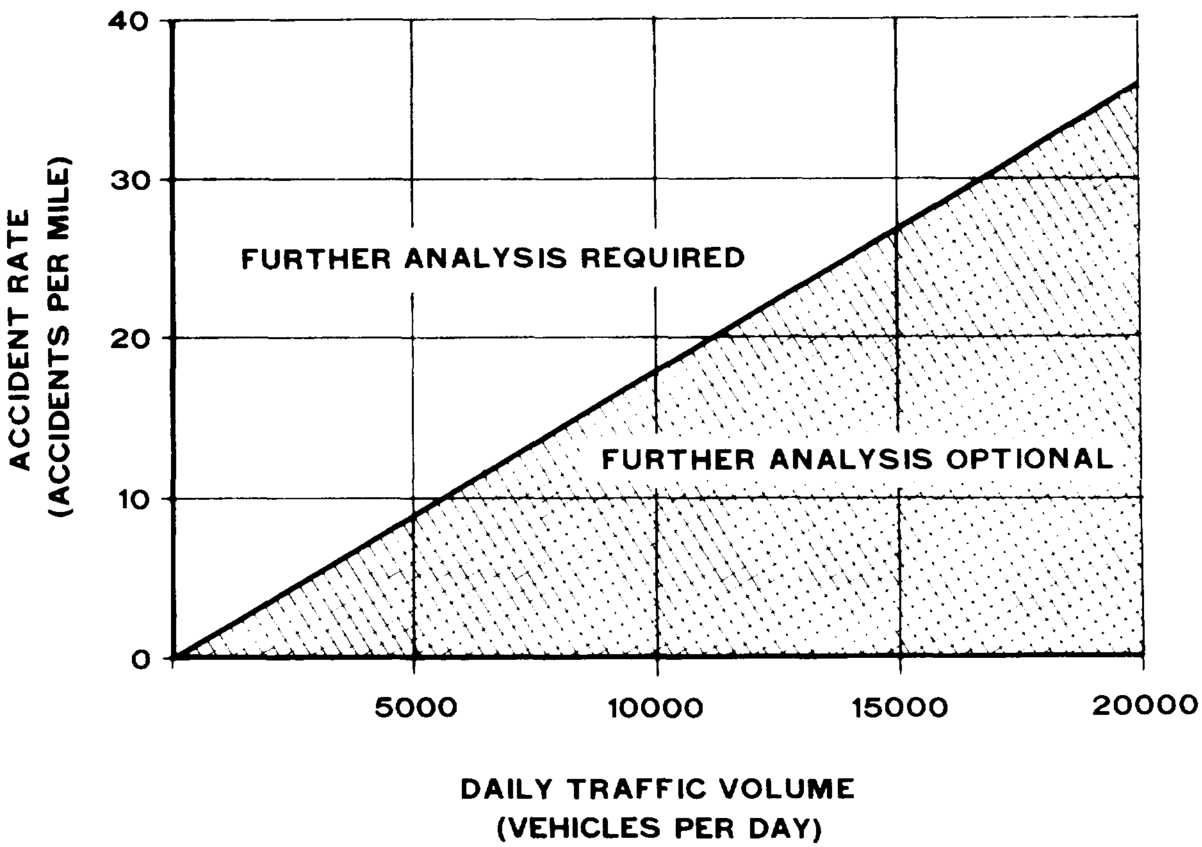


Figure 21. Accident analysis chart.

study. This figure was prepared based upon an accident rate of 500 accidents per 100 million vehicle-miles of travel. Each accident that occurs at a high-accident-frequency intersection or within a high-accident-frequency intersection or within a high-accident-frequency roadway section may be recorded on the suggested abbreviated accident summary format (fig 22) for later use in the accident analysis. The collision diagram symbols are covered in a later portion of this section.

(3) Sometimes additional details can be helpful when placed on the location map (see fig 19). This is done for the purpose of specifying what types of accidents occurred at what place. For example, designation of clusters of left-turn, rear-end, and fixed-object accidents can be helpful in establishing exactly what kind of improvement is needed. Many highway-accident statistics and location maps show clusters of fixed-object accidents at some locations involving horizontal curves. Generally, these can be remedied by better signing, edge lines, delineators, and/or guardrails.

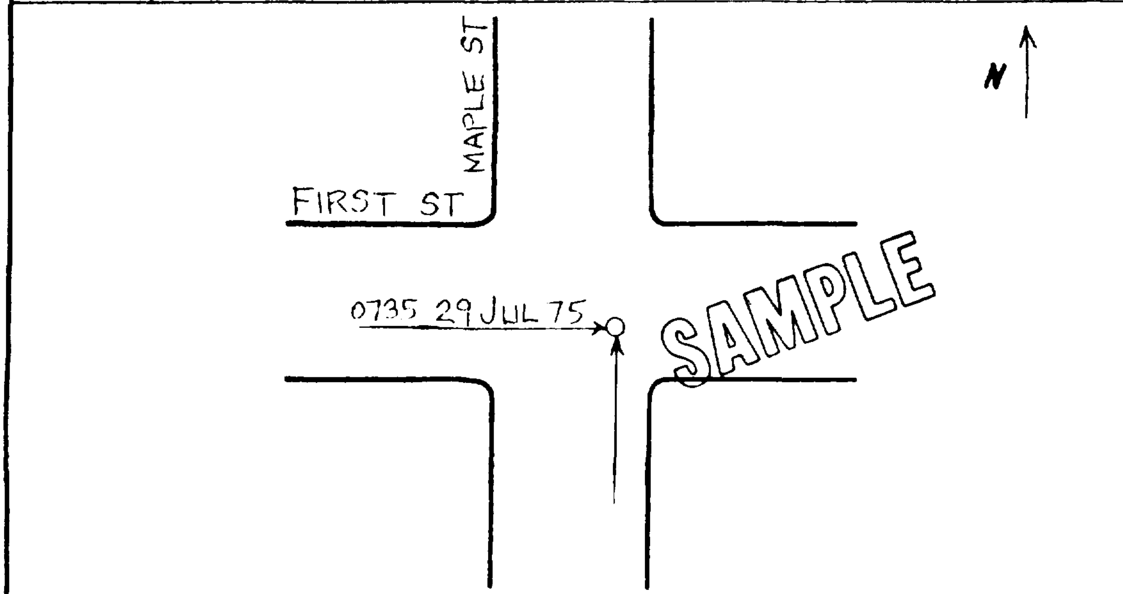
ABBREVIATED ACCIDENT SUMMARY SHEET

INSTALLATION FT. BATTLE FILE NO. 347

DATE 29 JULY 1975 DAY TUESDAY TIME 0735

WEATHER FAIR PREPARED BY J.W. JONES

LOCATION	ON FIRST ST., INTERSECTING WITH MAPLE ST.
	ON ______ ST. ______ FEET, N. S. E. W. OF ______ ST.
	ON ______ LOT NEAR BLDG NO. ______



SEVERITY	FATALITY NO. OF PERSONS	INJURY NO. OF PERSONS 2	PROPERTY DAMAGE ESTIMATED COST $ 400
DRIVER/PEDESTRIAN CONDITION (CHECK ONE)	☑ NORMAL	☐ TIRED/SLEEPY	☐ INTOXICATED
PROBABLE CAUSE OF ACCIDENT (CHECK ONE)	☐ DRINKING	☐ DRIVING TOO FAST	☑ FAILURE TO YIELD
	☐ FOLLOWING TOO CLOSE	☐ IMPROPER TURN	☐ IMPROPER PASSING
	☐ CARELESS DRIVING	☐ IMPROPER BACKING	☐ MECHANICAL FAILURE
	☐ OTHER		
LIGHTING CONDITION (CHECK ONE)	☑ DAY LIGHT	☐ DARK-NO LIGHTING	☐ DARK-STREET LIGHTS

Figure 22. Typical abbreviated accident summary sheet.

h. Traffic-volume data and base map. Twenty-four-hour-traffic-volume counts (part two, sec I) on major installation roadways as well as on approaches to high-accident-frequency intersections should be collected. An installation base map (to scale) will be needed to scale various lengths of high-accident-frequency sections to calculate accident rates.

47. Method. The method will consist of summarizing data, performing follow-up field checks of the high-accident-frequency locations, and developing potential measures to reduce accident occurrence in the future. These steps and procedures are explained under the analysis portion of this section.

48. Analysis. This will usually consist of calculation of accident rates to verify further the high-accident-frequency locations and to conduct detailed analysis of each problem location. The detailed analysis includes preparing collision diagrams to identify accident patterns, conducting field investigations, and determining potential corrective measures.

a. Intersection accident rate. The listing of high-accident-frequency intersections by consecutive order of number of accidents did not take into account the different traffic conditions at each intersection. A further rating is possible by determining the number of annual accidents per million vehicles entering the intersection. The yearly intersection rate per 100-million vehicles (IR) is calculated using the formula:

$$IR = \frac{N \times 100,000,000}{V \times 365}$$

where

N = Number of accidents in one year;
V = Sum of the 24-hour volumes entering the intersection on each approach (inbound only).

If the approach traffic volume is not known but the two-way total is available on each leg of the intersection, assume that the approach volume is one-half of the two-way total. When the rates are calculated, they can be summarized in a table as shown in figure 23.

b. Roadway accident rate. This is calculated in a manner similar to the intersection accident rate. This rate is based upon the number of vehicle-miles of travel rather than upon the entering vehicles. The yearly accident rate per 100-million vehicle-miles (AR) may be computed with the formula:

TABLE X
ACCIDENT INTERSECTION DATA

No.	Inter-section	No. of Accidents PDO	I	F	Total	Daily Entering Traffic Volume	Total Accidents per 100 Million Vehicles
1	C - 10th	8	0	0	8	15,000	146
2	A - 2nd	10	2	0	12	25,000	132
3	F - 4th	5	1	0	6	19,000	87

Figure 23. Typical accident intersection data table.

$$AR = \frac{N \times 100,000,000}{V \times 365 \times L}$$

where

N = Number of accidents in one year;
L = Length in miles of the roadway section;
V = Two-way 24-hour traffic volume.

The section of roadway for which the rate is calculated should be a section of reasonable length (1/2-mile or longer), which has similar characteristics in terms of traffic volumes, number of lanes, and adjacent development. The traffic volume used is the average for the section if more than one count is available. Figure 24 indicates a format for summarizing the results of these calculations for high-accident-frequency sections of roadway, or for any high-volume roadways on an installation, in order to identify the sections with high-accident-frequency rates. After high-accident-frequency sections have been determined for further study and improvements have been made, then other lower accident sections should be listed in descending order and improvements should be made at all locations (especially at locations where there appears to be a reasonable chance of potential accident reduction).

c. Collision diagrams.

(1) This summary technique is one of the most valuable tools in analyzing problem intersections or roadway sections. Using the individual abbreviated accident reports prepared earlier (see fig 22), the collision diagram is prepared for each high-accident-frequency location.

(2) The path of each vehicle should be represented by a solid line, and that of each pedestrian by a dotted line. The date and hour should be written beside each arrow. Unusual weather, road conditions, and pedestrian or driver conditions should also be noted on the diagram.

TABLE X
HIGH ACCIDENT ROADWAY SECTIONS

Roadway/Section	Length (Miles)	No. of Accidents PDO[a]	I[b]	F[c]	Total	Average Daily Volume (Vehicles per Day)	Annual Vehicle Travel (100 Million Vehicle-Miles)	Accidents per 100 Million Vehicle-Miles
A St, 1st to 5th	1.0	20	8	0	28	15,000	0.055	509
A St, 5th to 14th	2.2	32	4	1	37	9,000	0.072	513
C St, 4th to 12th	2.0	16	6	0	22	5,000	0.036	611
E St, 12th to 19th	1.8	4	1	1	6	1,000	0.007	857

[a] PDO - Property damage only.
[b] I - Injury.
[c] F - Fatality.

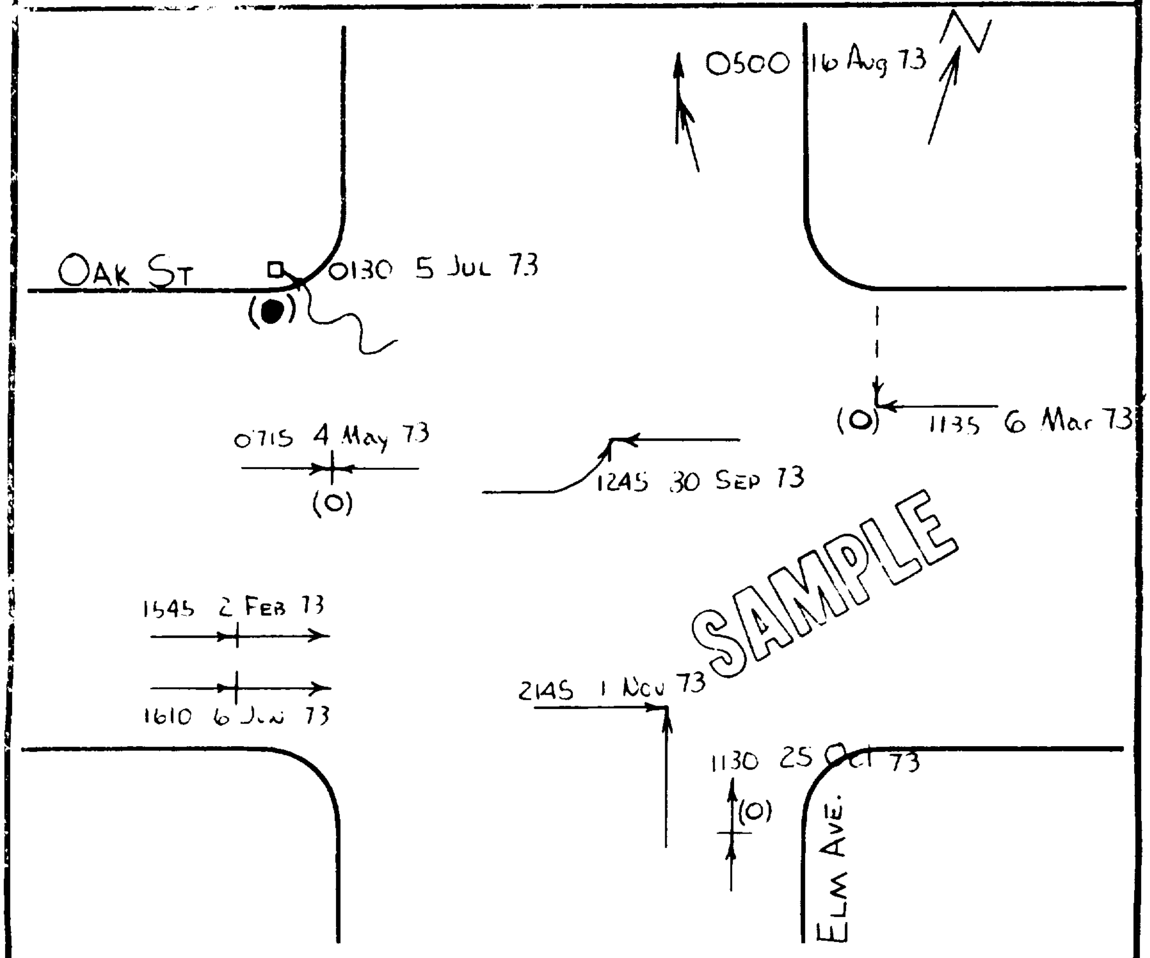
Figure 24. Typical high-accident roadway sections table.

Traffic volume and travel information are optional but helpful in reviewing the diagram to consider accident-reduction means. A sample collision diagram is shown in figure 25. By preparing collision diagrams after some change has been made (such as a turn prohibition or sight-distance improvement) that covers a period equal to the before period, the effect of the change on accident occurrence may be measured.

(3) When dealing with accident statistics, always note whether accidents involve fatalities (F), injuries (I), or property damage only (PDO). Also, note the minimum dollar amount for which PDO accidents have been recorded (usually $50 to $100). In this way, the calculation of military installation accident rates per 100-million vehicles or per 100-million vehicle miles for each severity category will be more meaningful and can be compared better with national, state, or regional rates.

d. Field study. In all areas where accidents occur in large numbers or where certain types of accidents occur frequently, a field investigation must be made. A condition diagram (fig 26) should be constructed to show existing physical conditions. Such a diagram should include roadway grade, curvature, shoulder width, view obstructions, sidewalks and driveways, property lines, type and condition of pavement, signals, sigrs and pavement markings, bridges, overpasses, culverts, street lighting, sight distance, and types of occupancy of adjacent property. An aerial photograph can serve much of the purpose of the condition diagram, particularly when supplemented with ground-level photographs taken on each intersection approach looking toward the intersection.

COLLISION DIAGRAM SUMMARY SHEET



SYMBOLS	TYPE OF COLLISIONS	ACCIDENT TOTALS BY TYPE			
MOVING VEHICLE	REAR END	TYPE	DAY	NIGHT	TOTAL
PEDESTRIAN	HEAD ON	FATAL	0	1	1
PARKED VEHICLE	BACKING	PED INJURY	1	0	1
PARKING OR UNPARKING VEHICLE	RIGHT ANGLE	OTHER INJURY	2	0	2
BACKING VEHICLE	LEFT TURN	PROP DAMAGE	3	2	5
FIXED OBJECT	SIDESWIPE	TOTAL	6	3	9
FATAL ACCIDENT	OVERTURN	LOCATION Oak St & Elm Ave			
INJURY ACCIDENT	OUT OF CONTROL	PERIOD 1 Jan 73 TO 31 Dec 73			

Figure 25. Typical collision diagram summary sheet.

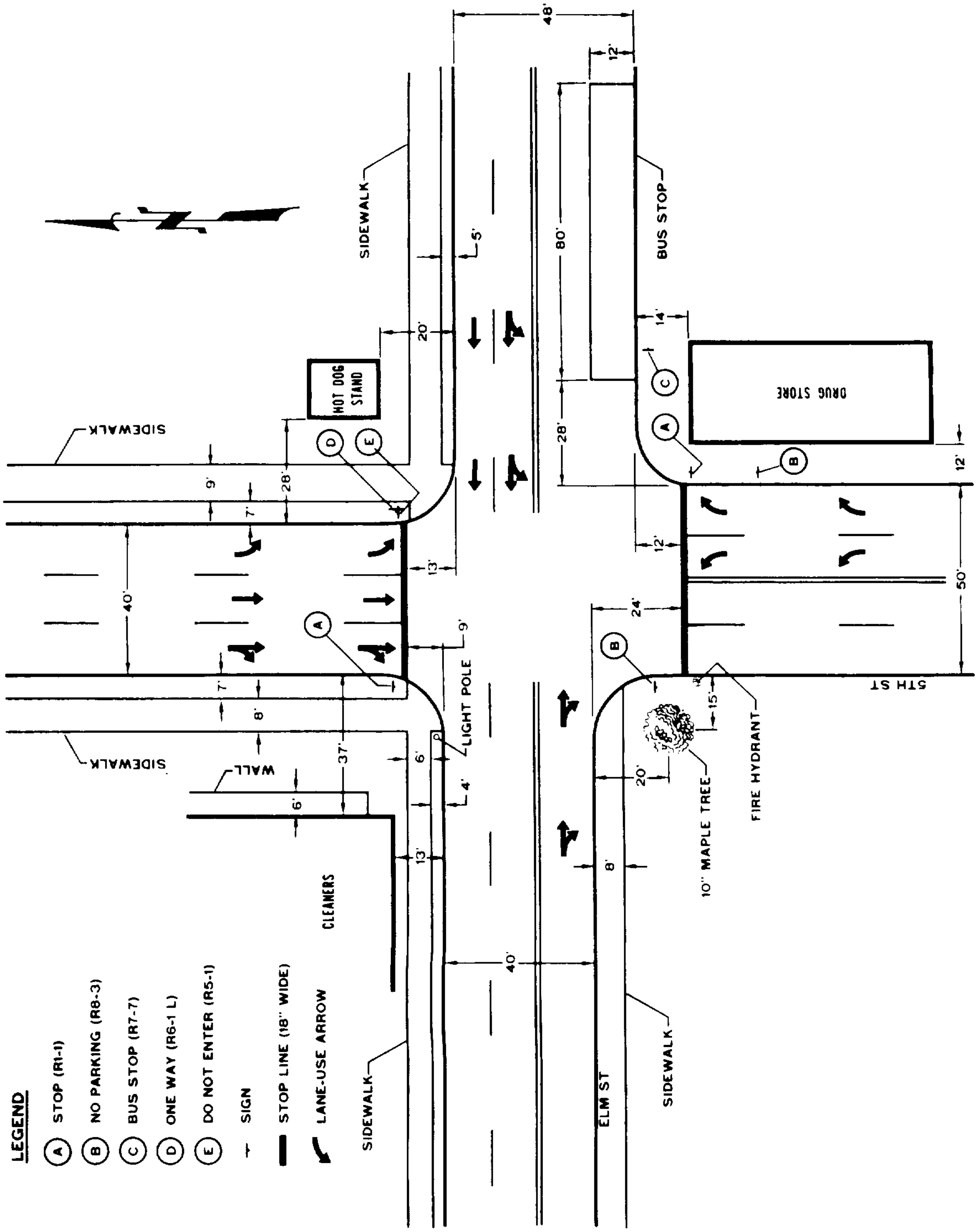


Figure 26. Typical condition diagram.

49. Interpretation. The results of the accident and volume studies as well as the field investigation allow the analyst to find answers to the following questions:

a. Are the accidents caused by physical conditions of the road or adjacent development, and if so, can the conditions be eliminated or corrected?

b. Is there a blind corner that could be improved to increase sight distance? If the obstruction cannot be removed, has adequate warning or control (STOP signs, YIELD signs, or traffic signals) been provided for the motorist?

c. Are the existing signs, markings, or signals doing the job for which they were intended? Are there too many signs of too small a size so that their clutter causes confusion and lack of observance? Are traffic-signal indications clearly visible without conflicting signs in the back ground, particularly at night?

d. Is traffic properly channelized and directed through the use of pavement markings and islands to reduce conflicts?

e. Would the potential for accidents be reduced by prohibiting some single turn if a reasonable alternate route is available to serve the prohibited move?

f. Can part of the traffic be diverted to other parallel roads where the accident hazard is lower? Are one-way streets practical to spread traffic loads and reduce intersection conflicts?

g. Are nighttime accidents far out of proportion to daytime accidents, indicating the need for improved street lighting? (About 36 percent of the nation's accidents occur from dusk to dawn when only 20 percent of the traffic flows.)

h. Do conditions show that additional enforcement would be helpful in improving driver observance of traffic-control devices? Would general public information programs be helpful in informing installation personnel of accident characteristics and problems?

i. Is parking in the vicinity of the problem area contributing to the accidents? If so, would prohibiting parking add to intersection capacity or improve sight distance at corners?

j. Have you met with other interested personnel such as the provost marshal or installation safety officer to obtain their ideas concerning the problem?

50. Application. The practical application of a study of accident types shown by the collision diagrams will assist in remedial action. Reviews of these patterns may suggest the corresponding engineering remedies as shown:

a. Right-angle and rear-end collisions at intersections.

(1) Remove view obstructions.

(2) Install warning signs on the higher volume (major) approach and STOP signs on the lower volume (minor) legs.

(3) Install four-way STOP signs; install traffic signals if traffic volumes warrant.

(4) Continue operation of traffic signals during certain light traffic periods when signals are normally off.

(5) Provide proper clearance interval (yellow) for higher speed approaches to signalized intersections.

(6) Relocate, repair, or provide other means of improving visibility of signs or signals. Change 8-inch signal indications to 12 inches for primary indications.

(7) Improve street lighting if there is a high percentage of nighttime accidents.

(8) Provide pedestrian crosswalk markings and barriers.

(9) Reroute through traffic onto specially designated and protected through streets.

(10) Create one-way streets or make one or more minor legs one way away from the intersection at complex multilegged intersections.

(11) Install left-turn storage lanes in the center of the roadway to reduce rear-end accidents and improve capacity.

(12) Provide a traffic-signal system timed for progressive movement so that traffic moves in platoons, which will aid side street vehicles to enter or cross. Reducing the number of stops for through traffic will reduce the potential for rear-end accidents.

b. Head-on and left-turn collisions at intersections.

(1) Provide left-turn storage lanes so that a turning driver has a place to wait without concern about rear-end accidents.

(2) Prohibit left turns.

(3) Provide channelizing islands or pavement markings.

(4) Separate left-turn phases at traffic-signal controls for high-volume turns (over 120 vehicles turning per hour).

(5) Install STOP signs (provided no other remedy works).

(6) Eliminate or modify view obstructions (trees, shrubs, signs, or buildings).

(7) Create one-way streets to eliminate head-on conflicts.

(8) Reroute turning traffic via an alternate route.

(9) Install pavement center and edge lines, but do not install both center and edge lines on pavements narrower than 18 feet when used for two-way traffic.

c. Pedestrian-vehicular collisions at intersections.

(1) Install pedestrian crosswalk lines and advance warnings.

(2) Install traffic signals with pedestrian indicators (WALK/DON'T WALK).

(3) Provide pedestrian refuge islands (must be at least 6 feet wide) and sidewalks.

(4) Prohibit curb parking to improve visibility of pedestrians.

(5) Provide adequate street lighting for nighttime problems.

(6) Create one-way streets to simplify movements.

(7) Reroute through traffic to specially designated and protected through streets when the vehicle-pedestrian problem is areawide; install malls or diverters to eliminate through traffic in areas where it should not be.

(8) Provide pedestrian indications at existing traffic signals.

(9) Provide overhead or below-grade pedestrian crossing when economically justified.

(10) Establish regulations and guidelines concerning pedestrian outer garments for night wear.

d. Head-on or sidewipe.

(1) Install painted pavement lane lines or raised pavement markers.

(2) Install center dividing islands.

(3) Install advance warning signs to warn drivers of the proper lane for certain destinations in order to reduce unsafe lane changing.

(4) Establish no-passing zones where passing sight distances are not available.

(5) Provide acceleration or deceleration lanes at intersections.

(6) Widen pavement.

(7) Create one-way streets.

(8) Eliminate side or width obstructions such as parked cars, narrow bridges, and utility poles.

e. Vehicles running off roadway.

(1) Install pavement center and edge lines.

(2) Install roadside delineators, reflectors, guide posts, or guardrails.

(3) Install advance warning signs indicating safe speeds.

(4) Establish speed zones.

(5) Install safety lighting at curves and intersections.

(6) Apply surface treatment and improve shoulder.

f. Collisions with fixed objects.

(1) Apply reflectorized paint and/or reflectors to fixed objects.

(2) Use pavement markings and/or channelization to guide traffic around obstructions.

(3) Improve street lighting.

(4) Remove fixed objects (if feasible).

(5) Install guardrails or impact-absorbing barriers.

g. Collisions with parked cars.

(1) Prohibit parking.

(2) Change from angle to parallel parking.

(3) Reroute through traffic to less congested, specially protected through streets.

(4) Create one-way streets.

In addition to the above recommendations, additional measures may be required. For example, there may be needed improved enforcement of speed or other traffic regulations, assignment of traffic officers or crossing guards to safeguard pedestrian crossings, enforced pedestrian observance of traffic rules, and special driver or pedestrian educational measures.

It must be emphasized that the above is a "shopping list" of potential treatments to reduce accidents. Sometimes none of these will have a beneficial effect; in other cases one or more may prove effective. A logical review of the facts and conditions at each problem location will usually identify some remedial treatment that will aid in accident reduction. It will be necessary to apply engineering judgment.

SECTION VII

TRAFFIC-CONTROL-DEVICES INVENTORY

51. Purpose. The purpose is to produce a detailed inventory of all traffic-control devices (pavement markings, signs, and signals) on an installation. The results are used to determine whether there is an adequate number of devices, if they have been properly located, and if they comply with regulations. Thus, the results are used to determine which devices must be removed, replaced, or relocated. The inventory will also aid in the establishment of schedules for cleaning, maintenance, and replacement. Traffic-control devices are classed as (1) pavement markings, (2) traffic signals, and (3) signs. Signs are, in turn, described as either regulatory, warning, or guide. The standard reference for all traffic-control devices is the Manual on Uniform Traffic Control Devices for Streets and Highways (hereinafter referred to as MUTCD). This publication also applies to DOD installations, as established by public law and DOD regulations (app B).

52. Information needed. The type, location, and condition of each traffic-control device on the installation is necessary.

53. Methods. Possible methods are (1) the manual inventory, and (2) the computer-produced inventory. At smaller installations the data recorded from the manual survey should be coded directly to a map of the street systems. Each traffic-control device should be coded on the map and an index number assigned it. Information such as description, condition, reason for, and date of installation should be typed on cards and filed by the index numbers. When manpower is available, larger installations should use a computer-produced inventory. This system is centered around the use of automatic data processing (ADP) equipment, though initial data assembly must be manual and the basic data record is the same. The ADP punch-card-coding format shown in appendix C has been reprinted from the Highway Safety Program Manual, Volume 13, Traffic Engineering Services. (Part two, sec XIV of this guide provides more details of the Highway Safety Program Standard (HSPS) No. 13.)

a. Signs. The inventory of signs should include (from MUTCD) "... all devices mounted on a fixed or portable support, whereby a specific message is conveyed by means of words or symbols, placed or erected for the purpose of regulating, warning, or guiding traffic." The recommended ADP procedures are presented in appendix C (from HSPM 13). Shown is a system to collect the required information, coding instructions, and a sample data sheet. Presented in appendix D are field-data sheets that permit a sign inventory without the use of the complex forms recommended in HSPM 13.

b. Pavement markings. The inventory of pavement markings should include (from MUTCD) "...all lines, patterns, words, or colors set into the surface of, applied upon, or attached to the pavement or curbing for the purpose of regulating, warning, or guiding traffic." The recommended ADP system is presented in appendix C (from HSPM 13). Shown are the required information, coding instructions, and a sample data sheet.

c. Traffic signals. The inventory of traffic signals should include (from the MUTCD) "...all signals manually, electrically, or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed." The recommended ADP coding system and the suggested format for a scale drawing (from HSPM 13) are presented in appendix C.

d. Data collection. The primary means of conducting the inventory is by arduous manual field observation. Usually two-man teams will travel every street on the installation by automobile. Each street must be traveled in both directions to avoid missing any device. If there is a concentration of devices in one spot (for instance at an intersection), it will be necessary to travel on foot. A travel plan should be adopted and adhered to. At signalized intersections, it will be necessary to time the traffic signal with a stop watch. An inspection of the controller will determine the type and the dial settings being used. It should also be noted whether the controller is traffic-actuated, and if so, by what means. Observations should be made over a sufficient number of cycles to prove that the actuator is indeed operable.

54. Analysis. This will consist of preparing inventory lists of all traffic-control devices. This listing may be produced manually. However, it is also possible to have the coding sheets keypunched and to use ADP system devices to produce the listing. Since the inventory should be up dated annually, the ADP system procedure may be desirable, particulary when the installation has a large number of devices. This system has the advantage of producing tables in a convenient printed format and of providing summary printouts with relative ease. The printouts may be

classified by (1) the number of each type of device, (2) the number of devices in various states of repair, (3) a maintenance list, and (4) a replacement list.

55. Interpretation. Only field personnel having a working knowledge of the MUTCD should be assigned to the inventory. They will be responsible in the field for interpreting the standards and for comparing each traffic-control device against them. After listings (or printouts) have been prepared, further interpretation should compare the MUTCD against the overall status of traffic-control devices on the installation. Action should be taken if the inventory reveals nonstandard or poorly mounted devices. For example, determine whether the devices have been located correctly to have the desired safety effect. Determine whether there are enough traffic-control devices for proper results. Determine whether there are too many devices in certain areas that perhaps complicate the driver's task. Determine whether each and every device GETS ITS MESSAGE ACROSS. That is the first function of any traffic-control device.

56. Application. The traffic-control-device inventory should be used to determine when to replace or relocate devices.

a. Maintenance. The inventory may also be used to establish schedules for the maintenance or replacement of the devices. For example, pavement markings should be repainted annually and more often in heavy traffic areas. Signs should be periodically cleaned, and any defaced, deteriorated, or damaged signs should be replaced. Traffic signals should be relamped periodically, the lens should be cleaned, and the wiring inspected. The controller should be examined and routine maintenance performed.

b. Records. The traffic-control-device inventory and all accompanying drawings should be preserved in files. This will provide a convenient source of information regarding the type, design, and location of traffic-control devices. The inventory should be updated annually.

c. HSPS 13. Highway Safety Program Standard 13 (part two, sec XIV) requires that traffic-control devices be standardized throughout the country and has established the MUTCD as the reference manual. Successive legislation has extended the standardization to cover all DOD installations or those portions permitting personal motor vehicle travel. HSPS 13 requires that a traffic-control-device inventory be performed and kept current by periodic rechecks. Devices that are nonstandard, incorrectly used, or poorly maintained must be replaced.

SECTION VIII

TRAVEL-TIME AND DELAY STUDIES

57. Purpose. The purpose of these studies is to determine typical travel times and delays experienced by motorists on the major roadways serving an installation. The results of a travel-time study will determine the effect that peak-hour-roadway congestion has on average travel speed; the results of a delay study will indicate the location, cause, and duration of traffic stoppages. These types of studies are sometimes called speed and delay studies. Both the travel-time study and the delay study are used to determine sources of traffic congestion, and to highlight problems that may require additional investigation. Together they indicate the serviceability of installation roadways.

58. Information needed. Data needs include the travel time on selected roadways serving the installation. Data may be collected on major installation streets and on public roads that provide access to the installation. Travel times may be recorded both during off-peak-travel periods and during the morning- or evening-peak hours. Also needed are the road location of any traffic delay, together with the time, length, and cause of the delay. A delay is considered to occur each time traffic is forced to stop or when it must travel much slower than a free-flowing speed.

59. Method. There are many ways of accomplishing travel-time and delay studies. The method selected here is thought to be most appropriate for military installations. It is called the test-vehicle or floating-car technique.

a. Equipment. A standard unmarked passenger sedan, a driver and an observer, street maps, stop watches, and a clipboard with data sheets will be needed.

b. Technique. The driver and observer travel each major roadway of the installation, recording their observations on a data sheet as shown in figure 27. The two stop watches are mounted at the top of the clipboard. One watch is run continuously and is used to indicate elapsed time; the other watch is started when a delay occurs, stopped when traffic moves again, and the duration of the delay time is then recorded. The cause of delay is noted by the use of symbols shown at the bottom of the data sheet. Space is provided for several possible delays between major intersections, and more can be inserted if necessary. A run along a particular street is begun at some landmark just prior to the first major cross-street. The elapsed time is then recorded when the center of each

TRAVEL TIME AND DELAY FIELD SHEET

LOCATION ELM ST WEATHER FAIR (PEAK)/OFF PEAK

DATE 18 JUN 1975 TIME PERIOD 0715 TO 0719 OBSERVER J. W. JONES

NODE	MAJOR CROSS STREET	RUN DIRECTION INBOUND			RUN DIRECTION			RUN DIRECTION		
		ELAPSED TIME	DELAY TIME	DELAY CAUSE*	ELAPSED TIME	DELAY TIME	DELAY CAUSE*	ELAPSED TIME	DELAY TIME	DELAY CAUSE*
(1)	PINE ST	0.00								
		0.30	0.30	PV						
(2)	OAK ST	1.00								
		1.30	0.53	SS						
(3)	BIRCH ST	1.83								
		2.35	0.55	MP RT						
(4)	MAPLE ST	2.90								
		3.15	0.40	RR						
		3.68	0.21	TS						
(5)	SPRUCE ST	3.89								

SAMPLE

*DELAY CAUSE SYMBOLS

PV = PARKING VEHICLE
PL = PASSENGER LOADING
SS = STOP SIGN
TS = TRAFFIC SIGNAL
BS = BACKUP AT SIGNAL
MP = POLICE CONTROL
PD = PEDESTRIAN
RT = RIGHT TURNING VEHICLE
LT = LEFT TURNING VEHICLE
RR = RAILROAD TRAIN
OT = OTHER CAUSE

Figure 27. Typical travel time and delay field sheet.

intersection is crossed. The driver is instructed to float with the traffic at a speed he considers to be that of an average car (rather than at the posted speed limit).

c. Preparation. Prior to the actual road travel-time measurements, it will be necessary to prepare a map sketch showing the major streets that will be included in the study. The intersection of two major streets is called a node. All the nodes on the sketch should be numbered sequentially, as are all segments of roadway. From accurate installation maps, exact segment distances (in feet) are scaled and then written alongside the segment number on the sketch. Scaled map distances are usually more accurate than car odometer readings over short distances.

d. When. Runs should be made during clear weather and when traffic conditions are fairly typical. Series of runs should be made during off-peak-travel periods to obtain normal travel times. These are compared with the results of other runs made during the morning- and the evening-peak hours. Peak-hour runs are made in the direction of the maximum traffic flow. It is necessary to make several runs and average the results. For practical purposes five runs are usually sufficient. Several teams in other test cars can aid in collecting travel-time data by departing at 5-minute intervals.

60. Analysis. Analysis will consist of computing the average travel time for each segment and then calculating the travel speed aided by the suggested work sheet in figure 28. A table should be prepared summarizing travel-time and delay results. A table suitable for this purpose is shown in figure 29 and a sample published table is shown in figure 30. Note that the delay codes used correspond to those on the suggested travel-time and delay field-data sheet (see fig 27). It is desirable to prepare a map that summarizes the travel times and emphasizes road segments with significant delays (fig 31). A written commentary should accompany the map, and should describe field observations concerning the causes of delay. A list of formulas applicable to travel-time and delay studies is presented below:

Distance = Length of road segment (feet)

$$\text{Travel time (min)} = \text{Elapsed time}_{\text{End run}} - \text{Elapsed time}_{\text{Start time}}$$

Total delay time (min) = Sum of delay times

Running time (min) = Travel time - Total delay time

TRAVEL TIME WORK SHEET

LOCATION Elm St WEATHER Fair

DATE 18 Jun 1975 TIME 0715 TO 0719 (PEAK)/OFF PEAK

NODE	MAJOR CROSS STREET	DIST. (FEET)	SEG NO.	ELAPSED TIME (MIN:SEC)	ELAPSED TIME (MIN. DEC)	TRAVEL TIME (MIN. DEC)	TRAVEL SPEED (MPH) = DISTANCE (FEET) / TRAVEL TIME X 88
A	Pine St			0:00	0.00		
		1320	1			0.50	30.0
B	Oak St			0:30	0.50		
		3550	2			1.00	40.3
C	Birch St			1:30	1.50		
		4,200	3			1.08	44.2
D	Maple St			2:35	2.58		
		4,820	4			1.55	35.3
E	Spruce St			4 08	4.13		
		720	5			0.35	23.4
F	Orange St			4:29	4.48		

Figure 28. Typical travel time work sheet.

ROADWAY SEGMENTS WITH SIGNIFICANT DELAYS

ROADWAY	MILEAGE	TERMINAL POINTS	SEGMENT NO.[a]	TIME PERIOD[b]	POSTED SPEED LIMIT (MPH)	OVERALL SPEED (MPH)	DELAY CAUSE SYMBOL[c]	OVERALL TIME (MIN)	DELAY TIME[d] (MIN)
ELM ST	0.4	PINE ST TO OAK ST	1	MORNING PEAK	30	16	TS	1.54	0.64
				OFF PEAK	30	27		0.90	
				EVENING PEAK	30	18	RR	1.33	0.43
ELM ST	0.35	OAK ST TO BIRCH ST	2	MORNING PEAK	30	22		0.97	0.22
				OFF PEAK	30	28		0.75	
				EVENING PEAK	30	16	PD, LT	1.32	0.57
BIRCH ST	0.25	ASH ST TO HOLLY ST	3	MORNING PEAK	25	9	MP, PK	1.60	0.90
				OFF PEAK	25	21		0.70	
				EVENING PEAK	25	10	MP, PD	1.55	0.85
BIRCH ST	0.20	HOLLY ST TO SPRUCE ST	4	MORNING PEAK	25	11	RT, TS	1.08	0.58
				OFF PEAK	25	24		0.50	
				EVENING PEAK	25	18	PL	0.67	0.17

SAMPLE

a/ NUMBERS USED TO IDENTIFY ROUTE SEGMENTS.

b/ MORNING- AND EVENING-PEAK SPEED AND DELAY RUNS WERE MADE IN THE DIRECTION OF MAXIMUM TRAFFIC FLOW.

c/ DELAY CAUSE SYMBOLS-- TS=TRAFFIC SIGNAL; BS=BACKUP AT SIGNAL; MP=POLICE CONTROL; PK-PARKING VEHICLE; SS=STOP SIGN; RR=RAILROAD TRAIN; PL=PASSENGER LOADING (CAR OR BUS); OT=OTHER CAUSE; PD=PEDESTRIAN; RT=RIGHT TURNING VEHICLE; LT=LEFT TURNING VEHICLE; IC=INSUFFICIENT CAPACITY

d/ MINUS SIGN INDICATES THAT TRAVEL TIME WAS GREATER FOR THE OFF-OEAK RUN THAN FOR THE PEAK-HOUR RUN.

Figure 29. Typical summary sheet for roadway segments with significant delay.

TABLE X
ROADWAY SEGMENTS WITH SIGNIFICANT DELAY

Roadway Traveled and Mileage	Terminal Point and Segment No.	Time Period[a]	Posted Speed Limit (mph)	Overall Speed (mph)	Overall Time (min)	Delay Time (min)
	Drumm Dr					
		Morning Peak	30	11.1	0.7	0.4
Franklin Rd	1 [b]	Off Peak	30	26.0	0.3	
(0.13 mile)		Evening Peak	30	26.0	0.3	0.0
	Aultman Ave					
	Coleman Cir					
		Morning Peak	30	22.0	0.6	0.1
Aultman Ave	2	Off Peak	30	26.4	0.5	
(0.22 mile)		Evening Peak	30	12.0	1.1	0.6
	Greene Rd					
	Pendleton Pike					
		Morning Peak	30	28.2	1.0	0.1
Greene Rd	3	Off Peak	30	31.3	0.9	
(0.47 mile)		Evening Peak	30	14.1	2.0	1.1
	Hebert Lord Rd					
	Aultman Ave					
		Morning Peak	30	20.0	0.3	-0.1[c]
Greene Rd	4	Off Peak	30	15.0	0.4	
(0.10 mile)		Evening Peak	30	8.0	0.8	0.4
	Otis Ave					

[a] Morning- and evening-peak speed and delay runs were made in the direction of maximum traffic flow.
[b] Numbers encircled are segments of routes and correspond to those shown in Figure 8.
[c] Peak-hour travel time faster than off-peak travel time.

Figure 30. Typical table of roadway segments with significant delay.

$$\text{Overall travel speed (mph)} = \frac{\text{Distance (ft)}}{\text{Travel time (min)} \times 88}$$

$$\text{Running speed (mph)} = \frac{\text{Distance (ft)}}{\text{Running time (min)} \times 88}$$

61. Interpretation. For every automobile trip, there exists a desirable travel time including a minimum number of delays. Details are provided below:

a. Travel time. A comparison should be made between both the peak- and off-peak-travel periods for the same roadways. On most roads, as traffic volumes increase, average speeds decrease and travel times increase. A significant increase in segment travel time is considered to have occurred if the peak-period-travel time is more than twice the off-peak-travel time. On very short segments, such as one or two blocks, a delay of 0.5 minute is considered to be significant.

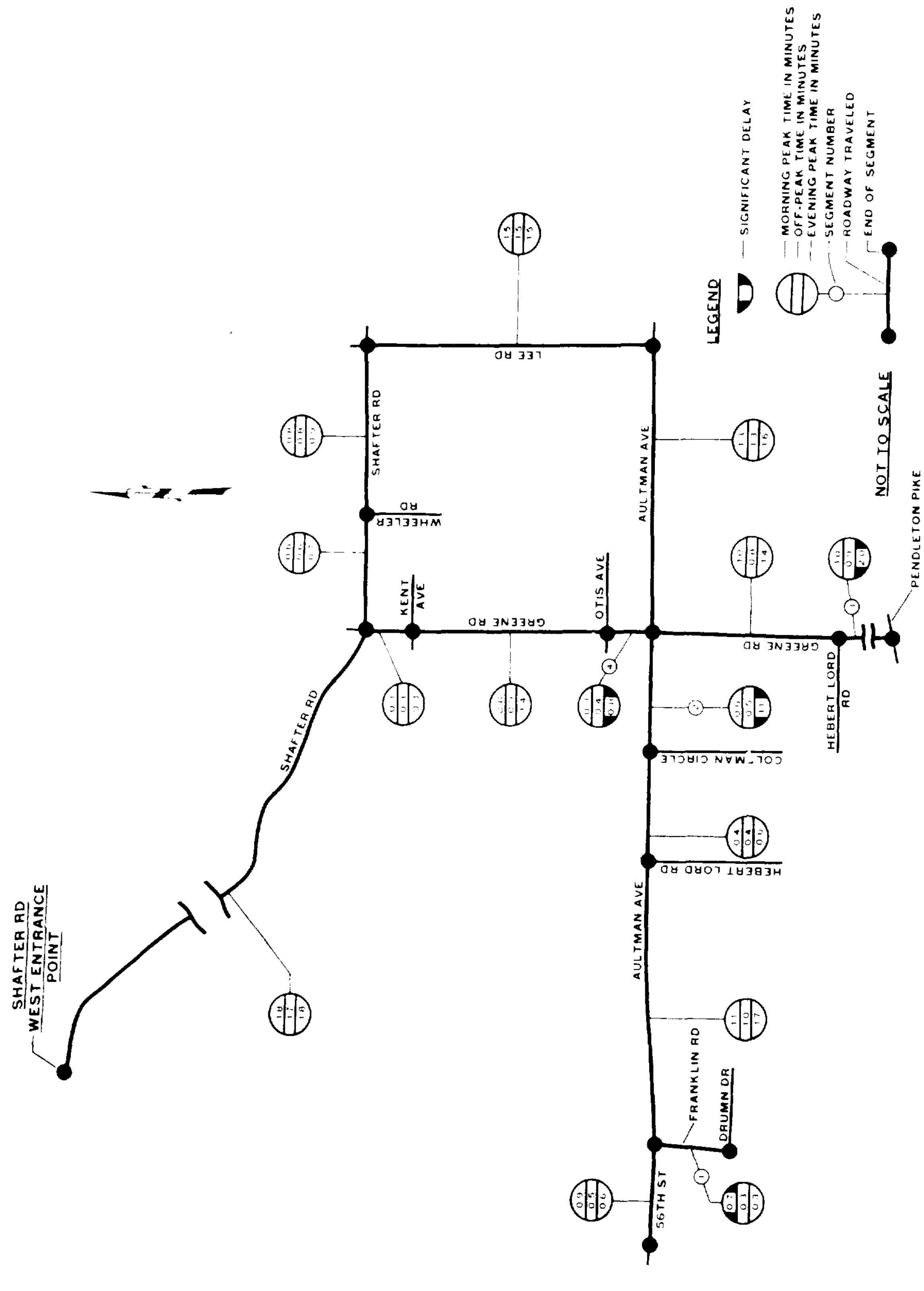


Figure 31. Typical speed and delay map.

b. Delays. The number (frequency) of delays along a route indicate the frustration a driver experiences during his trip. Delays cost the driver money, both in terms of the value of his own time and in terms of gas and oil expended while going nowhere. It is thus desirable to minimize delays. When significant delays have been encountered during the travel-time and delay study, it will be necessary to revisit the scene of the delay and to study the causes in detail.

62. Application. If the data from the study show that resultant delays are few, and that peak-hour-travel times are approximately the same as off-peak times, then no further action is necessary.

a. Travel-time standards. From experience it has been found that it is possible to establish standards for travel time and running speed. The suggested standards shown in table 9 represent a goal toward which the installation should aspire. Of course, special speed restrictions, such as for schools, should be considered in the overall evaluation.

TABLE 9
SUGGESTED MINIMUM DESIRABLE
OVERALL TRAVEL SPEEDS (MPH)

Road Class	Off Peak	Peak Hour
Arterial (primary)	30-45	25-35
Collector (secondary)	25-35	20-25
Local (tertiary)	15-25	10-20

b. Delays. When excessive delays exist and the causes have been determined, the following actions should be considered.

(1) Traffic signals. Recalculate the signal timing. Check the warrants for traffic signals contained in the Manual on Uniform Traffic Control Devices for Streets and Highways. Perhaps the signal is not warranted and should be removed. Consider the addition of a signal controller with settings for morning-, evening-, and off-peak-travel periods. Consider the use of traffic-actuated-signal controllers. Where there are several signals in short succession, consider synchronizing the system so that traffic may progress from one to another on a green band.

(2) Stop signs. When traffic is delayed by a STOP sign, several items must be considered. Recheck the warrants for a traffic signal; perhaps the STOP sign should be replaced. Determine if the sight distance along the cross-street is sufficient or whether sight is blocked by

parked cars, buildings, unnecessary signs, or shrubbery; then, remove the sight restriction. Check to see if the STOP sign is on the correct approach and is not stopping a major flow for the benefit of a smaller group.

(3) Turning movements. When delay is caused by left- or right-turning vehicles, consider prohibiting such turns. Consideration should also be given to adding separate turn lanes or separate traffic-signal-turning phases. Determine if the curb radius is adequate to facilitate right turns, particularly where there are numerous trucks and buses. When right turns into driveways are a problem, determine if the curb radius and curb-cut openings are sufficient, or if any other obstructions exist.

(4) Parking. When parking, unparking, or double-parking vehicles are obstructing traffic, parking prohibitions (NO PARKING signs) should be considered and they should be backed up by saturation enforcement and tow-away zones. Off-street parking lots should be established whenever curb parking inhibits traffic or wastes valuable pavement.

(5) Passenger loading. When traffic is delayed by cars stopping to load or unload passengers, consideration should be given to providing an off-road turnout lane. This could be supplemented by using NO PARKING signs along the road. The same could be done for problems involving school, troop, or commercial buses during peak hours.

(6) Pedestrians. The large volumes of pedestrian crossings obstruct traffic, consideration should be given to providing pedestrian overpasses or underpasses. If these are too expensive or are not warranted by pedestrian conflict with vehicle movements, then crosswalks could be established at either signalized or manually controlled intersections. Mid-block pedestrian crossing signals should be installed only when warranted and then should be synchronized with signals at nearby intersections. Troop movements can be rescheduled so they will not occur during peak hours, and off-road troop-movement trails can be created.

(7) Police control. When backups occur at police-controlled intersections, the actual need for such a control point should be checked. Consideration should be given to the use of a traffic signal where the traffic volumes warrant. Another item to check is whether the police officer is performing efficiently. He should be instructed always to favor the major flow and not to interrupt arterial traffic just to let one or two cars out of a side street or to make a left turn. Also, he should wait for several pedestrians to collect on the curb before stopping traffic for them.

(8) Railroad. Railroad crossings at high-volume roads should be identified by flashing red lights and automatic crossarms. Where traffic and train volumes are higher, grade separation should be considered. When spotting and siding operations block roadways during peak hours, these operations should be rescheduled to other times. Coordination with the railroad activity may be necessary.

(9) Inadequate capacity. All of the above problems limit roadway capacity. In addition, geometric and design features of the road itself may be responsible for delays (see part two, sec III). Roadway capacity is limited by inadequate pavement width (not enough lanes), lateral obstructions (phone poles, no shoulders, narrow bridges), narrow-radius curves without superelevation, steep grades (slow trucks), and finally, rough or broken pavement. Following a highway capacity study, these conditions may be remedied by major construction. Another cause of restricted capacity would be speed limits that have been set too low (part two, sec IX). As indicated in part two, sections IV and V, inadequate capacity during peak periods can most easily and economically be overcome by car pooling and on-installation duty-hour staggering. Before spending large sums of money to increase capacity and/or reduce time and delay requirements, consideration should be given to these two no- or low-cost programs.

c. Before/after studies. The results of roadway improvements can be demonstrated by comparing travel-time and delay runs that have been performed before and after the revision.

SECTION IX

SPOT-SPEED STUDIES

63. Purpose. Spot-speed studies determine typical traffic speeds at a given point on a roadway. The instantaneous speed at a specific checkpoint is called the spot speed. The results of a traffic speed study are often stated in terms of the average speed. The data may sometimes be presented as a plotted distribution curve of speeds for the collected sample. Speed information may be used: (1) for provision of posted speed limits; (2) to determine driver compliance with existing speed limits; (3) to determine the need for new traffic-control devices for regulation or warning; (4) to determine the relationship of speed at high-accident-frequency locations; and (5) to determine the effect of a road change by a before/after

study. As required by Highway Safety Program Manual Vol. 13 (part two, sec XIV), each installation shall have an ongoing program to reevaluate speed zones according to prevailing traffic speeds.

64. Information needed. The data needed are the instantaneous speed (in miles per hour) of each free-flowing vehicle that passes the checkpoint. Average-speed data may be categorized by the type of vehicle (cars, buses, or trucks) or by the ownership (civilian or military). The accuracy of the speed data will improve with the number of samples performed. A sample size of 100 is desirable, but never should the sample size be less than 50.

65. Method. The method used will vary with the installation depending on availability of equipment.

a. Where. By concealing the observer and his equipment from the driver to insure the accuracy of the measurements, traffic-speed data may be collected at any location where a speed problem is thought to exist. Usually data will be collected:

(1) At open areas on all major thoroughfares.

(2) At midblock street locations at least 200 feet from the nearest intersection.

(3) At points several hundred feet prior to congested areas such as intersections, shopping areas, schools, hospitals, or entrance gates.

(4) At points prior to dangerous situations such as curves, hills, or bridges.

b. When. As traffic volume increases, the average speed automatically decreases until eventually all vehicles are moving at the same speed in one long platoon. The purpose of a speed study is to measure the speed of free-flowing traffic. A vehicle is considered to be free flowing if the driver is free to choose his own travel speed, unhindered by other traffic. Thus, a speed measurement should be performed only for a randomly selected lone vehicle moving along a roadway. Free-flowing traffic is seldom observed during peak-travel periods. Sufficient time should be allowed to collect the desired sample size of 100 measurements. Observations should be taken during normal weather and traffic conditions.

c. Equipment. Listed in the following paragraphs are various types of techniques and equipment that can be used in obtaining spot-speed data. Trade names cited in this guide do not constitute an official indorsement or approval of the use of such commercial hardware or software.

(1) Radar. The single most desirable piece of equipment is the radar spot-speed meter. A typical radar device may be vehicle-mounted, tripod-mounted, or of the newer hand-held-gun type. A radar meter is the only device that measures the true spot speed of a vehicle. It operates at microwave frequency by determining the Doppler shift of the signal reflected from the vehicle. A suggested field data sheet suitable for use with a radar meter is presented in figure 32. The observer must be careful to collect accurate data. A radar speed meter may lock on either the fastest vehicle in a stream or on the largest vehicle in a stream and give undesired readings.

(2) Time-distance methods. All methods of this type involve the measurement of the time required for the subject vehicle to traverse a predetermined distance. A device named VASCAR (Visual Average Speed Computer and Recorder) is one of the most accurate and popular devices using the time-distance principle. VASCAR should be mounted in the survey car. It then times or measures the distance betwen two highway reference points. While the target car travels the same course, the operator switches the unit on and then off as the reference points are passed. The speed of the vehicle may be read directly from the VASCAR. Training is required to insure accuracy.

A simple manual system is sometimes useful for occasional spot-speed studies. It involves recording the time for the subject vehicle to travel between two marks on the pavement. The time is clocked manually by a stop watch, and the reading is recorded to the nearest one-fifth of a second. The speed, S, for the subject vehicle is given by:

$$S = \frac{D}{(1.47 \times T)}$$

where:

D = the distance (in feet) between pavement markings;
T = time (in seconds) to travel the distance.

The formula simplifies when D is a multiple of 88 feet. The suggested field-data sheet shown in figure 33 has been devised to provide S in miles per hour automatically when the distance is either 88 or 176 feet. In addition, if exactly 100 passenger-vehicle-speed samples are made, the subtotal for each speed grouping will read directly in percent.

SPEED STUDY FIELD SHEET USING RADAR/SPEED GUN

LOCATION ASH ST DIRECTION NORTHBOUND

DATE 30 JULY 1975 TIME 1015 TO 1115 POSTED SPEED LIMIT 25 MPH

ROAD SURFACE DRY WEATHER FAIR OBSERVER J.W. JONES

SPEED (MPH)	VEHICLE COUNT	NO.	% OF TOTAL	CUM %	SPEED (MPH)	VEHICLE COUNT	NO.	% OF TOTAL	CUM %
21	|	1	1.0	1.0					
22	||	2	2.0	3.0					
23	||	2	2.0	5.0					
24	卌 |	6	6.0	11.0					
25	||||	4	4.0	15.0					
26	||||	4	4.0	19.0					
27	卌 |||	8	8.0	27.0					
28	卌 卌 |||	13	13.0	40.0					
29	|||	3	3.0	43.0					
30	卌 卌 卌 |	16	16.0	59.0					
31	卌 |||	8	8.0	67.0					
32	卌 ||||	9	9.0	76.0					
33	卌 |||	8	8.0	84.0					
34	||	2	2.0	86.0					
35	卌 ||	7	7.0	93.0					
36	|||	3	3.0	96.0					
37	|	1	1.0	97.0					
38		0	0.0	97.0					
39	||	2	2.0	99.0					
40	|	1	1.0	100.0					
	SUBTOTAL	100				SUBTOTAL			
						TOTAL			

SAMPLE

10 MPH PACE 26 TO 35 85 PERCENTILE SPEED 33.5 MPH AVERAGE SPEED 29.8 MPH

Figure 32. Typical speed study field sheet using radar/speed gun.

SPEED STUDY FIELD SHEET USING MEASURED DISTANCES

LOCATION Oak St. DIRECTION East/West

DATE 8 May 1975 TIME 0900 TO 0930 POSTED SPEED LIMIT 35 MPH

ROAD SURFACE Dry WEATHER Fair OBSERVER J. D. Brown

TIME (SEC.)	MPH FOR 88 FT.	MPH FOR 176 FT	CAR COUNT	NO.	PCT OF TOTAL	CUM PCT	TRUCK AND BUS COUNT	NO.	PCT OF TOTAL	CUM PCT
1	60.0	120.0								
1-1/5	50.0	100.0								
1-2/5	42.8	85.7	卌 卌 卌 I	16	11.9	100.0				
1-3/5	37.5	75.5	卌 卌 卌 卌 卌 IIII	29	21.5	88.1				
1-4/5	33.3	66.6	卌 卌 卌 卌 卌 III	28	20.7	66.6				
2	30.0	60.0	卌 卌 卌 卌 卌 卌 卌	35	25.9	45.9				
2-1/5	27.2	54.5	卌 卌 III	13	9.6	20.0				
2-2/5	25.0	50.0	卌 II	7	5.2	10.4				
2-3/5	23.0	46.1	卌 I	6	4.5	5.2				
2-4/5	21.4	42.8	I	1	0.7	0.7				
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	28.4								
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								
TOTAL				135						

10 MPH PACE 28 mph TO 37 mph 85 PERCENTILE SPEED 37 MPH

AVERAGE SPEED 33 MPH

Figure 33. Typical speed study field sheet using measured distance.

An L-shaped mirror box, the Enoscope, may be useful to obtain a perpendicular view across the street. The perpendicular view eliminates the parallel error that is inherent in determining the exact time the vehicle crosses a pavement reference point. The observer is separated from the Enoscope by a measured distance. As a vehicle passes the Enoscope, the observer starts the timer. When the vehicle passes the reference line in front of the observer, the timer is stopped.

A spot-speed measurement may also be made using an electronic meter (whammy) connected with two pneumatic road tubes, which have been placed a known distance apart. This device is somewhat obsolete.

d. Accuracy. Accuracy will depend on the calibration of the equipment and on the skill of the operator. Radar is the most accurate, typically having an error less than 1.0 mph. VASCAR normally has an error less than 2.0 mph. The accuracy of the calculated average speed will improve as the size of the sample increases.

66. Analysis. Analysis will usually consist of determining the average speed, the 85-percentile speed (critical speed), the pace speed, the possibly the standard deviation if statistical measures are to be applied. A speed-distribution curve also may be plotted. These terms are defined as:

a. Average speed. The mean, or average, speed is calculated by adding each of the individual speed observations, S, and dividing by the total number of observations, N.

$$S\ Avg = \frac{\text{Sum of S's}}{N}$$

Such an average is called the time-mean-speed. However, the average of those readings taken by the time-distance method is called the space-mean-speed. Time-mean-speed should not be directly compared with space-mean-speed, since the two represent different quantities. However, for most practical purposes of spot-speed studies, the difference is insignificant. The average speed is useful for making comparisons between several sets of data, such as before/after studies; for example, "The average speed observed on Maple Street north of 1st Street increased from 31 miles per hour in 1965 to 37 miles per hour in 1975".

b. 85-percentile speed. This is the speed at or below which 85 percent of the drivers travel. Restated, only 15 percent of the drivers travel faster than the 85-percentile speed. Accident studies have shown that the typical driver is a relatively good judge of what constitutes a safe operating speed. Accordingly, the 85-percentile speed is often used to establish a realistic speed limit. To determine this value, list the speed observations in order of increasing speed. Next, determine a key number by multiplying the number of observations, N, by 0.85. Count up the list of observations until the vehicle having the key number is reached. The observation for that vehicle is the 85-percentile speed. For example, if 100 observations were made, the 85-percentile speed is that of the 85th vehicle.

c. Pace speed. The pace is that 10-mile-per-hour range that contains the greatest number of vehicles. The percentage of vehicles within the pace is a measure of the spread of the speed data. For example, speed data having 80 percent of the observations falling within the pace have less spread than data having only 40 percent in the pace.

d. Standard deviation. This is a statistical parameter and is a measure of the spread (variation) of the sample data. A higher standard deviation indicates a larger spread of data about the sample mean. The calculation of the standard deviation is not usually part of a speed zoning study, but may be used in before/after comparisons.

67. Interpretation.

a. The spot-speed data should be totaled and the numerical average speed computed, as previously discussed. If statistical comparisons of speed data are to be made, the standard deviation should be calculated.

b. A speed-accumulation curve may be plotted by starting at the lowest speed grouping and consecutively adding each higher speed group (one after another) to produce a cumulative count. Next, calculate the percentage for each number by dividing by the number of observations, N. These values are then plotted, and a smooth curve is drawn through the points as shown in figure 34. In that illustration, the pace is approximately 30 to 40 miles per hour.

c. Several indications may be found on the speed-accumulation curve. Some curves are fairly vertical in appearance, while others appear to be more horizontal. The more vertical curve usually shows better driving conditions than the gently sloping curve and indicates that most traffic is traveling at nearly the same speed. A reduction in the spread of speed data is one of the primary goals of speed zoning. Effective speed

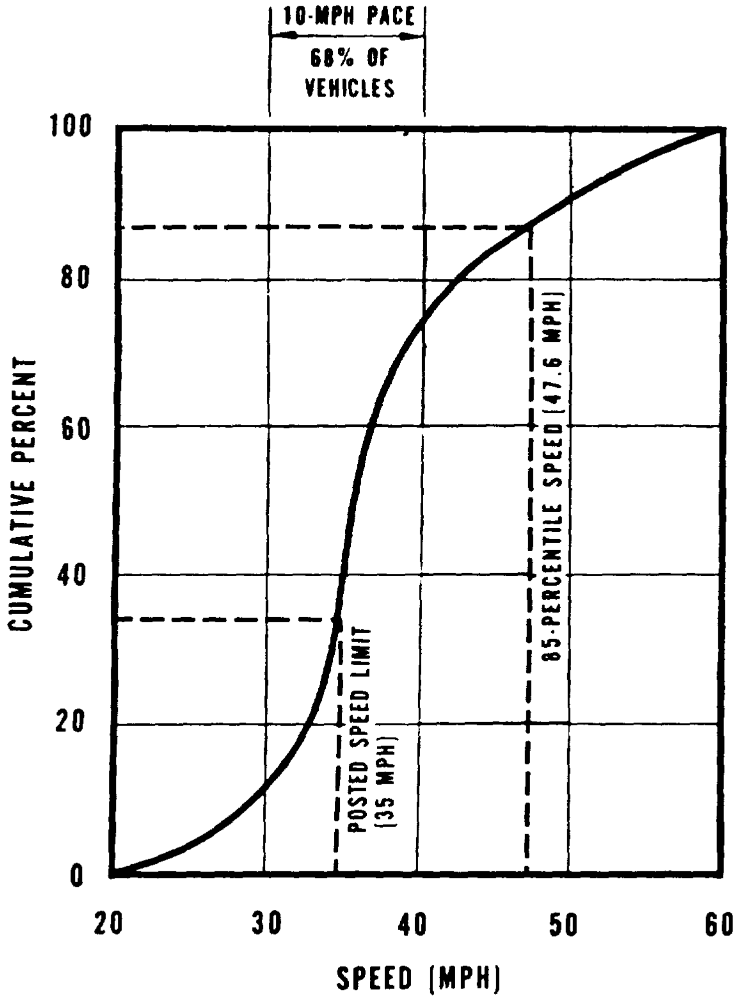


Figure 34. Typical speed-accumulation curve.

zoning will automatically make roadways safer, since it is speed differential and not speed alone that is a principal cause of traffic accidents.

d. Proper speed zoning will reduce the speed of the faster vehicles and will tend to increase the speed of the slower. From the speed-accumulation curve, determine the 85-percentile speed. The speed limit should usually be set at the 5-mile-per-hour increment closest to this value. However, it is necessary to consider other conditions such as traffic volumes, accident experience, and type of roadside development when selecting the exact value. The format of speed-limit signs must comply with the Manual on Uniform Traffic Control Devices for Streets and Highways.

68. Application. Listed below are several typical applications for spot-speed studies.

a. Speed zones. Each speed-zoning problem should be considered separately. For example, speeds higher than the posted limit may indicate the need for greater enforcement if they occur in a congested area. However, out on an open boulevard, an 85-percentile speed more than 5 miles per hour higher than the posted limit may indicate an unrealistically low posted speed limit. Increments of 5 miles per hour should be used on the sign. Each installation shall have an ongoing program to reevaluate speed zones according to prevailing needs.

b. Signs. An informational or warning sign must be legible to the driver. Typical vehicle speeds may be used to design effective signs by allowing choice of the proper size letters for the sign, and by permitting placement of the sign far enough in advance so that the driver can take action. In general, with higher speeds, larger signs are required and should be mounted at greater advance distances.

c. Approach speeds. The average, free-stream road speed is used to determine the proper clearance interval (yellow plus all red) for signalized intersections. Speed is also a factor in determing the warrants for a new traffic signal.

d. Before/after. The before/after spot-speed study is used to determine what effects (if any) recent changes to the road environment may have had on typical speeds. For example, a before/after spot-speed study may be used to show the results of road improvements such as widening a dangerous bridge. The study may indicate whether newly placed Hazard Warning signs are having any effect on driver behavior, or will show the effect of a newly revised speed zone.

SECTION X

ORIGIN AND DESTINATION STUDIES

69. Purpose. Origin and destination studies determine the travel desires of the population in and around the military installation. Every trip is considered to have a point of origin and a destination. The results of an origin and destination (O-D) study may be grouped to determine travel desires according to trip purpose and preferred transportation mode. O-D information may be used: (1) for all master planning decisions; (2) to

determine the optimum location for new highway routes; (3) to determine the location and size of bridges, entrance gates, and parking lots; and (4) to design mass transit facilities.

70. Information needed. Data vary with O-D method used. The O-D study will always need the point of origin, the point of destination, and the travel mode (vehicle type). Some study methods may also require the trip purpose (work or shopping), the number of persons in each vehicle, the route chosen, the time of trip, and the parking facility used. Some questionnaires may require the person to supply certain socioeconomic data such as the number of vehicles he owns, his employment status (civilian, military, or retired), his wage or service grade, and his residence type (BOQ, post housing, or private dwelling). It may be necessary to use several types of O-D methods to gather complete travel information.

71. Methods.

a. Type. These will vary with the type of O-D survey used. The methods most applicable to military installations are as follows:

(1) The O-D personnel questionnaire.

(2) The interview survey.

(3) The license-plate survey.

(4) The tag-on-vehicle method.

b. Design. An O-D survey is not to be undertaken without careful consideration of the time and manpower required. If a survey is justified, the proper type of method must be selected. This decision should be based on the way in which the data will be used. For example, if the traffic flow at one point in the street network is needed, a simple turning-movement count (see part two, sec I) will suffice. On the other hand, a personnel questionnaire should be considered when it is necessary to predict the effects of closing an entrance gate.

c. Zones. The O-D survey should begin by carefully establishing and numbering zones on and around the installation. The purpose of zoning is to permit summarizing travel patterns into suitable small local areas. It is assumed that all trips having an origin or destination (trip end) within the boundaries of a particular zone occur from the centroid of that zone. Several pointers for establishing zones are:

(1) Design the zoning small enough to discern travel patterns. For example, if 4,000 trips are destined for a training area, it may be desirable to split the area into several zones. The more densely an area is settled, the more zones will be needed.

(2) Do not establish too many zones; they just increase the complexity of the data reduction, without providing any new knowledge. If less than 5 percent of the total trips are bound for many of the zones, then too many have been made.

(3) Establish zone boundaries along natural or recognizable barriers such as railroad tracks or rivers.

(4) Establish boundaries so as to group similar land-use activities. Be logical. For example, perhaps a suitable boundary can be found to include all of the directorate of industrial operations in one zone.

(5) Establish separate zones for heavy traffic generators. For example, one zone could be used to hold both the PX and the commissary, and another zone used for the large hospital.

(6) Use established zones. For example, the surrounding community may be zoned by using ZIP codes or township lines, or the installation could be zoned using building numbers, block numbers, or zones established by a previous traffic engineering study.

(7) Develop external zones to include the major portion of the off-installation working population. This can usually be accomplished by zoning an area within a 25-mile radius of the installation. Zones outside the radius should have infinite boundaries. For example, let one zone include all other areas to the north and establish similar zones for other directions.

d. <u>Method 1: The O-D personnel questionnaire</u>.

(1) On a military installation, this questionnaire is distributed to each person (military, civilian, and contractor) having a duty station on the installation. A distribution and collection system must be devised to make sure every organization receives a supply of questionnaires. The questionnaire collection system must include a tally of the filled-in questionnaires received, which should then be compared with the authorized strength of each organization. Any differences should be corrected at that time. Ideally, the questionnaires should be filled in by all personnel on the very same day and should be collected as soon as possible thereafter.

The week of the questionnaire distribution should be a typical work week with all organizations operating near strength. This would exclude periods containing a holiday, a training-school vacation, special maneuvers, or periods when the fleet is at sea. The typical midweek days normally are the best times to conduct such a survey.

(2) The O-D personnel questionnaire must be carefully prepared; it must be very easy for the workers to read and understand; and it must be in a format for the data to be quickly processed. Because of the large amount of data collected, it is desirable to use the computer automatic data processing system (ADPS). However, it is also possible to process the data manually at small installations (less than 5,000 employees) if the number of questions are held to a minimum. If manually processed, the number of questions and the number of travel zones should be limited to about 10 or less to reduce the man-hours required to collate the data.

(3) A sample questionnaire designed for manual processing is shown in figure 35, with the accompanying zone map in figure 36. The questionnaires are processed to usable data by using a sample tally sheet (or several workers could use identical tally sheets, which would later be combined). Simple tables may be created by a straight-answer count. For example, the response to Q1 may be counted, which will provide the number of people who drove, rode, walked, and so forth. More complicated tables may be created by using a tally sheet similar to figure 37. Each table will contain the results of two questions. The person performing the tabulation will inspect each questionnaire for its reply to the two questions and will place a tally mark in the appropriate box on the data sheet.

(4) When automatic data processing (ADP) tabulation is used, it is feasible for the questionnaire to contain several more questions and to provide more answer choices to each. An example of such a questionnaire is shown in figure 38. Care must still be used when devising the questions. For example, if the question involves off-installation live-zone numbers, a provision must be made for those who live on the installation. For faster keypunching, the questionnaire should be limited to one side of the printed page; the zone map may be printed on the other side.

e. <u>Method 2: The O-D interview survey</u>.

(1) Various names are used to describe interview surveys, depending upon where the interview is made. For example, the interview could be made at roadside, at heavy traffic generators (such as PX,

FORT BENJAMIN HARRISON -- TRAFFIC STUDY QUESTIONNAIRE (PLEASE DO NOT FOLD)

Circle the number corresponding to the statement which is the most correct answer. Circle only one answer for each question. If you are unable to complete this questionnaire, contact your supervisor for assistance.

PART A - ALL PERSONNEL

Q1. How did you get to work today?

01. Drove Car	04. Commercial Bus
02. Drove Motorcycle	05. Military Bus
03. Car Passenger	06. Walked/Bicycle
	07. Taxi

Q2. Where do you work? (See map on reverse side). Circle below the zone in which you report to work.

01. Zone A	04. Zone D	07. Zone G
02. Zone B	05. Zone E	08. Zone H
03. Zone C	06. Zone F	

For Questions 3 and 4 indicate your duty hours today using the 24-hour time system. (e.g., start at 0730, end at 1600)

Q3. What time did you start duty today?

Q4. What time will you end duty today?

PART B - DRIVERS ONLY
(Answer this section only if you DROVE TODAY)

Q5. Drivers Only. What entrance gate did you use to enter the post on your way to work today?

01. None, I Live on Post	04. Lee Road Gate (northeast gate)
02. Main Gate (south gate, post Rd)	05. Fall Creek Road Gate (Shafter Rd)
03. 59th Street Gate (east gate)	06. 56th Street Gate (Aultman Ave)

Q6. Drivers Only. Check the zone map again, please, and indicate the area in which you parked your car at the beginning of this work day.

01. Zone A	04. Zone D	07. Zone G
02. Zone B	05. Zone E	08. Zone H
03. Zone C	06. Zone F	

Q7. Drivers Only. How many people rode to work in your car today? (Include yourself)

01. One	03. Three	05. Five
02. Two	04. Four	06. Six or more

PLEASE RETURN THIS QUESTIONNAIRE TO YOUR SUPERVISOR TODAY

Figure 35. Typical sample origin and destination questionnaire (manual processing).

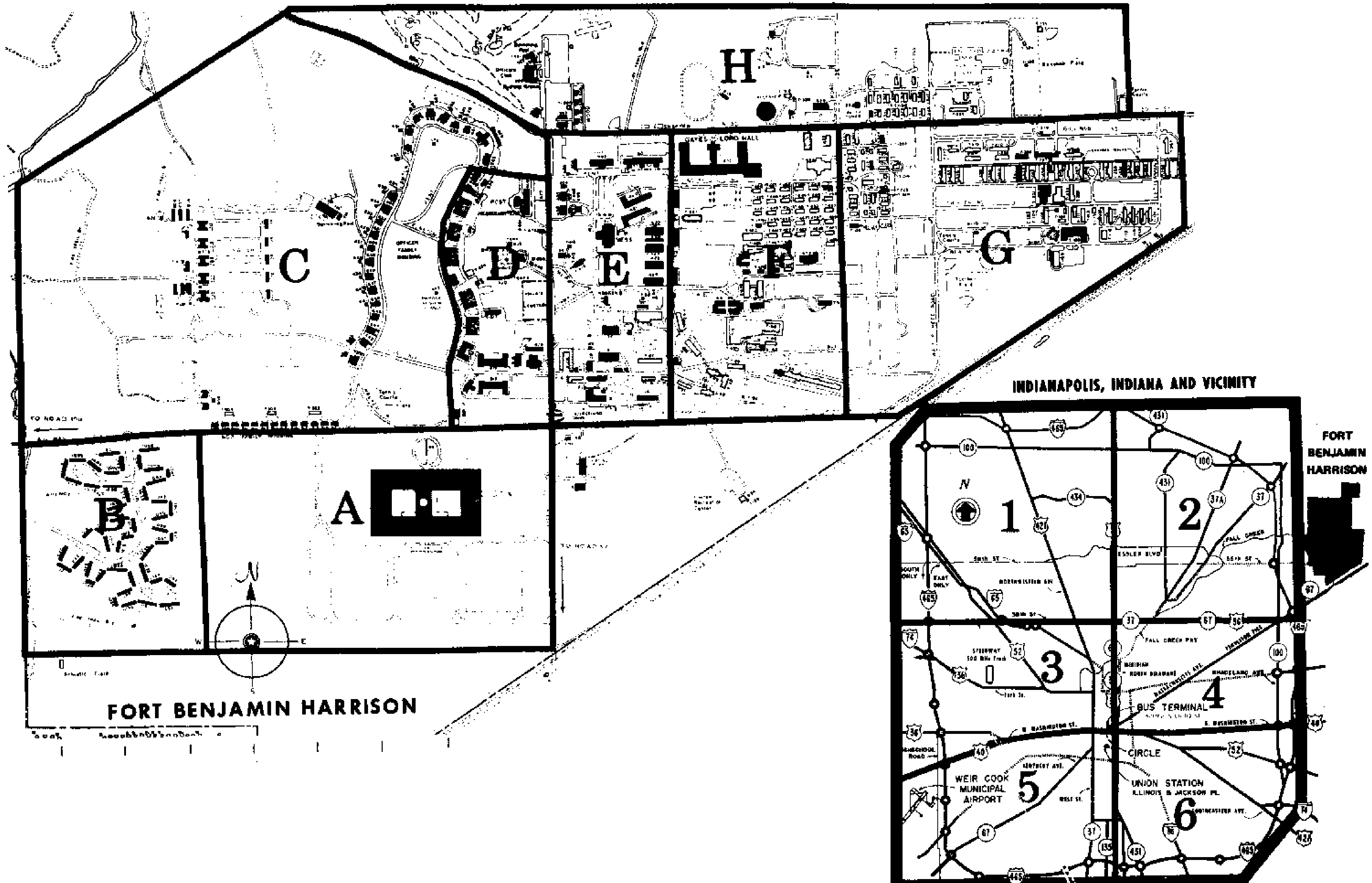


Figure 36. Typical zone map.

ORIGIN AND DESTINATION STUDY MANUAL TABULATION SHEET

INSTALLATION NAME Ft Buttle

DATE July 22, 1975

QUESTION NO. IV TITLE Live Zone

QUESTION NO. III TITLE Work Zone

ANSWER NO.	01	02	03	04	05	06	07	08
01	2	8		4		4	5	2
02	4	3		13		2	2	3
03	5	14		8		11	10	7
04						5	2	
05	30	20	27	30		47	40	42
06	10		3	20		15	17	10
07	20	7	10	40		28	2	12
08		2	2	5		8	6	
09								

SAMPLE

Figure 37. Typical origin and destination study manual tabulation sheet.

FORT BENJAMIN HARRISON TRAFFIC STUDY
EMPLOYEE SURVEY QUESTIONNAIRE

(PLEASE DO NOT FOLD)

Do not write in space below

Your cooperation in this survey will aid in improving traffic conditions on this post. If you drove a vehicle to work today, please answer all questions. If you were a car passenger, walked, came by public transit, or came by any other means, answer only Part A.

Circle the number corresponding to the statement which is the most correct answer. Circle only one answer for each question. If you are unable to complete this questionnaire, contact your supervisor for assistance.

Column

PART A – All Personnel

1–2 I. What is your personnel status?

01. Officer 02. Enlisted 03. Civilian

3–4 II. What is your employing organization? Circle only one. If your organization is not listed, indicate the organization with which you are most closely associated.

01.	HQ, FBH	11.	AGPERSCEN	21.	AAA
02.	MEDDAC	12.	RCPC	22.	TNG AIDS
03.	USAAGS	13.	SR. ADV. USAR	23.	PIA
04.	USAFS (FINANCE SCHOOL)	14.	VFIS	24.	OMAHA DIST. CORPS ENG
05.	226th MP	15.	DINFOS	25.	SUPPLY DET
06.	74th AB	16.	5th MP	26.	36th ENG
07.	64th ORD DET	17.	DEF CONTR ADMIN	27.	MED HOLD DET
08.	FCUSA (FINANCE CENTER)	18.	DCAA	28.	BANK, CREDIT UNION
09.	EEC	19.	5A AMEDS	29.	PX, COMMISSARY
10.	PASA	20.	GAO	30.	OTHER

5–6 III. Where do you work? (See map on reverse side). Circle below the zone in which you report to work.

01. ZONE A 03. ZONE C 05. ZONE E 07. ZONE G
02. ZONE B 04. ZONE D 06. ZONE F 08. ZONE H

Indicate the building number at which you primarily work ______________________.

7–8 IV. Where do you live? If you live on post see map on reverse side. Circle below the zone in which you live.

01. ZONE A 03. ZONE C 05. ZONE E 07. ZONE G
02. ZONE B 04. ZONE D 06. ZONE F 08. ZONE H

If you live off post check the list below and circle the number corresponding to the area of your residence. If your residential area is not listed, circle the number corresponding to the city or town nearest your residence.

06. Indianapolis – Zone 1
07. " – Zone 2
08. " – Zone 3
09. " – Zone 4
10. " – Zone 5
11. " – Zone 6

12.	Noblesville	19.	Greenfield	26.	Danville
13.	Lebanon	20.	Rushville	27.	Brownsburg
14.	Anderson	21.	Shelbyville	28.	Crawfordsville
15.	Pendleton	22.	Franklin	29.	Lawrence
16.	New Castle	23.	Bloomington	30.	Carmel
17.	Kokomo	24.	Mooresville	31.	Lafayette
18.	Richmond	25.	Terre Haute	32.	Oaklandon

For Questions V. and VI., indicate your duty hours today using the 24-hour time system (e.g., start work at 0700 and end at 1530).

9–12 V. I start work at ______________

13–16 VI. I end work at ______________

17–18 VII. How did you get to work today?

01. Drove Car 03. Commercial Bus 05. Cycle
02. Car Passenger 04. Military Bus 06. Walked

PART B – Drivers Only
(Answer this section only if you drove today)

19–20 VIII. Drivers Only. What off post approach road or roads did you use for coming to work today? *(Please read carefully)*

01. None – Live on Post
02. Shafter Road via 82nd St. and Route 100
03. Shafter Road via Indiana 37 from NE and Route 100
04. Shafter Road via Route 100 from South
05. Shafter Road via Fall Creek Road from NE
06. Shafter Road via Fall Creek Road from SW
07. 56th Street via 82nd Street and Route 100
08. 56th Street via Indiana 37 from NE and Route 100
09. 56th Street via Route 100 from South
10. 56th Street via Interstate 465 from North
11. 56th Street via Interstate 465 from South
12. 56th Street from West
13. Post Road from South
14. Post Road via Pendleton Pike from NE
15. Post Road via Pendleton Pike from SW
16. 59th Street via Pendleton Pike from NE
17. 59th Street via Pendleton Pike from SW
18. 59th Street via Sunnyside Road
19. Lee Road via 63rd Street

21–22 IX. Drivers Only. What entrance gate did you use to enter the post on your way to work today?

01. None – Live on Post 04. Lee Road Gate (northeast gate)
02. Main Gate (south gate, Post Rd) 05. Fall Creek Road Gate (Shafter Rd)
03. 59th Street Gate (east gate) 06. 56th Street Gate (Aultman Ave)

23–24 X. Drivers Only. What exit gate do you normally use to exit the post at the end of your working day?

01. None – Live on Post 04. Lee Road Gate (northeast gate)
02. Main Gate (south gate, Post Rd) 05. Fall Creek Road Gate (Shafter Rd)
03. 59th Street Gate (east gate) 06. 56th Street Gate (Aultman Ave)

25–26 XI. Drivers Only. Check the zone map again, please, and indicate the area in which you parked your car at the beginning of this work day.

01. ZONE A 03. ZONE C 05. ZONE E 07. ZONE G
02. ZONE B 04. ZONE D 06. ZONE F 08. ZONE H

27–28 XII. Drivers Only. What area do you work in? This is the same area as answered in Question III. Circle below the area in which you work.

01. ZONE A 03. ZONE C 05. ZONE E 07. ZONE G
02. ZONE B 04. ZONE D 06. ZONE F 08. ZONE H

29–30 XIII. Drivers Only. How many people rode to work in your car today? (Include yourself.)

01. 1 03. 3 05. 5 07. 7
02. 2 04. 4 06. 6 08. 8 or more

Figure 38. Typical origin and destination questionnaire (computer processing).

commissary, or hospital), at bus stations, in parking lots to survey arrivals, or even in the home. The advantages of the interview survey are flexibility of the questions and the presence of the interviewer to aid in interpreting questions and maps.

(2) At the interview location, a large official-looking sign should announce the nature of the study. Typical questions asked or observed by the interviewer involve:

(a) Where the subject has come from.

(b) Where he is bound.

(c) His mode of transportation.

(d) The number of persons traveling with him.

(e) The purpose of the trip.

(f) The duration of his stopover at that location.

(g) Where he parks.

With the aid of the interviewer, it is also possible to compile a complete list of the trips each person made that day. A typical suggested form used to collect the data is shown in figure 39.

(3) A roadside interview involves the hazards of dealing with moving traffic. Special precautions must be taken to prevent accidents between vehicles, to safeguard the interviewers, and to prevent traffic jams. You will be responsible for any mishaps. Measures that may be taken include warning signs prior to a stopping point, flares and signal flags, informatory signs, day-glow safety vests for interviewing personnel, a police car parked on the road shoulder with lights flashing, and the presence of a police officer to provide legal authority.

(4) Adequate personnel must be used to obtain a sufficient sample of traffic without causing a traffic jam. Normally, four interviewers and one vehicle recorder per lane will suffice. When traffic volumes are heavy (such as during peak hours), it will be necessary to take a representative sample of the total. A percentage sample should be chosen in advance and adhered to. The results for the sample may be multiplied by a suitable factor to bring them up to 100 percent. To obtain a 25-percent sample, the survey should interview 4 drivers and wave on the next 12.

ORIGIN AND DESTINATION INTERVIEW FIELD SHEET

LOCATION Elm Ave DESTINATION ZONE 3

DATE 7/22/75 TIME 1000 TO 1015

TIME (MILITARY TIME UPDATED EVERY 5 MINUTES)	TRIP PURPOSE (SHOP, BUSINESS, WORK, MEDICAL, OTHER)	NO. OF OCCUPANTS INCLUDING DRIVER	ORIGIN ZONE	STAY TIME (MINUTES)	NEXT ZONE
1000	PX	2	4	30	6
	Bank	1	4	15	4
	Bank	3	4	20	8
	Barber	2	3	30	4
	Florist	1	3	10	5
	Commissary	1	4	60	3
1005	PX	3	4	30	8
	Commissary	1	3	60	4
	Theater	3	5	60	5
	Cleaners	1	4	10	7
	Bank	2	3	15	4
	Commissary	1	4	60	5
	Shoe Repair	2	3	15	4
	PX	2	4	30	5
	Bank	3	8	10	4
	Theater	4	5	60	4
1010	PX	3	4	30	3
	Commissary	2	4	60	4
	Bank	2	5	10	4
	Cleaners	1	5	10	1
1015	PX	2	4	15	4

SAMPLE

Figure 39. Typical origin and destination interview field sheet.

To obtain a 50-percent sample, interview four and wave on the next four. Roadside interviews are generally conducted at a point such as a bridge, an entrance gate, or even municipal boundary lines.

f. Method 3: The license-plate survey.

(1) Basically, this consists of recording vehicle license numbers at several locations and then matching up the written lists later to determine who went where. This method is actually a variety of the tag-on-vehicle survey, but here the vehicles supply their own tag--their license plate. The license-plate survey (LPS) is well-suited to computer analysis. A form used to collect the necessary data is shown in figure 40. The first (or last) three or four digits (alpha or numeric) of the license number are recorded, as are time, vehicle type, gate number, and whether the vehicle was inbound or outbound. A time span must be allowed for the vehicle to travel from one checkpoint (gate) to another. Vehicles falling outside the permissible time span are not counted as a matched license. Also the vehicle types must correspond. These two conditions will eliminate some of the random matches of license numbers that occur.

(2) One advantage of the license-plate survey over the roadside interview is that the traffic being surveyed is never stopped, and therefore this method can be used on roads having high traffic volumes, or where stopping vehicles would be hazardous. However, it is necessary to have adequate personnel to read and record the license numbers. For each lane of continuous traffic flow, one worker can call out the last three digits of the license number while the other writes it down. No one worker should attempt to record both inbound and outbound vehicles simultaneously. A dry run should be attempted first to determine that data collection at a particular location is feasible.

(3) The license-plate survey, if taken at the gates, can be used to determine the amount of traffic passing through the installation. An estimate of through traffic is useful on installations located on a major artery, or those installations open to public traffic. Survey checkpoints can be set up at entrance and exit gates, or at other natural boundaris. A preferred location for a checkpoint would be where traffic speeds were low enough to permit reading the license plate easily; for example, at a STOP sign or at the approach to a traffic signal.

g. Method 4: Tag-on-vehicle survey.

(1) For this method, a precoded identification tag is placed on each vehicle entering the study area and is retrieved as it leaves. A

LICENSE PLATE SURVEY FIELD SHEET

LOCATION Gate 1 (Main Gate) DATE July 22, 1975

TIME 0700 TO 0800 OBSERVER L. R. Smith

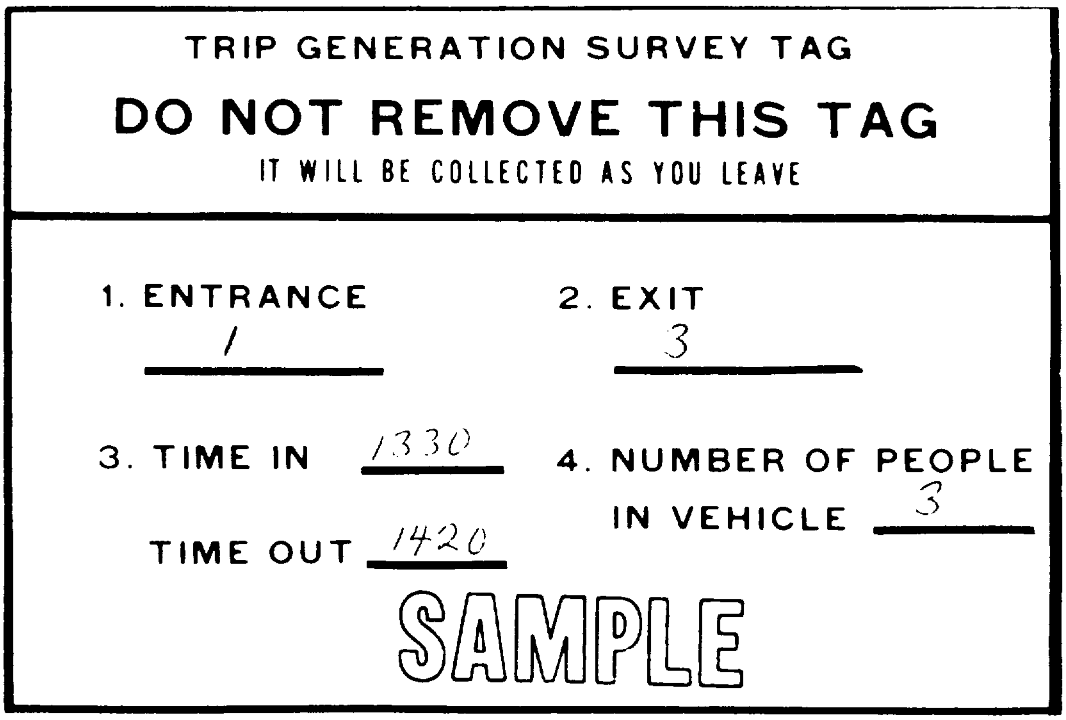
GATE NO.		IN = 1 OR OUT = 2	TIME (MILITARY)				VEHICLE TYPE		LICENSE NUMBER			
1	2	3	4	5	6	7	8	9	10	11	12	13
Ø	1	1	Ø	7	Ø	Ø	Ø	1	A	4	7	5
Ø	1	2	Ø	7	Ø	Ø	Ø	1	X	3	8	5
Ø	1	2	Ø	7	Ø	5	Ø	3	T	4	4	4
Ø	1	1	Ø	7	Ø	5	Ø	2	X	3	4	1
Ø	1	1	Ø	7	Ø	5	Ø	1	Y	2	2	6
Ø	1	1	Ø	7	Ø	5	Ø	1	B	5	1	Ø
Ø	1	1	Ø	7	Ø	5	Ø	1	Z	8	5	Ø
Ø	1	1	Ø	7	Ø	5	Ø	3	1	Ø	2	4
Ø	1	2	Ø	7	Ø	5	Ø	1	Z	7	5	Ø
Ø	1	2	Ø	7	Ø	5	Ø	1	A	8	5	Ø
Ø	1	2	Ø	7	Ø	5	Ø	1	A	7	8	Ø
Ø	1	1	Ø	7	Ø	5	Ø	1	T	5	2	5
Ø	1	1	Ø	7	Ø	5	Ø	1	T	Ø	5	Ø
Ø	1	1	Ø	7	Ø	5	Ø	1	B	7	7	6
Ø	1	1	Ø	7	Ø	5	Ø	1	R	7	2	8
Ø	1	1	Ø	7	Ø	5	Ø	1	U	2	6	6
Ø	1	1	Ø	7	Ø	5	Ø	1	D	1	2	9
Ø	1	2	Ø	7	1	Ø	Ø	1	R	9	7	1
Ø	1	2	Ø	7	1	Ø	Ø	1	S	5	7	Ø
Ø	1	2	Ø	7	1	Ø	Ø	1	S	2	8	7
Ø	1	2	Ø	7	1	Ø	Ø	1	P	4	1	7
Ø	1	1	Ø	7	1	Ø	Ø	1	S	5	7	1
Ø	1	1	Ø	7	1	Ø	Ø	2	N	2	7	8
Ø	1	1	Ø	7	1	Ø	Ø	1	Y	6	4	7
Ø	1	1	Ø	7	1	Ø	Ø	1	H	4	7	4
Ø	1	1	Ø	7	1	Ø	Ø	3	L	5	4	1
Ø	1	1	Ø	7	1	Ø	Ø	2	Y	5	6	5
Ø	1	1	Ø	7	1	Ø	Ø	1	N	1	1	7
Ø	1	1	Ø	7	1	Ø	Ø	1	L	1	2	9
Ø	1	2	Ø	7	1	Ø	Ø	1	A	4	7	5
Ø	1	2	Ø	7	1	Ø	Ø	1	N	5	4	9
Ø	1	2	Ø	7	1	Ø	Ø	1	L	4	4	0
Ø	1	2	Ø	7	1	Ø	Ø	2	X	3	4	1
Ø	1	1	Ø	7	1	Ø	Ø	1	2	1	0	4
Ø	1	1	Ø	7	1	Ø	Ø	1	U	8	1	6
Ø	1	1	Ø	7	1	Ø	Ø	1	S	5	7	7
Ø	1	1	Ø	7	1	Ø	Ø	1	A	5	2	5
Ø	1	1	Ø	7	1	Ø	Ø	1	W	6	4	4
Ø	1	1	Ø	7	1	Ø	Ø	1	W	6	3	2

SAMPLE

GATE NO.		IN = 1 OR OUT = 2	TIME (MILITARY)				VEHICLE TYPE		LICENSE NUMBER			
1	2	3	4	5	6	7	8	9	10	11	12	13
Ø	1	2	Ø	7	1	Ø	Ø	2	H	5	8	5
Ø	1	2	Ø	7	1	Ø	Ø	1	P	5	2	5
Ø	1	1	Ø	7	1	Ø	Ø	1	P	9	2	6
Ø	1	1	Ø	7	1	5	Ø	1	V	8	4	9
Ø	1	1	Ø	7	1	5	Ø	1	J	8	1	3
Ø	1	1	Ø	7	1	5	Ø	3	V	8	4	3
Ø	1	2	Ø	7	1	5	Ø	1	E	6	2	1
Ø	1	2	Ø	7	1	5	Ø	1	A	9	2	8
Ø	1	1	Ø	7	1	5	Ø	1	S	2	2	3
Ø	1	1	Ø	7	1	5	Ø	1	V	3	1	6
Ø	1	1	Ø	7	1	5	Ø	1	U	6	3	4
Ø	1	1	Ø	7	1	5	Ø	1	R	2	4	7
Ø	1	2	Ø	7	1	5	Ø	2	L	5	1	8
Ø	1	1	Ø	7	1	5	Ø	1	B	0	7	9
Ø	1	1	Ø	7	1	5	Ø	1	B	4	4	0
Ø	1	2	Ø	7	1	5	Ø	1	B	9	5	3
Ø	1	2	Ø	7	1	5	Ø	1	H	9	9	6
Ø	1	1	Ø	7	1	5	Ø	1	C	8	7	4
Ø	1	1	Ø	7	1	5	Ø	1	T	6	1	5
Ø	1	1	Ø	7	1	5	Ø	1	V	2	8	0
Ø	1	1	Ø	7	1	5	Ø	1	D	5	0	2
Ø	1	1	Ø	7	1	5	Ø	2	P	4	1	7
Ø	1	1	Ø	7	1	5	Ø	1	D	1	2	8
Ø	1	2	Ø	7	1	5	Ø	1	A	4	2	5
Ø	1	2	Ø	7	1	5	Ø	1	H	4	7	4
Ø	1	2	Ø	7	1	5	Ø	1	G	8	6	0
Ø	1	1	Ø	7	1	5	Ø	1	K	5	5	5
Ø	1	1	Ø	7	1	5	Ø	1	O	0	0	1
Ø	1	1	Ø	7	1	5	Ø	1	O	3	3	2
Ø	1	2	Ø	7	2	Ø	Ø	1	X	9	7	5
Ø	1	1	Ø	7	2	Ø	Ø	1	A	7	9	5
Ø	1	1	Ø	7	2	Ø	Ø	1	C	2	9	7
Ø	1	1	Ø	7	2	Ø	Ø	3	G	4	2	0
Ø	1	1	Ø	7	2	Ø	Ø	1	K	9	9	2
Ø	1	2	Ø	7	2	Ø	Ø	1	X	3	4	1
Ø	1	1	Ø	7	2	Ø	Ø	1	A	1	0	0
Ø	1	1	Ø	7	2	Ø	Ø	1	P	3	2	5
Ø	1	1	Ø	7	2	Ø	Ø	1	S	5	T	2
Ø	1	2	Ø	7	2	Ø	Ø	2	Y	9	2	2

Figure 40. Typical license-plate survey field sheet.

typical paper tag is shown in figure 41. The tag is slipped under the windshield wiper or is given to the driver at the entrance point. Half the form is filled out at the entrance point and the remaining information is filled in by the worker collecting the tags. Cards may also be printed in various colors and prenumbered to simplify the coding. Thus it is possible to determine where the vehicle entered, where it exited, the times involved, and the vehicle occupancy. The tag-on method is also useful in some types of parking surveys.


TRIP GENERATION SURVEY TAG

DO NOT REMOVE THIS TAG

IT WILL BE COLLECTED AS YOU LEAVE

1. ENTRANCE 1

2. EXIT 3

3. TIME IN 1330

TIME OUT 1420

4. NUMBER OF PEOPLE IN VEHICLE 3

SAMPLE

Figure 41. Typical trip survey tag.

(2) A variation of this method is the lights-on survey where the vehicle headlights are used as the tag. A large sign (with a police car parked nearby) asks the driver to PLEASE TURN ON HEADLIGHTS FOR NEXT X MILES. A sign reading THANK YOU, PLEASE TURN LIGHTS OFF is placed at the study terminus. An observer counts the number of vehicles complying. At various points, observers count the cars passing with their lights on. The count permits calculations such as number of vehicles that entered at the lights-on station and then departed at the exit point.

72. Analysis.

a. This will consist of preparing numerical tables of raw data and then creating visual aids to help interpret the results. The visual aids will consist of simple tables, graphs, desire-line drawings, and bar charts. Examples of these are found in figures 42 to 46. On a bar chart (fig 43), the height of the bar represents the number of persons desiring to travel in a certain direction. The lines may be drawn straight from the origin zone to the destination zone (fig 44), or they may be drawn along existing roadways if the travel route is know (fig 45). Figure 46 represents the entrance-gate-to-work-zone desires.

TABLE X
TRANSPORTATION MODE OF BASE WORKING POPULATION BY WORK ZONE

Work Zone*	Mode							Total
	Drove	Passenger	Commercial Bus	Military Bus	Bicycle	Motor-cycle	Walked	
1	1,038	119	7	0	3	9	42	1,218
2	97	17	0	0	0	1	9	124
3	173	20	1	2	3	0	24	223
4	45	5	0	2	0	2	1	55
5	1,852	290	20	2	20	5	45	2,234
6	987	166	8	10	13	4	2	1,190
7	678	73	2	0	11	6	27	797
8	559	45	7	4	18	5	16	654
9	1,239	119	0	4	13	25	46	1,446
Total	6,668	854	45	24	81	57	212	7,941

*See Table VIII for zone identification.

Figure 42. Typical mode table from origin and destination questionnaire.

b. When analyzing raw data, care must be taken to reject illogical or or impossible conclusions. For example, if a particular statement on the O-D questionnaire were misunderstood by the reader, many wrong answers could result. A system of cross checks should be devised to prevent possible errors. For example, if only 300 cars were actually counted at Gate 6, but 750 drivers said they entered there, something was wrong with your questionnaire or its instructions.

73. Interpretation. This will depend on the subject matter of the table, graph, or desire-line drawing. It will also depend on the original purpose for undertaking the O-D study. The interpretation will usually place much greater emphais on the larger numerical answers. Then, some statement should be made about the conclusion you reach. It is also appropriate to make comparisons between data. For example, for figure 42 one might state: "It is seen that 6,668 persons drove to work, while only 45 persons

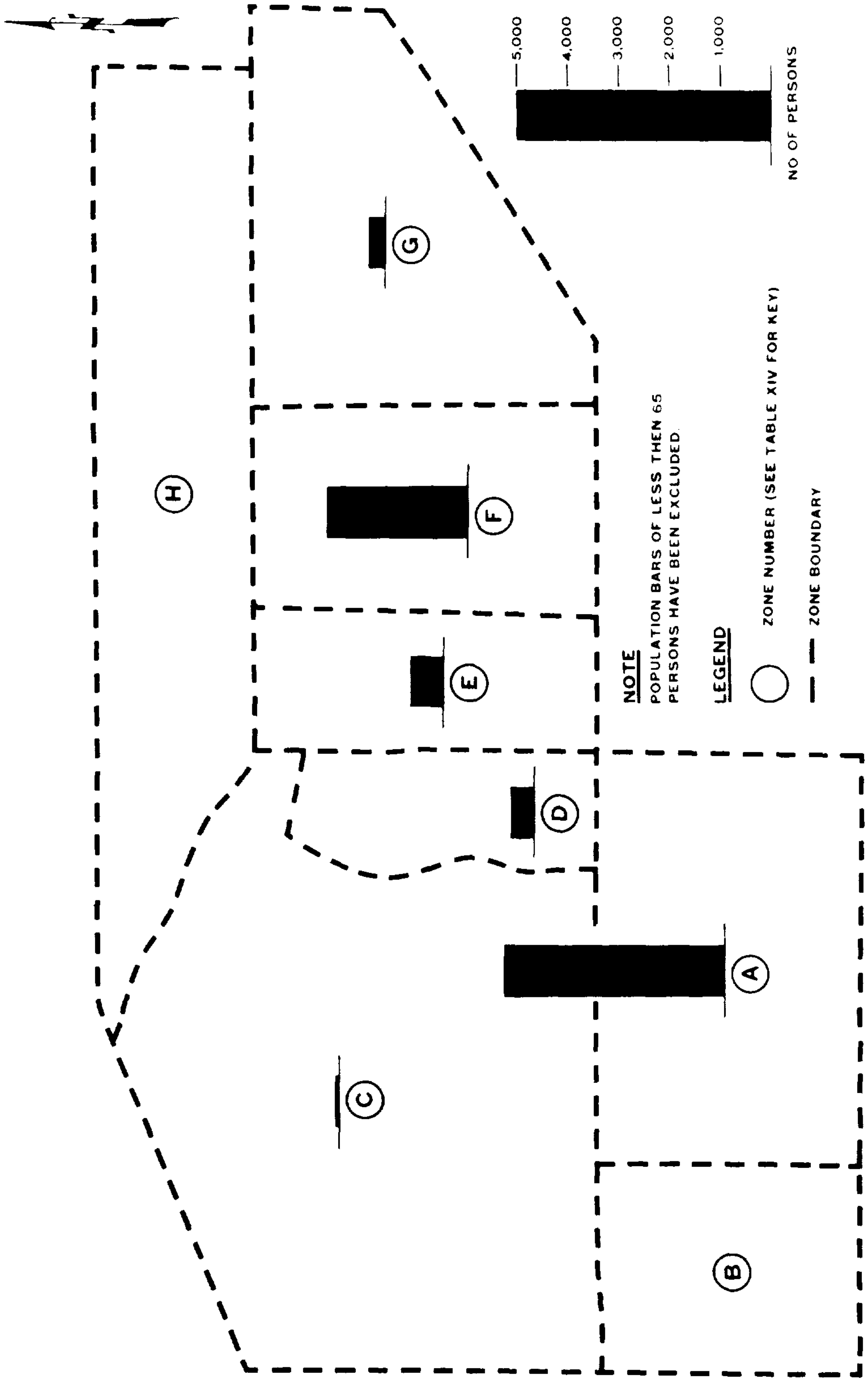


Figure 43. Typical bar graph from origin and destination questionnaire.

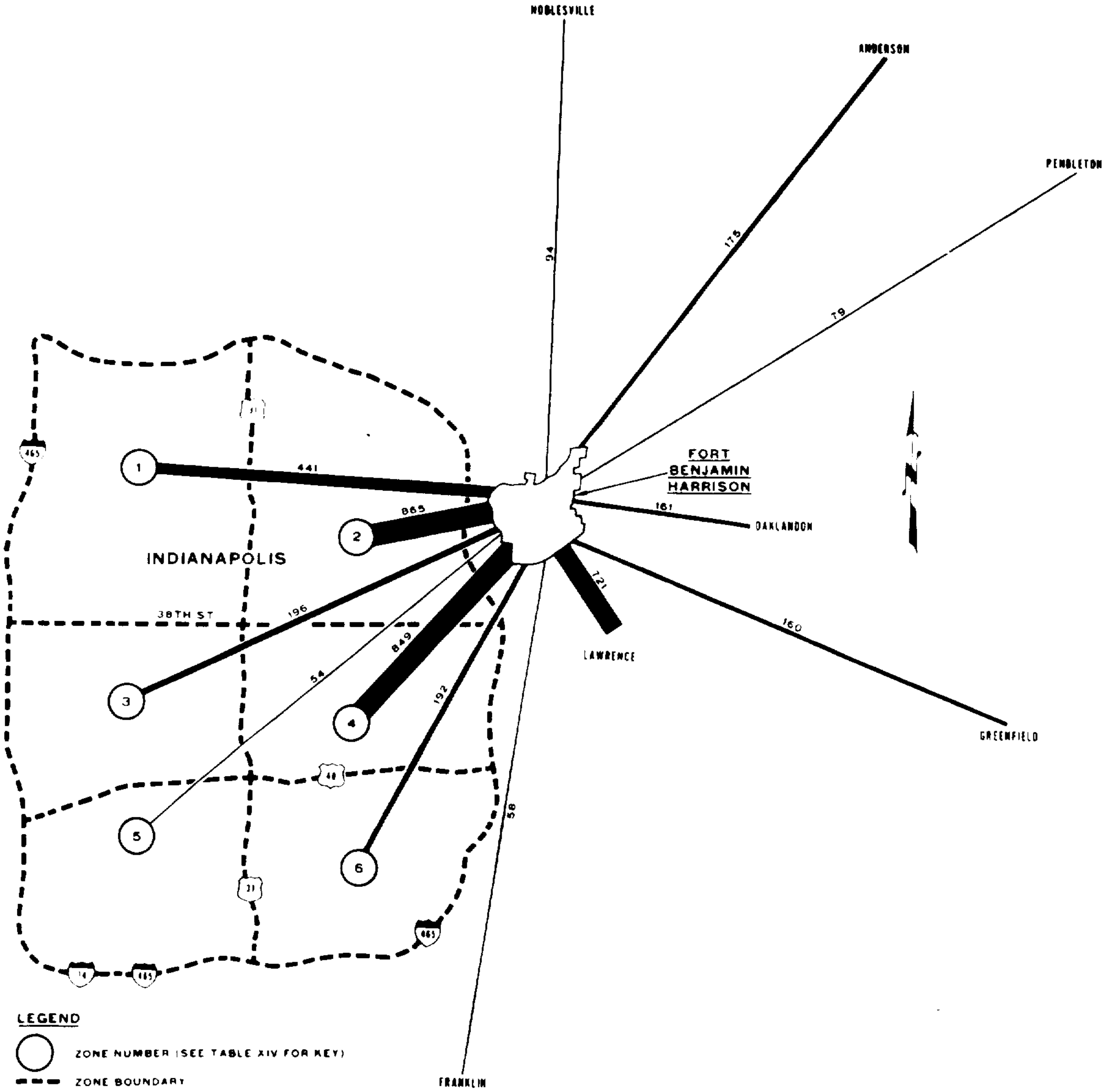


Figure 44. Typical origin-destination map.

used the commercial bus service." Also for example, from figure 44 one might conclude that: "It is seen that the town of Lawrence generates almost as many trips as some of the more populated zones of Indianapolis."

74. Applications. As stated, the purpose of the O-D study is to determine the travel desires of the population as generated by a military installation. Once the travel desires are known, applications in terms of practical transportation decisions can be made.

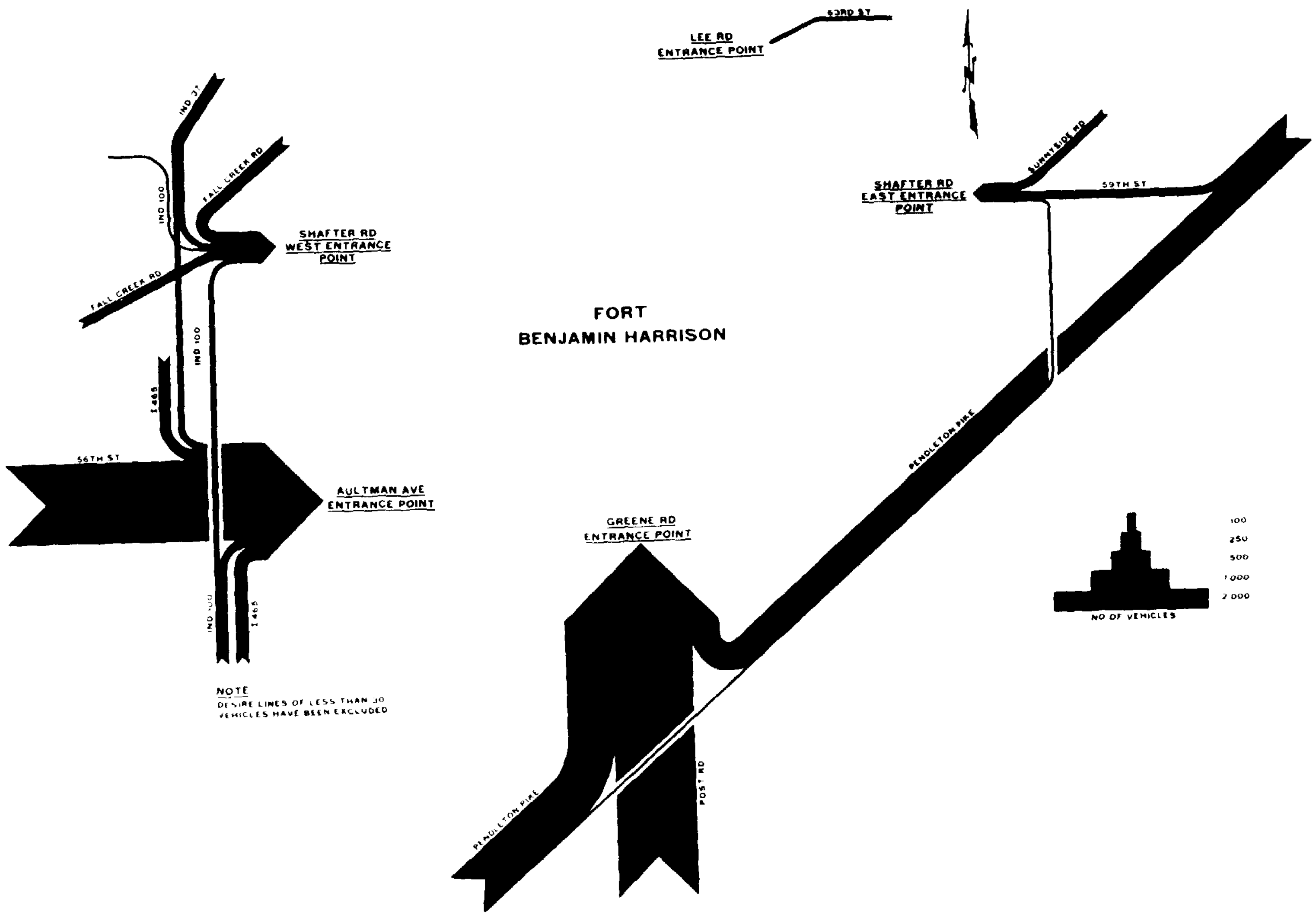


Figure 45. Typical approach-road-to-entrance-gate map.

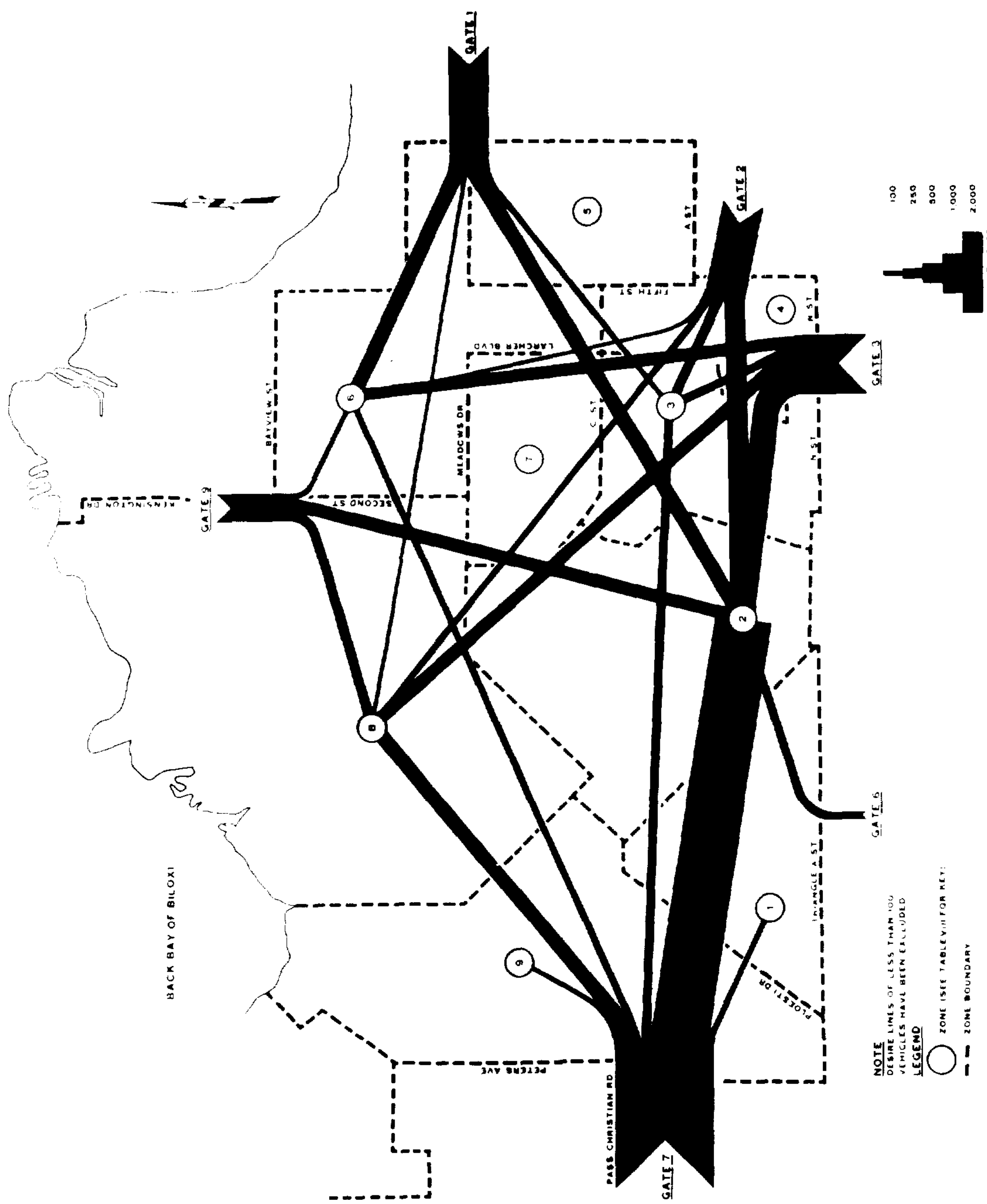


Figure 46. Typical entrance-gate-to-work-zone map.

a. Building location. The results of the O-D study may be applied to help determine the optimum location for new building locations. For example, if the survey reveals that most of the customers of the commissary are traveling from off post, consider locating a new commissary nearer an entrance gate rather than at a far corner of the installation. The goal is to reduce both the number of trips, and the average trip length.

b. Route location. The optimum location for a new roadway would be along a wide desire line. Of course it is necessary to modify the final design to allow for terrain, communities, and other practical considerations. The point where a heavy desire line crosses a river, railroad track, or other natural obstacle, is an indication of a favorable site for a new crossing. Where a desire line follows an existing roadway, it is indicative of a higher priority for the expenditure of maintenance funds.

c. Transit routes. When planning routes for mass transit (part two, sec XII), it is again better to attempt to follow a heavy desire line. It is also desirable to have the route pass through major population concentrations, as indicated by the population bar chart (see fig 43).

d. Entrance gates. When a problem involves either entrance gates or approach roads, it is usually best to ask those specific questions on the O-D questionnaire. The replies may be used to determine the effect of any planned changes. For example, if only 5 percent of the post working population use Gate 7, it might be feasible to close it completely. Using the travel desire lines, it would then be possible to predict the amount of increased traffic at other gates.

e. Through traffic. Once the amount of through traffic has been determined by performing a license-plate or other appropriate survey, it may be desirable to alter existing traffic routing. For example, a large amount of traffic following routes through housing areas would be an indication that existing arterial routes were inadequate or improperly defined. In such a case, it may be desirable to either upgrade the arteries or to establish THRU TRAFFIC ROUTES by means of proper signs. Also, for example, if it were found that a large number of vehicles without official business were entering an installation, it might be desirable to construct gatehouses and to require an official bumper sticker for entry.

f. Parking. Parking-space adequacy may be obtained by comparing the supply with the demand indicated by parking-zone replies. In general, it is desirable to locate parking lots within or near zones having a large working population.

g. Duty hours/car pools. The results of an O-D survey may indicate that too many employees have the same duty hours. Excessive concentrations can cause traffic congestion and delays. The results may also indicate the number of employees using car pools. Comparison of duty hours with organizational working strengths will indicate places for improvement (part two, sec V).

h. Other jurisdictions. It is of mutual benefit for military installations to exchange O-D results with civil authorities.

SECTION XI

TRAFFIC-CONTROL-DEVICE OBSERVANCE STUDY

75. Purpose.

a. The purpose of these studies is to determine the effectiveness of certain traffic-control devices by studying the degree of compliance or observance by drivers and pedestrians. This study is generally conducted only where a specific problem exists, particularly at high-accident-frequency locations. The results of the study also are useful in determining the need for existing or proposed devices; in indicating steps necessary to improve obedience; and to note the effect of changes in regulations, devices, or other items affecting traffic operations. In certain cases, it may aid in the removal of existing restrictions that are no longer justified.

b. The study described in this section can be applied to regulatory devices, such as STOP signs, traffic signals, and speed-limit signs. Other regulatory signs such as Turn Prohibitions, One-Way Restrictions, and Parking Prohibitions may be studied by similar methods. Parking-time-limit observance may be checked by conducting parking-duration studies as described in part two, section XIII.

c. The studies are conducted on a sample basis; it is not practical to maintain a continuous study over an extended period. Normally, the time period identified as the most common time of traffic accidents should be used for the field observations.

76. Information needed. In studying observance or obedience to traffic-control devices, the following information is needed:

a. STOP signs.

(1) Number of drivers making full stop:

(a) Stopped voluntarily.

(b) Stopped by traffic.

(2) Number of drivers not making full stop:

(a) Slowed.

(b) Made no attempt to stop.

(3) The direction of each driver upon entering the intersection such as right turn, left turn, or straight through.

b. Traffic signals:

(1) Driver observance of signals controlling his movement:

(a) Number of vehicles entering intersection on red indication.

(b) Number of vehicles entering on yellow indication.

(c) Number of vehicles starting up immediately prior to green indication.

(d) Number of vehicles making turns not permitted by signals or signing at intersection.

(2) Pedestrian observance:

(a) Number of pedestrians stepping off curb on green or WALK indication.

(b) Number of pedestrians stepping off curb on a flashing DON'T WALK indication or yellow indication, if pedestrian signals are not installed.

(c) Number of pedestrians stepping off curb on solid DON'T WALK indication or red indication, if pedestrian signals are not installed.

(d) Number of pedestrians crossing outside marked crosswalks, if applicable.

c. Speed limit signs.

(1) Note location of speed limit or speed-reduction signs.

(2) Observation of vehicle speeds (as outlined in part two, sec IX).

d. General.

(1) For all studies discussed in this section, the following information should be recorded when applicable:

(a) Approach grade (flat, moderate, or steep; indicate uphill or downhill for each approach).

(b) Weather.

(c) Street classification (see part two, sec II).

(d) Type of surface (concrete, asphalt, or other).

(e) Condition of surface (wet, dry, muddy, or icy).

(f) Approach curves (indicate sharp, medium, flat, or none).

(g) Street width; number of traffic lanes; and presence of any separate turning lanes, crosswalks, or other striping.

(2) If there are traffic-control devices in effect, other than those that are under observation, they should be noted on the field form. In many cases it may be advantageous to make a sketch of the intersection similar to the condition diagram described in part two, section VI.

(3) In some instances, it may be desirable to classify vehicles by group (see part two, sec I).

(4) In most cases, a minimum of 100 observations should be made.

77. Methods.

a. For studies of STOP-sign obedience, one observer is normally required for each sign to be checked. In light traffic, one observer can check STOP signs on two approaches to an intersection. The action of each vehicle approaching a STOP sign is recorded in the appropriate block on the field-data sheet shown in figure 47. Although desirable, it is not necessary to record every vehicle since this is a sample survey of actions.

b. At traffic signals, the action of each driver and pedestrian is recorded. If pedestrian volumes are heavy, the action of at least every fifth pedestrian should be recorded for a satisfactory sample. Figures 48 and 49 may be used as guides for necessary field-data sheets. Modifications can be made in these sheets for signals that provide special pedestrian indications such as WALK and DON'T WALK.

78. Analysis. This will usually consist of preparing a summary of the results of each STOP sign or traffic-signal study. Percentages should relate actual field observations and total voluntary movements (not influenced by other traffic or pedestrians) at each respective location.

a. Figure 50 shows a format for a table summarizing STOP-sign-obedience observations. The following general percentage of drivers making full stops, excluding those stopped by traffic, may be used to compare STOP-sign-study results.

(1) 95 to 100 percent - excellent.

(2) 75 to 94 percent - good.

(3) Under 75 percent - poor.

b. Some of the usual causes of failure to obey the STOP sign are the poor condition of sign faces, improper location of the sign, or obstructions to view of the sign. Unnecessary, unwarranted, or temporarily installed STOP signs are often poorly observed by drivers. Obedience to signs often varies with the season because vegetation obscures signs during the growing season. Left-turning violators often cannot see the STOP sign because of its location, while violations by right-turning vehicles often result from placing the sign in advance of corners with large turning radii. When the principal reason for a relatively poor obedience to a traffic-control device is a temporary condition (such as view obstructed by vegetation or defaced sign), another study should be made after this temporary condition has been corrected.

STOP SIGN OBSERVANCE STUDY FIELD SHEET

LOCATION *Elm Ave. at Maple St.* DIRECTION *NW Bound*

DATE *7/22/75* DAY *Tuesday* TIME *1300* TO *1330* WEATHER *Fair*

CLASS *Secondary* LANES *1* APPROACH GRADE *Level* OBSERVER *L. R. Smith*

FULL STOP		SLOWED DOWN	NO ATTEMPT TO STOP
VOLUNTARY	STOPPED BY TRAFFIC		
𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 𝍸 𝍸 𝍸 𝍸	𝍸 ||	|
𝍸 𝍸 𝍸 𝍸 𝍸	|		
𝍸 𝍸 𝍸 𝍸 |||			
(73)	(26)	(7)	(1)

SAMPLE

REMARKS: *the no attempt to stop violation was a right-turn movement*

Figure 47. Typical stop-sign observance study field sheet.

PEDESTRIAN SIGNAL OBSERVANCE FIELD SHEET

LOCATION 1st St & Maple Ave DATE 7/22/75

TIME 1400 TO 1430 WEATHER cloudy

SURFACE Asphalt SURFACE CONDITION good

APPROACH GRADE Level OBSERVER L.R. Smith

STEPPED FROM CURB ON	CROSSED IN CROSSWALK AREA	CROSSED OUTSIDE CROSSWALK AREA	TOTAL
GREEN OR "WALK"	63	4	67
YELLOW OR FLASHING "DON'T WALK"	26	2	28
RED OR SOLID "DON'T WALK"	8	2	10

SAMPLE

TOTAL SAMPLES 105 YELLOW: 27 PERCENT

GREEN: 64 PERCENT RED: 9 PERCENT

Figure 48. Typical pedestrian signal observance field sheet.

DRIVER SIGNAL OBSERVANCE FIELD SHEET

LOCATION 1st at Maple Ave DATE July 23 1975

TIME 0700 TO 0800 SURFACE Asphalt APPROACH GRADE Level

WEATHER cloudy SURFACE CONDITION good OBSERVER L. R. Smith

		VEHICLE ENTERING INTERSECTION ON			
		GREEN	YELLOW	RED	OTHER
PASSENGER VEHICLES	RIGHT	60	10	9	
	STRAIGHT	265	50	17	
	LEFT	110	30	7	
NON-PASSENGER VEHICLES	RIGHT	5	2		
	STRAIGHT	27	10		
	LEFT	7	5		

TOTAL VEHICLES												
	Right	NO.	65	PCT.	75.6	NO.	12	PCT.	14.0	NO.	9	PCT.	10.4
	Straight	NO.	292	PCT.	79.1	NO.	60	PCT.	16.3	NO.	17	PCT.	4.6
	Left	NO.	117	PCT.	73.6	NO.	35	PCT.	22.0	NO.	7	PCT.	4.4

SAMPLE

Figure 49. Typical driver signal observance field sheet.

TABLE X
STOP-SIGN OBSERVANCE SUMMARY

Intersection/ Direction of Travel	No. of Observations	Percentage		
		Full Stop	Slowed Down	No Attempt To Stop
Ellsworth Rd at Wright Dr eastbound	50	44.0	50.0	6.0
Ellsworth Rd at Wright Dr westbound	100	28.0	64.0	8.0
Depot Parkway at Donaldson Rd southbound	100	53.0	45.0	2.0
Brookley Rd at Wright Dr eastbound	50	40.0	60.0	0.0
Hill Rd at Perimeter Rd northbound	50	46.0	46.0	8.0
Total	350	41.7 (Avg)	53.4 (Avg)	4.9 (Avg)

Figure 50. Typical stop-sign observance summary table.

c. The main causes of lack of obedience to traffic signals are similar to those for STOP signs: poor locations, lack of visibility, and unwarranted signals.

d. Poor observance of signals by pedestrians is often caused by improperly located signals, no signal indication visible to pedestrians, green or walk period too short for crossing, vehicle turns hindering crossings, or lack of adequate crosswalks.

e. In studying effectiveness of speed-reduction signs, averages of the observed speeds before and after are determined and compared, and if the difference is slight, it is probably due to chance and does not reflect the effectiveness of the signs. In this case, another survey should be made as a further check. Large differences indicate effectiveness of the signs. Mathematical methods of determining the significance of differences in averages (arithmetic mean) can be used if more precise methods are desired.

79. Application.

a. In general, the observance of, obedience, to or effectiveness of traffic-control-device studies are used to assist in determination of accident causes at high-accident-frequency locations, to assist in evaluating the efficiency of traffic-control and enforcement plans and policies, and to improve control measures by relocating or removing unwarranted or ineffective devices.

b. To improve observance of necessary STOP signs, the following actions should be considered:

(1) Refinish or replace defaced or nonreflective signs.

(2) Erect STOP AHEAD signs approaching isolated STOP signs; the advance distance is related to approach speed.

(3) Improve visibility of signs and intersections by removing or trimming vegetation, restricting parking, or relocating adjacent signs.

(4) Increase selective enforcement and driver education.

(5) Add pavement markings or extra signs.

(6) Install a flashing red beacon at particularly hazardous locations.

c. Obedience to traffic signals may be improved by:

(1) Improving view of signal by relocating signal indications, removing obstructions to view, or increasing the size of the indications.

(2) Retiming signal controller for maximum effectiveness.

(3) Coordinating the traffic signal with other adjacent signalized intersections to reduce the number of required stops.

(4) Installing pedestrian signal heads to control pedestrian movements.

(5) Erecting TRAFFIC SIGNAL AHEAD signs.

(6) Increasing enforcement.

d. The study of speed signs can be used to improve enforcement and driver-education programs and to determine need for improving visibility of such signs. This study is also useful in planning an installation-wide program to remove unnecessary signs or to increase speed limits to more reasonable levels. A complete procedure for conducting a study of speed signs is given in part two, section IX of this pamphlet.

SECTION XII

TRANSIT STUDIES

80. Purpose. Transit studies are conducted to obtain information concerning either privately owned or Government-owned transit vehicles that serve the installation. The information serves as basic material for future route planning, analysis of effectiveness of present operations, determination of points of heavy passenger loads, and planning additional stops if needed. This study can be used in conjunction with the duty-hour study (see part two, sec V) to determine whether public transportation schedules fit with starting and ending times of base personnel.

81. Information needed. There are two types of studies: (1) the transit load check, and (2) the transit boarding-and-alighting check. Either can be utilized to yield the required information, depending upon the objectives of the study. They can be used independently or together. Basic information required for any type of transit check should include a map showing all transit routes, location of all stops, and transit schedules. A third study that might be considered, is a transit travel-time and delay study. This study is accomplished using the same procedures outlined in part two, section VIII. This study would be used to analyze delays that occur and how service might be improved.

a. Transit load check. This is a count of the number of transit vehicles and the number of passengers on each at selected locations. The number of passengers in each vehicle is either counted or estimated at selected vehicle arrival and departure stops or when it passes a given location such as a gate. The vehicle number, time of arrival, and time of departure are noted. The vehicle number can be used to ascertain the seating capacity from the operating agency. The observer(s) are located at each location where the data are required.

b. Transit boarding-and-alighting check. This requires the number of passengers boarding and alighting from the vehicle at each stop and the vehicle arrival and departure times for the entire route. An observer rides on the vehicle to obtain these data.

82. Method. Method is determined by the type of study.

a. Transit load check. This is to be conducted in the following manner:

(1) The points that are of interest to the study are chosen. These are usually the points where high ridership occurs.

(2) One observer is assigned to each location.

(3) Each observer is equipped with field-data sheets and a wrist watch. The observer enters the appropriate information as shown in the format suggested in figure 51.

(4) The time and length of the study will be determined by the purpose of the study. It may be conducted during peak-traffic hours only or during a complete day by taking a sample of each major period to allow expansion to the full day, using the scheduled number of buses in each period.

b. Transit boarding-and-alighting check. This is to be made in the following manner:

(1) Information is obtained on the length of the route and the location of each stop from the transit route map.

(2) One or more observers are assigned to each vehicle, depending upon the passenger volume and the number of doors in the vehicle. At stops where volume is exceptionally heavy, an observer may be required at the curb to tally the number alighting.

(3) Each observer rides the vehicle continually between terminal points on the route and enters the appropriate information on the suggested field-data sheet (fig 52). In addition to the field-data sheets, the observer must be equipped with a wrist watch.

(4) Enough trips must be made to provide a complete picture of passenger volumes during peak- and off-peak periods.

TRANSIT LOAD STUDY FIELD SHEET

LOCATION Oak St. at Texas Ave

TIME 0700 TO 1200 DAY Thursday DATE 24 July 1975

OBSERVER J. D. Brown

TRANSIT DATA						PASSENGERS			REMARKS
ROUTE NO.	DIR	BUS NO.	SEATING CAPACITY	TIME ARRIVE	TIME DEPART	OFF	ON	THROUGH (STAY ON BUS)	
3	NB	126	44	0715	0717	0	10	32	
7	SB	071	44	0745	0748	6	4	32	
6	EB	049	24	0830	0845	11	2	15	Traffic Accident Btwn Elm St & Willow St. Delayed Depart.
8	WB	110	44	0915	0920	5	6	20	
3	NB	126	44	1005	1008	3	12	10	
7	SB	071	44	1030	1033	13	3	36	
6	EB	049	24	1106	1110	6	10	7	
8	WB	110	44	1140	1143	6	16	32	
TOTAL						50	63	184	

SAMPLE

Figure 51. Typical transit load study field sheet.

MASS TRANSIT BOARDING AND ALIGHTING STUDY FIELD SHEET

DAY Wednesday DATE 11 June 1975 WEATHER Cloudy

LINE NUMBER 5 BUS CAPACITY 60 SEATS 44

DIRECTION Northbound OBSERVER J. D. Brown

LOCATION OF STOP	TIME		PASSENGERS		
	ARRIVAL	DEPARTURE	OFF	ON	LEAVING*
Terminal		0725	0	0	0
Elm Street	0730	0733	0	31	31
Willow Street	0748	0752	5	23	49
Bluebonnet Street	0810	0814	24	11	36
Maple Street	0835	0840	21	6	21
Birch Street	0855	0858	8	11	24
Pine Street	0915	0918	6	4	22

SAMPLE

*LEAVING: TOTAL NUMBER OF PASSENGERS ON BUS WHEN LEAVING INDICATED STOP. RECORD FOR FIRST STOP THEN ADD THE "ON" AND SUBTRACT THE "OFFS" FOR EACH OTHER STOP. RECHECK THE VALUE FREQUENTLY BY COUNTING THE NUMBER OF PASSENGERS.

Figure 52. Typical mass transit boarding-and-alighting study field sheet.

83. Interpretation.

a. Data gathered in the transit load check can be analyzed by comparing seated passengers, standing passengers, and seats available by time of day. Figure 53 shows one method of presenting the information.

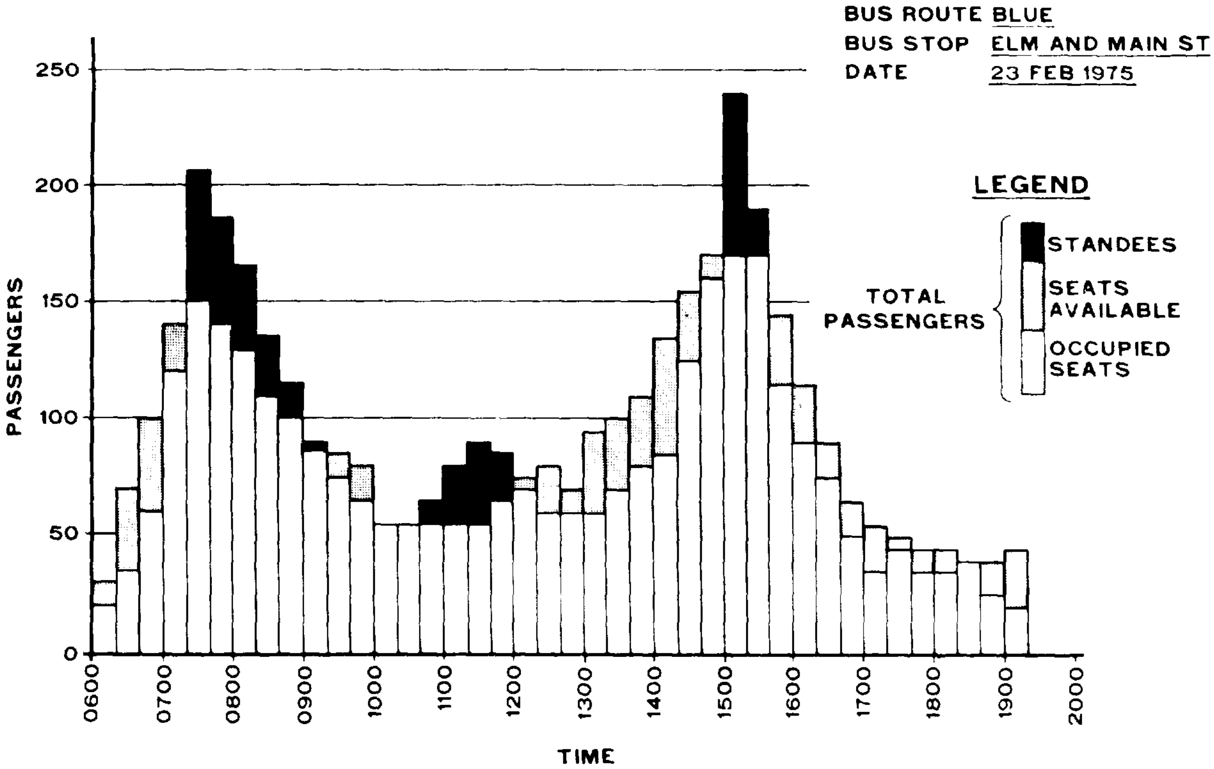


Figure 53. Typical transit load-check graph.

b. Information gathered in the transit boarding-and-alighting check may be analyzed by the following methods:

(1) A load profile may be constructed with the abscissa corresponding to points along the route and the ordinate representing the total number of passengers at various points on the route. This profile can be made for each trip or for the average of individual trips during selected periods. A sample load profile is shown in figure 54.

(2) A boarding and alighting summary can be made for points on the route in graphic form as suggested in figure 55.

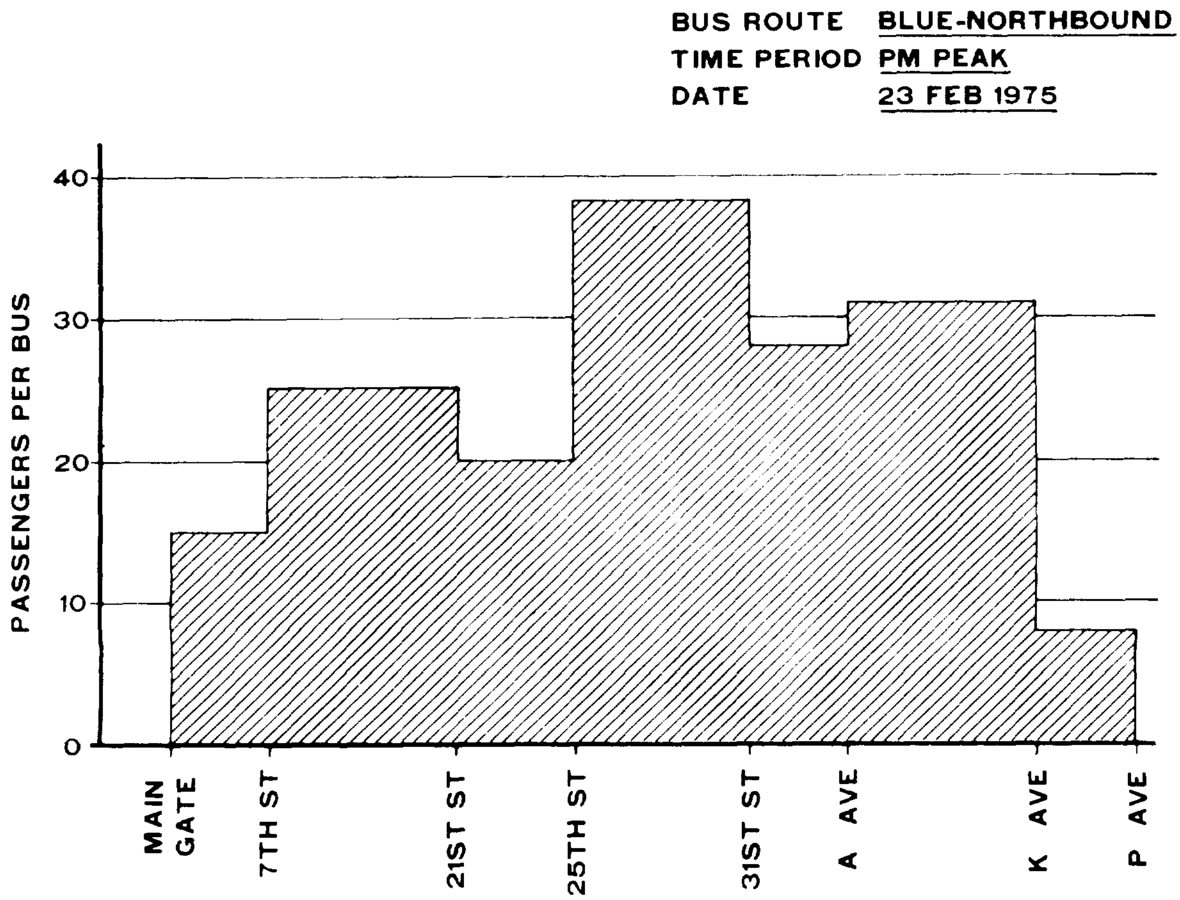


Figure 54. Typical sample busloading profile.

84. Application. Information obtained can be utilized for purposes of safety, planning, and as background information when dealing with privately owned transit lines that serve the installation.

a. The transit load check will point up conditions of overcrowding that violate the provisions of AR 385-55 (app B).

b. The results of the transit load check or transit boarding-and-alighting check may be used as follows:

(1) For possible consolidation or rerouting of lines.

(2) For possible elimination of stops.

(3) For additional information when developing a staggered duty-hour plan.

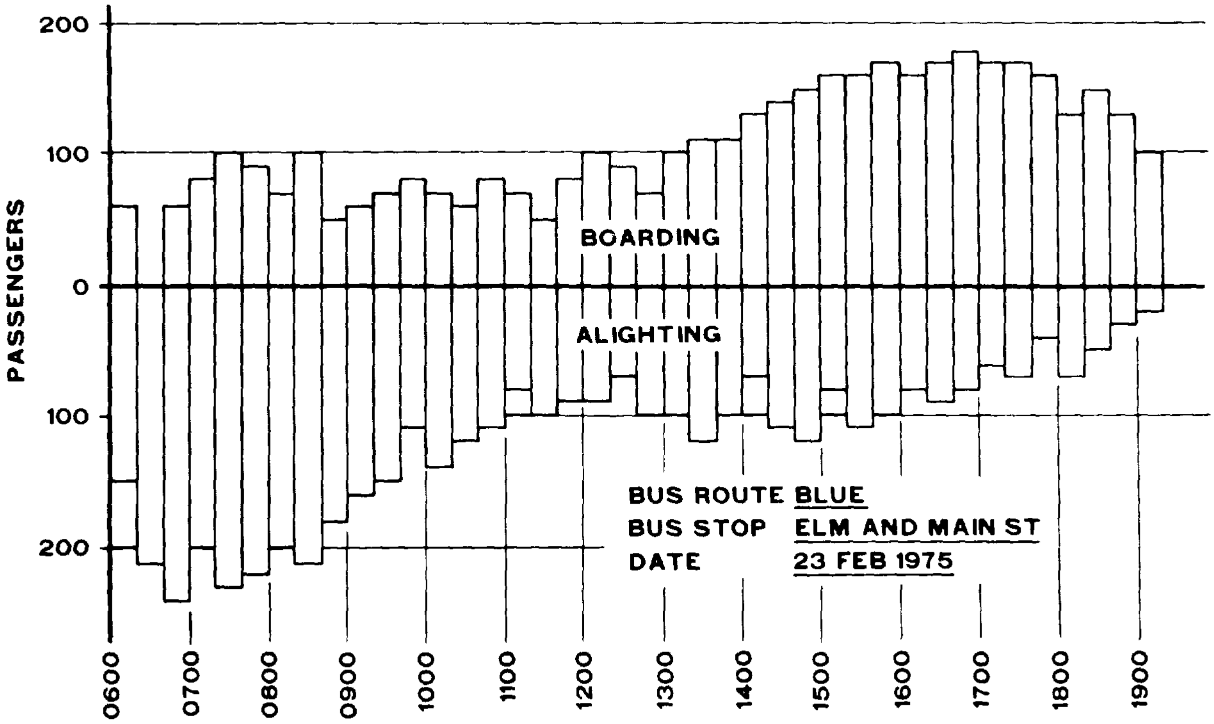


Figure 55. Typical boarding and alighting graph.

(4) For determining the daily passenger circulation at points on the route.

(5) For determining vehicle headways.

(6) For determining requirements for additional service.

(7) For future planning.

c. The transit load check will provide information that will be valuable in dealing with private transit firms in regard to schedules and passenger-volume requirements of the installation.

SECTION XIII

PARKING STUDIES

85. Purpose.

a. Parking studies provide information relative to the adequacy, location, and use of existing parking facilities to analyze whether additional parking is required to meet existing parking demands. The information also can be utilized to make projections of the future requirements for parking space if there is to be expansion of development.

b. Lack of adequate parking presents a significant problem at many installations. The problem usually is localized in only a portion of the base; often at commissaries, exchanges, barracks areas, and major employment concentrations. Actually, the problem is one of walking distance rather than of parking. If you are willing to walk far enough, you can always find a space somewhere. The objective of parking studies is to develop an improvement program to place the proper number of stalls, with properly designed layout and traffic circulation patterns, in convenient locations to serve the many different portions of an installation. Usually when a parking study is desired, a problem area already has been identified and solutions are needed. In other cases, the parking study will be used to identify problem areas through an overall installation check and then will be followed with more detailed study in the problem areas. This section will cover the procedures to be used in either case. Normally, parking areas used only for military vehicles (motor and equipment pools) are omitted from the study, since their special problems are more easily identified and solved.

86. Information needed.

a. In general, the necessary information will include an inventory of existing parking, a classification of the types of spaces (open, reserved, or visitor), an identification of which installation facilities are served by the parking spaces, and a measurement of parking-space usage.

b. Parking supply is the actual number of spaces available, both on street and off street, to serve parkers within reasonable walking distance of their destination. In addition to counting the actual number of spaces, the information collected should include the generalized location and parking time limits (if any) of the spaces. If the spaces are located off street, physical characteristics of the lots should be noted or sketched. The characteristics should include entrance and exit locations; type of surface; details of space markings; and dimensions of aisles, spaces, and entrances. If the lot has a one-way circulation pattern, this should be described.

c. To determine how present parking spaces are used, information must include the number of cars parked at the peak time of the day, how long vehicles are parked (parking duration), and the average number of cars parked in each parking space (turnover) during the selected study period. Vehicle types, incorrect parking practices, and violations also will be noted during the study.

87. Methods. The field work consists of identifying the study area, taking a parking-space inventory, and determining parking-usage characteristics. These steps involve the following procedures:

a. Determine study area. The purpose of the parking study must be defined prior to defining the area where it will occur. If it is the entire installation, the objective will be to identify where parking shortages exist. If the study is to cover a limited portion of the base, it will normally be associated with an identified land use (hospital, work area, commissary, or exchange). This is the more common case. To identify the study area, a field check of the area during a period of heavy parking demand is required. Parking demand refers to the number of cars (normally the maximum) present in a given area. Individual parking demands normally are related to an individual land use or groups of uses in an area. The field check will result in drawing a line on a map around the principal study site to include all locations where people park who are destined for that site--both on street and off street. This line then defines the study area. If the entire base is to be studied, it will normally be divided into sectors that logically split the different functional areas of the base.

b. Parking-space inventory.

(1) Parking supply is determined by a parking inventory. Obtain a map of reasonable scale that covers the study area. A vertical aerial photograph can be of significant help also. The map should be zoned in a similar fashion to that of the origin and destination zone map (see fig 36). Each parking area, both on street and off street, should be designated on the zone map by a letter or number.

(2) The actual inventory is made by field observers who enter the proper information on field sheets. One sheet is the parking-zone map. The second sheet is the inventory form. Each sheet is identified by the proper code number from the zone map. If the parking spaces

are defined by painted stall markings, the actual number of parking spaces is counted; if not, measurements should be made and the number estimated. The number of on-street spaces is estimated by measuring the length between driveways and calculating the number of stalls that can fit in that length. The number of stalls possible in an unmarked off-street lot may be estimated by dividing the area of the lot in square feet by 300 (the average area for each car, including aisles, in a normal lot). For example, a lot 125 feet by 400 feet contains 50,000 square feet and could accommodate approximately 166 cars in self-parking stalls. If there are any restrictions on use of the stalls in any facility, the number of stalls in each category should be tallied separately:

(a) Reserved for individuals.

(b) Restricted by a time limit.

(c) Unlimited usage.

(3) Any restrictions on use, permit systems, and the message on the face of any restrictive signs should be indicated on the back of the inventory form. A sample form for parking space inventory is shown in Figure 56.

c. Parking utilization study. This study determines the number of vehicles parked within the study area. If the entire installation is to be covered, by sector, two observers riding in a vehicle can accomplish this easily; the driver counts vehicles parked on the left side of the street or aisle and the other observer counts those on the right side. For smaller areas, a single observer can obtain the data on foot. The checks should be made on the heaviest day of a normal week; a complete count should be made at 1000, 1215, and 1430 hours, since normally the peak number of parked vehicles occurs during one of these periods. The route followed should be set so that it can be covered in approximately 30 minutes, starting 15 minutes before the time indicated and finishing approximately 15 minutes after. Do only a portion of the installation in 1 day, if necessary, finishing the remainder on other days with similar parking-demand characteristics. All on-street and off-street facilities in one area should be covered on the same day. The route should be laid out on a map (or aerial photograph) in advance to insure complete coverage. The data can be recorded on the map using different colors for each of the three observation periods. Show the number of cars parked along each block face and in each off-street facility. Illegally parked vehicles and those parking in unauthorized areas are shown separately in parentheses. The objective of the study is to determine the highest number of vehicles parked in each

INSTALLATION PARKING INVENTORY SUMMARY SHEET

INSTALLATION *Ft Battle* DATE *7/23/75*

LOCATION OF PARKING INVENTORY[1/] *Zone 4*

TOTAL PARKING SPACES *791* RESERVED *20* OPEN *771*

ON-STREET (CURB) SPACES *28* RESERVED *4* OPEN *24*

OFF-STREET (LOT) SPACES *763* RESERVED *16* OPEN *747*

ON-STREET					OFF-STREET				
LOCATION[2/]	NO. OF SPACES				LOT/AREA	NO. OF SPACES			
	RESERVED	OPEN	PARALLEL	ANGLE[3/]		RESERVED	OPEN	ANGLE[3/]	PAVED[4/]
1st St					Bank	2	8	90°	✓
between A & B Sts	0	8	No	60°					
					PX	2	213	60°	✓
Main St									
between 1st & 2nd Sts	2	3	yes		Commissary	2	300	60°	✓
Maple St					Post Office	1	20	90°	✓
between									
Elm Ave & Apple Ave	2	13	No	60°	Bowling Alley	0	100	90°	✓
					Credit Union	4	25	90°	✓
	SAMPLE				Service Club	5	81	90°	✓

1/ Location, lot, or area by name keyed to a coded map on site plan.
2/ Extent of parking (name of street; i.e., John Street between A Street and B Street, north side.
3/ Relates to stall or parking angle (i.e., 90 degrees; 60 degrees; 45 degrees).
4/ Use check mark (✓) if yes; (x) if no.

Figure 56. Typical installation-parking-inventory summary sheet.

sector and/or facility so that it may be compared with the available parking supply to identify areas and amounts of parking shortage. Some areas may require checks at times other than those noted above if their heaviest parking demands occur during different hours.

d. Parking-duration and turnover study. This study is conducted during normal hours to obtain a picture of typical usage. When the spaces serve special-purpose facilities such as post exchange, commissary, and theaters, the study should be conducted during the period of maximum use. The purpose of this study is to identify how many cars use the spaces in a given time period (called turnover), whether the time limits are proper and are being observed, what number of cars are present at the time of peak accumulation, and what the average length of time parked is. Each observer is assigned an area to cover that will allow him to check each parking space once during every 15-minute period or less. This period may be extended when the parking area obviously is utilized by long-time parkers (30-minute or 1-hour intervals). As a rule, one observer can cover from about 60 to 80 spaces in a 15-minute period. The observer walks a predetermined route and records the right-hand four numbers or letters of the license plate or decal number on the field-data sheet as shown in figure 57. Parking time limits for each space should be recorded on the field-data sheet the first time the route is covered. The same route is followed on subsequent trips so that each parking space corresponds to a horizontal row of spaces on the field sheet. All parking space must be accounted for on the field sheet. An empty parking space can be recorded by leaving the appropriate space blank on the field sheet. When the same vehicle is observed in the same parking space during subsequent trips, the observer records it as a check mark rather than repeating the license plate or decal number. This makes it easier to pick out long-time parkers. Parking spaces that are reserved for either permanent personnel or visitors should be so identified on the field sheet. The method described above for making the space-utilization study can be used for on-street or off-street parking. Normally, a 30-minute round trip is adequate for off-street parking.

e. In many cases, the facility that is served by a particular group of parking spaces, whether on street of off street, can be easily identified by field observation. However, when several possibilities exist, the use of the spaces can be determined by questionnaire, direct interviews, or tracing of decal numbers. These techniques are costly and should only be used if there is a special problem that can be analyzed only through their use.

f. Direct interviews or use of returnable questionnaires require adequate advance publicity in order to carry out the study with a minimum

PARKING UTILIZATION FIELD SHEET

LOCATION: Post Office WEATHER: Sunny / Dry

DATE: 25 July 1975 TIME: 1000 TO 1035 OBSERVER: T. White

LICENSE PLATE NUMBER OF VEHICLES

TIME							
1000	1005	1010	1015	1020	1025	1030	1035
CB65	✓	✓		8927	7502	✓	B765
	XL04	3201	✓		9320	B750	CB00
1786	9302		7878	✓	1976	G755	✓
BL56		7333	0059		XL75		7652
7575	DC75		1903	1654		1876	
9053		2765	✓	2022	GL63		7803
	9737	0042	1014		1988	0505	6230
1900	6378		ML82	A555		1678	4303
C759	✓	8201		3075	C788	✓	7007
GB07	2982	1472	1688		7905	✓	9123
0090	✓	✓	1505	7386	1514		0065
7676	0976	✓		8090	2223	1784	
WL89		1698	✓	5555	PU76	✓	7803
	0988	9070		7679	M532		0665
NL78	✓	4202	1997		1600	1491	
TB40	8007	B766		T468	✓	1878	
6636	1050	D888	✓	✓	✓	6565	✓
0402		1842		9606		7575	0796
0901	1565	✓	1789	✓	✓	✓	7876
	1804	✓	✓	✓	✓	2011	
5707	0304		7015		6373	✓	✓

SAMPLE

Figure 57. Typical parking-utilization field sheet.

of explanation to parkers. The data are collected either by on-the-spot interviews when the driver returns to his vehicle, or by inserting a questionnaire under the windshield wiper to be filled in by the driver when he returns to his vehicle. Personnel distributing the questionnaires should be instructed not to open or enter unattended vehicles. In either case, the questions should be simple but should yield enough information to accomplish their purpose. The following is an example of some information that might be requested:

(1) Time of arrival at parking space (in the case of direct interviews, the observer records this when the parker arrives, as well as the license number).

(2) Time of departure from parking space.

(3) Reason for visiting destination (work, or shopping).

(4) Frequency of parking in the area.

Other items might include the number of persons in each vehicle, home location, next destination after unparking, and any special items involved in solution of the problem being studied. Questionnaires also should include instructions for returning it through the desired channels, and some method of identifying the location of the parking space (probably entered by the person distributing the questionnaires).

g. In parking areas that normally serve employees, the parker's destination after unparking may be estimated by listing installation decal numbers and checking this listing against installation vehicle-registration records to determine home location, zip code, and duty station (employment location).

88. Interpretation.

a. The supply of available parking spaces may be summarized according to area or sector of the installation. These areas may be located on a map by the block and facility numbers, and the parking capacity of each area can be noted directly on the map. Figure 58 is a graphical comparison of the peak number of cars parked and employees by sector; similarly, parked cars could be compared with available parking stalls by sector. A summary in table form should be prepared to indicate usage of the available parking supply by parking category similar to that shown in figure 59. The calculation of the percentage of stalls filled is valuable in identifying areas of high usage.

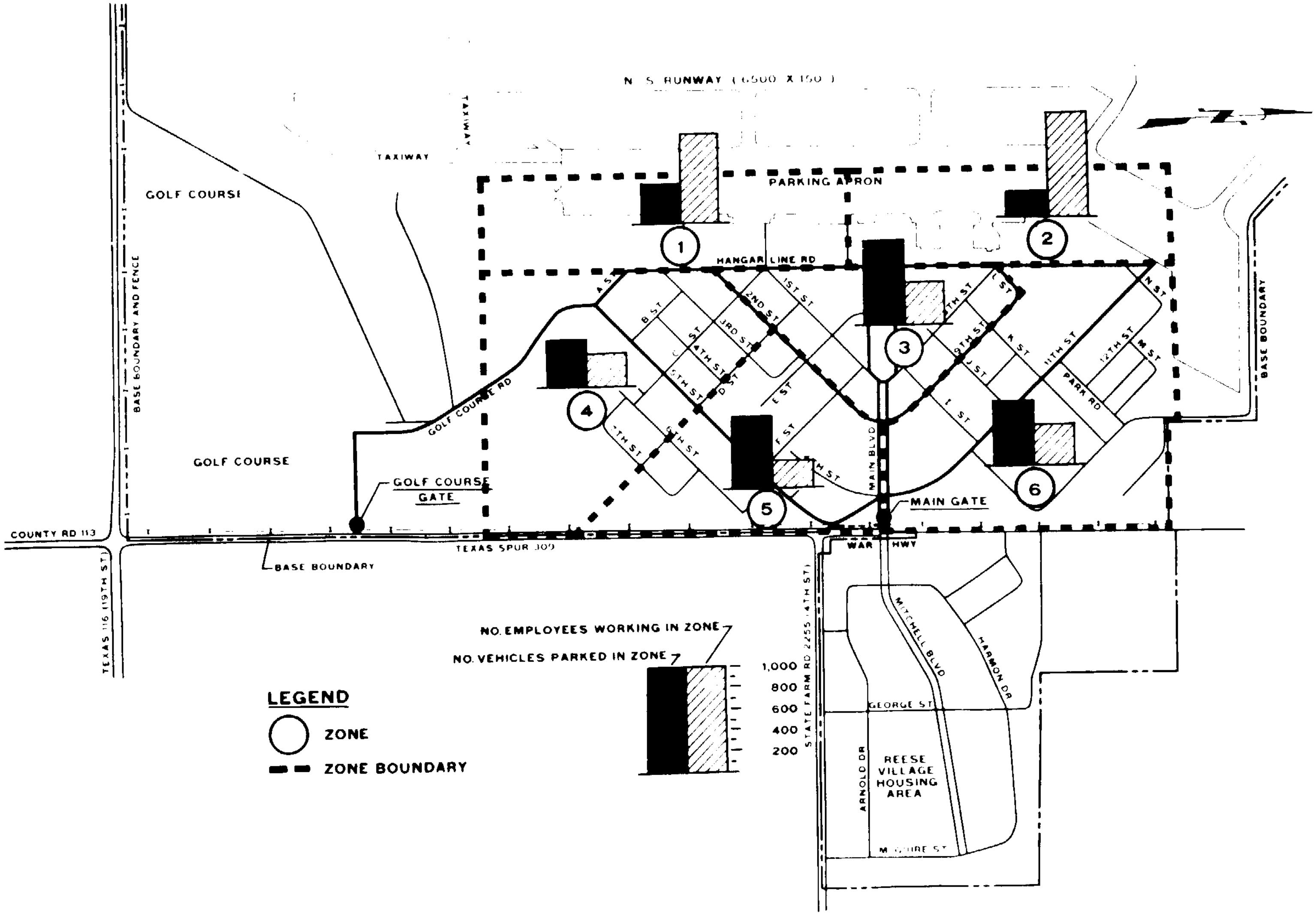


Figure 58. Typical map of relationship of vehicles parked in zone to employees working in zone by volume.

TABLE X
PARKING INVENTORY AND USAGE*

Zone	Off Street				On Street				Total		Pct	Total		Pct
	Gen		Res		Gen		Res							
	Empty	Filled	Empty	Filled	Empty	Filled	Empty	Filled	Empty	Filled	Filled	Gen	Res	Res
1	170	22	7	11	0	0	0	0	177	33	15.7	192	18	8.6
2	215	126	15	24	23	37	0	0	253	187	42.5	401	39	8.9
3	53	132	43	113	7	50	2	6	105	301	74.1	242	164	40.3
4	143	244	145	144	1	27	0	0	289	415	59.8	415	289	41.1
5	15	276	126	379	3	35	2	12	146	702	82.8	329	519	61.2
6	135	412	10	2	0	0	0	0	145	414	74.1	547	12	2.1
7	660	370	36	44	0	0	0	0	696	414	37.3	1,030	80	7.2
8	377	581	264	643	0	32	0	0	641	1,256	66.2	990	907	47.8
									(2,452)	(3,722)	60.4	(4,146)	(2,028)	32.9
Total	1,768	2,163	646	1,360	34	181	4	18	6,174			6,174		

*Data collected during the morning hours (0900-1200).

Figure 59. Typical parking inventory and usage table.

b. The physical characteristics of parking lots should be studied for deficiencies similar to the following:

(1) Entrance or exit located too close to an intersection.

(2) Deteriorated pavement surface and poor drainage.

(3) Inadequate dimensions of stalls, aisles, and entrances or exits.

(4) Deteriorated stall markings.

(5) Improper traffic-control signing.

(6) Poor circulation of traffic flow, particularly near driveways.

c. Space usage data can be analyzed by entering it on a summary sheet similar to that shown in figure 60. The duration of parking is determined by the number of consecutive times the same vehicle was observed in the same parking space and by the time period required for each round trip on the route. For example, if the time period for each round trip averages 15 minutes, then a vehicle that is observed only once would have a parking duration of 1 to 29 minutes or a mean of 15 minutes; if it were observed twice, then the duration would be 15 to 44 minutes or a mean of 30 minutes, and so forth. Other values in the summary are computed as follows:

PARKING UTILIZATION SUMMARY SHEET

LOCATION COMMISSARY

DATE 25 JULY 75 TIME 0800 TO 1800

PARKING DURATION (HR)	VEHICLES		VEHICLE HOURS PARKED		PARKING DURATION	VEHICLES		VEHICLE HOURS PARKED	
	NUMBER	PERCENT	NUMBER	PERCENT		NUMBER	PERCENT	NUMBER	PERCENT
0.25	120	17.1	30						
0.50	60	8.5	30						
0.75	200	28.4	150						
1.00	250	35.7	250						
1.50	54	7.7	81						
2.00	15	2.1	30						
2.50	3	0.4	7.5						
3.00	1	0.1	3						
CONTINUED NEXT COLUMN					TOTALS	703	100	581.5	100

AVERAGE DURATION 581.5/703 = .83 HR

PARKING SPACES AVAILABLE 60

LEGAL TIME LIMIT 1.00 HR

SPACE HOURS AVAILABLE 600

PERCENT OVERTIME 10.3

EFFICIENCY 581.5/600 = .97

Figure 60. Typical parking-utilization summary sheet.

Vehicle-hours = Parking duration (hours) x Number of vehicles parked for that length of time. (This is a cumulative total.)

Average duration = Total vehicle-hours ÷ Total vehicles parked.

Space hours of parking available = Number of spaces available for parking x Number of hours covered in study (100 spaces available during an 8-hour-study period represents 800 space-hours).

Utilization ratio = Total vehicle-hours used ÷ Space-hours available.

Percent overtime = Sum of figures in vehicle percent column for all durations longer than legal limits; the number of overtime parkers as a percentage of total parkers.

89. Application.

a. The practical uses of parking studies include determination of:

(1) Geographical distribution of parking supply on the installation as found in the parking-inventory study.

(2) Existing parking problem areas on the installation through the parking accumulation study. This study also allows comparison of parking demand with other factors such as installation population or land use.

(3) Areas where parking time limits are not consistent with usage and should either be changed or enforced more rigidly through the parker-duration and turnover study.

(4) Whether additional parking supply should be provided closer to parker destinations, through the results of parker interviews or questionnaires.

(5) Future parking needs as an integral part of new or expanded installation facilities. This can be done by directly relating existing characteristics such as employment, population, or floor space to the estimated future characteristics. DOD 4270.1-M, Construction Criteria Manual, contains parking authorization for land-use functions, such as barracks (app B).

b. There should be some surplus parking in any parking facility to reduce cruising or blocking of aisles while waiting for a vacant space and to provide a reasonable level of convenience for the user. The capacity of on-street parking spaces or employee off-street facilities is taken as 90 percent of its supply (10 percent of the stalls should be available at peak times). The practical capacity of off-street facilities that serve short-term customer or visitor parkers is 85 percent of the available stalls. When these allowances are made, the total deficiency or shortage (in terms of parking stalls) may be calculated.

c. Many times present problems may be relieved by better layout and organization of existing facilities. While parking-lot design is beyond the scope of this guide, the analyst should consider:

(1) Improving parking-lot layout (fig 61). Long-term parking stalls should be about 9 feet in width and high-turnover spaces should be about 9.5 feet. Reference TM 19-251 for additional guidance (app B).

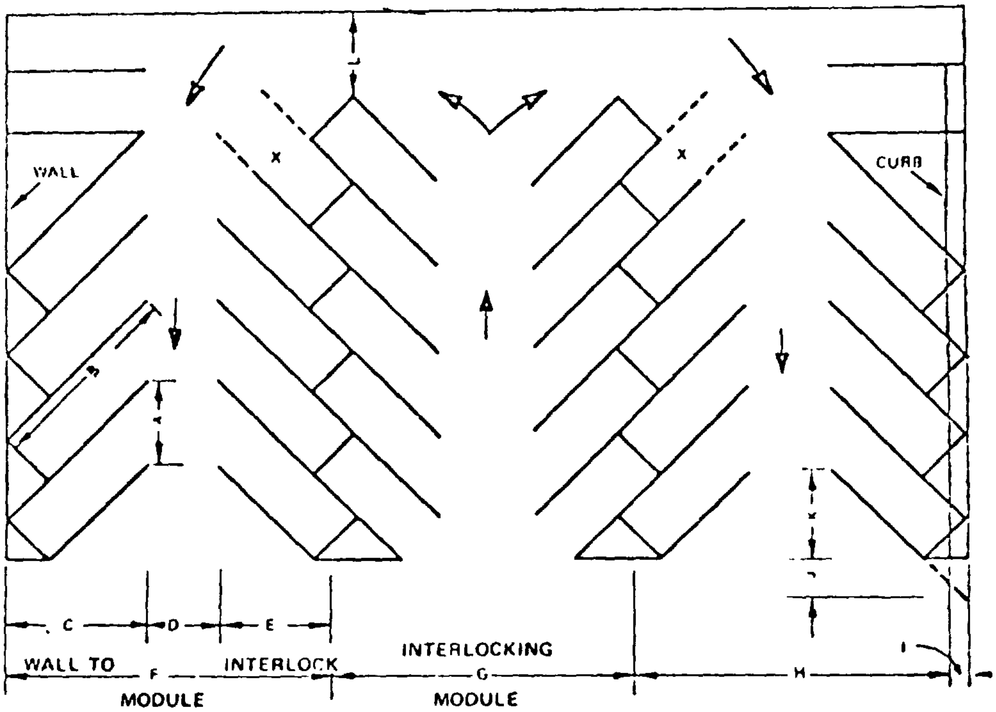
(2) Reducing the number of reserved spaces that are not being used often in order to reduce problems for other parkers.

(3) Setting aside areas for small or compact cars can increase the amount of parking supply by over 10 percent; these areas should be in a convenient location so that smaller cars will use them and not fill up normal-size spaces first. Stall sizes should be approximately 8 feet by 16 feet.

(4) Providing motorcycle and bicycle parking in separate areas so that conventional stalls will not be used.

(5) Setting and enforcing time limits on street and off street so that the desired vacancy levels are provided.

(6) Recognizing the fact that short duration parkers should be located closer to their destination than those with a longer duration; that is, the longer the parker will be at a destination, the farther he is willing to walk. Place short-time-limit parking stalls close to the destination.



X = STALL NOT ACCESSIBLE INCERTAIN LAYOUTS

PARKING LAYOUT DIMENSIONS (in feet) FOR 9-FT STALLS
AT VARIOUS ANGELES

Dimension	On Diagram	45°	60°	75°	90°
Stall width, parallel to aisle	A	12.7	10.4	9.3	9.0
Stall length of line	B	25.0	22.0	20.0	18.5
Stall depth to wall	C	17.5	19.0	19.5	18.5
Aisle width between stall lines	D	12.0	16.0	23.0	26.0
Stall depth, interlock	E	15.3	17.5	18.8	18.5
Module, wall to interlock	F	44.8	52.5	61.3	63.0
Module, interlocking	G	42.6	51.0	61.0	63.0
Module, interlock to curb face	H	42.8	50.2	58.8	60.5
Bumper overhang (typical)	I	2.0	2.3	2.5	2.5
Offset	J	6.3	2.7	0.5	0.0
Setback	K	11.0	8.3	5.0	0.0
Cross aisle, one-way	L	14.0	14.0	14.0	14.0
Cross aisle, two-way	–	24.0	24.0	24.0	24.0

Figure 61. Accepted dimensions for parking-area layout.

(7) Checking the layout dimensions of the facility with those in a standard reference to see if a different angle of parking will yield added stalls.

(8) Considering the use of temporary, remote parking lots tied into the destination with shuttle-bus routes for peak seasonal parking demands if sufficient bus capacity is available.

(9) Developing programs to increase vehicle occupancy and to reduce parking demand through car pools, with preferential parking spaces in best locations for high-occupancy vehicles (four persons or more).

SECTION XIV

STUDY REQUIREMENTS OF HIGHWAY SAFETY PROGRAM STANDARD 13

90. Purpose.

a. The Highway Safety Act of 1966 (Public Law 89-564) requires all Government agencies operating highway systems to comply with the Highway Safety Program Standards (HSPS) issued by the Secretary of Transportation. The purpose of the law is to establish a coordinated national highway safety program designed to reduce traffic fatalities, injuries, and other accidents.

b. In 1967, Executive Order 11357 established the National Highway Safety Bureau (NHSB) within the Federal Highway Administration (FHWA) of the Department of Transportation (DOT). The NHSB developed a Highway Safety Program Manual (HSPM), each volume of which is designed to provide guidance on preferred highway safety practices. Volumes comprising the manual are:

0 - Planning and Administration
1 - Periodic Motor Vehicle Inspection
2 - Motor Vehicle Registration
3 - Motorcycle Safety
4 - Driver Education
5 - Driver Licensing
6 - Codes and Laws
7 - Traffic Counts
8 - Alcohol in Relation to Highway Safety
9 - Identification and Surveillance of Accident Locations
10 - Traffic Records
11 - Emergency Medical Services
12 - Highway Design, Construction, and Maintenance
13 - Traffic Engineering Services
14 - Pedestrian Safety
15 - Police Traffic Services

16 - Debris Hazard Control and Cleanup
17 - Pupil Transportation Safety
18 - Accident Investigation and Reporting

c. Subsequent reorganization of DOT resulted in the separation of NHSB from FHWA, with FHWA retaining authority for administration of the highway-related safety standards. These standards are referred to as the "three-plus standards" and include:

(1) Identification and surveillance of accident locations.

(2) Highway design, construction, and maintenance.

(3) Traffic engineering services.

(4) Highway-related aspects of pedestrian safety. The Highway Act of 1970 established the National Highway Traffic Safety Administration (NHTSA) and assigned it responsibility to administer the safety programs standards pertaining to the automobile and the driver.

d. DOD Directive 5160.60 designates the Secretary of the Army as the executive agent for DOD for all matters pertaining to public highways and highway needs of other Federal agencies. In turn, MTMC is the liaison agent with public agencies for all highway traffic engineering matters within the DOD. Consequently, MTMC is responsible for coordinating the DOD program for implementing the Highway Safety Program Standard related to Traffic Engineering Services, or HSPS 13.

e. All installation roadways that are open to public, visitor, or dependent traffic are governed by HSPM 13. It is required that each installation submit through channels an annual report to MTMC who, in turn, will summarize the progress made toward compliance with the public law and submit a formal report to the Secretary of Transportation.

91. Information needed. To determine the status of the DOD traffic engineering program, installations are surveyed regarding their available expertise, traffic-control devices, and accident-recording procedures. Presented in figure 62 is a Highway Safety Program Standard 13 Status Report (MTMC Form 214 (TEST), which is used to collect this information.

92. Method. To complete MTMC Form 214, it may be helpful to perform the following studies as presented in part two of this pamphlet: Section II, "Street-Classification Study"; Section VI, "Traffic-Accident Study";

HIGHWAY SAFETY PROGRAM STANDARD 13 STATUS REPORT | *REPORTS CONTROL SYMBOL* MTMC-108

INSTRUCTIONS: *Read CAREFULLY the instructions before completing this form.*

THRU:	TO: Commander Military Traffic Management Command ATTN: MTMC-SA Washington, DC 20315	FROM: *(Installation)*

1. INSTALLATION CHARACTERISTICS	TOTAL
a. Employment population: MILITARY ______ CIVILIAN ______	
b. Military personnel residing on installation *(exclude dependents).*	
c. Retired military members in your area.	
d. Paved streets *(do not include collector streets in housing and remote training areas)* in miles: TWO LANE ______ FOUR LANE ______	
e. Intersections of two major streets.	
f. Intersections with traffic signals.	
g. Number of gates or entrances points: 24-HOUR OPERATION ______ PART-TIME ______	
2. PERSONNEL QUALIFICATIONS/APPLICATION	
a. Person with the most training and experience in traffic engineering: GRADE/RANK ______ YEARS OF EXPERIENCE ______	
b. Percentage of time person devotes to traffic engineering.	%
c. Formal education/training:	
(1) BA or BS college degree.	☐YES ☐NO
(2) College degree in engineering.	☐YES ☐NO
(3) Number of weeks in traffic engineering short courses.	
d. Man-hours devoted to traffic engineering annually by installation.	
e. Do other organizations contribute to the installation traffic engineering program? *(If "YES" name appropriate organization(s))*	☐YES ☐NO
3. TRAFFIC CONTROL DEVICES	TOTAL
a. Traffic signs on all streets *(exclude streets only in remote training areas).*	
(1) Guide *(exclude street name signs).*	
(2) Regulation.	
(3) Warning.	
b. Traffic sign faces not in conformance to the 1971 edition of MUTCD.	
(1) Guide *(exclude street name signs).*	
(2) Regulation.	
(3) Warning.	
c. Approximate number of signs posted at substandard heights:	
(1) Less than 5 feet with parking prohibited.	
(2) Less than 7 feet with parking permitted.	
d. Number of STOP or YIELD signs on installation.	
e. Number of STOP or YIELD signs posted on same support as other signs.	
f. Is a permanent sign inventory map record maintained.	☐YES ☐NO
g. At signalized locations, how many intersections are provided with only a single traffic signal unit *(i.e., one set of indicators per approach)? (see chapter IV, MUTCD)*	
h. Percentage of streets *(reference 1d above)* that are not painted *(striped)* in accordance with MUTCD.	
(1) All paved *(reference 1d above).*	%
(2) Major streets only.	%
i. Dollar value to bring installation traffic control devices up to that contained in MUTCD: SIGNS ______ MARKINGS ______ SIGNALS ______	$
j. Are appropriate orange and black signs used in maintenance and construction operations? *(see chapter VI, MUTCD.)*	☐YES ☐NO
4. ACCIDENTS OCCURRING ON INSTALLATION ROADS	TOTAL
a. Number of accidents occurring ON STREETS during the last 12 months:	
(1) Property damage: DISABLING ______ FUNCTIONAL ______ OTHER ______	
(2) Personal Injury.	
(3) Fatality.	

SAMPLE

MTMC FORM 1 APR 75 214 (TEST) EDITION OF 1 FEB 74 IS OBSOLETE.

Figure 62. Highway Safety Program Standard 13 status report.

4. ACCIDENTS OCCURRING ON INSTALLATION ROADS (CON'T) — TOTAL

b. Number of accidents occurring OFF STREETS during the last 12 months:

(1) Property damage: DISABLING ________ FUNCTIONAL ________ OTHER ______

(2) Personal Injury. ______

(3) Fatality. ______

c. Number of ON STREET locations with four or more accidents during the last 12 months ______

d. Is an accident spot map maintained on annual basis? ______ ☐ YES ☐ NO

e. Has spot map data been retained for each of the previous three years? ______ ☐ YES ☐ NO

f. Which of the following information is recorded for your records concerning each accident:

☐ Cause ☐ Type ☐ Date ☐ Time ☐ Weather ☐ Collision diagram

☐ Property damage estimate ☐ All of these

5. ENERGY CONSERVATION

a. Which of the following carpooling aids and/or incentives do you use to reduce traffic congestion, accidents, and gasoline consumption:

☐ Manual (map) locator system ☐ Computerized locator system

☐ Publicity Techniques ☐ Preferential parking

☐ Flexible duty-hours ☐ Other______ — TOTAL

b. Approximate vehicle-occupancy ratio for your installation. ______

REMARKS:

SAMPLE

TYPED NAME, TITLE AND TELEPHONE NUMBER	SIGNATURE	DATE

Figure 62 - cont.

and Section VII, "Traffic-Control-Devices Inventory." Other information required by the form can come from statistical reports or by questioning installation officials. Data should be updated annually or as required by the status report.

93. Analysis. As problems or deficient areas are uncovered during the preparation of this status report, apply the required analyses described in the individual study sections of this guide.

94. Interpretation. HSPM 13 requires that the installation have an ongoing traffic-engineering program to reduce the number and severity of traffic accidents. The specific objectives are:

"a. To provide the needed traffic engineering expertise to develop traffic-control plans and programs in all jurisdictions.

"b. To identify both the short-term and long-range need for traffic-control devices.

"c. To apply warrants for the application of traffic-control devices.

"d. To upgrade periodically existing traffic-control devices on all streets and highways to conform with standards issued or endorsed by the Federal Highway administrator.

"e. To ensure that the need for new traffic-control devices has been determined by adequate traffic-engineering studies.

"f. To inspect periodically and maintain all traffic-control devices.

"g. To devise methods for correcting hazardous roadway deficiencies and for installing improved features when modifications to the roadway are made.

"h. To provide the necessary authority, personnel, equipment, and facilities for carrying out these efforts.

"i. To evaluate the safety adequacy of the roadway, including its capacity and efficiency."

The traffic-engineering activities of each installation shall be compared with the above goals.

95. Application. In the process of completing the HSPS 13 status report, many installations will uncover deficiencies in their program. It is up to the installation to correct those deficiencies. Most of the concepts of HSPM 13 are included in specific sections of this guide. The following areas are particularly important:

a. A traffic-control-device plan including:

(1) An inventory of all traffic-control devices.

(2) Periodic review of existing traffic-control devices, including a systematic upgrading of substandard devices to conform with standards of the MUTCD.

(3) A maintenance schedule adequate to insure proper operation and timely repair of control devices, including daytime and nighttime inspections.

(4) Application and evaluation of new ideas and concepts in applying control devices and in modifying existing devices to improve their effectiveness through controlled experimentation.

b. An implementation schedule that will utilize traffic-engineering manpower to:

(1) Review road projects during the planning, design, and construction stages to detect and correct features that may lead to operational safety difficulties.

(2) Install safety-related improvements as a part of routine maintenance and/or repair activities.

(3) Correct conditions noted during routine operational surveillance of the roadway system to adjust rapidly for the changes in traffic and road characteristics as a means of reducing accident frequency or severity.

(4) Conduct traffic-engineering analyses of all high-accident-frequency locations, and develop corrective measures.

(5) Analyze potentially hazardous locations such as sharp curves, steep grades, and railroad grade crossings, and develop appropriate countermeasures.

(6) Identify traffic-control needs, and determine short- and long-range requirements.

(7) Evaluate the effectiveness of specific traffic-control measures in reducing the frequency and severity of traffic accidents. This implies documentation and benefit/cost analysis of before/after data (app E).

(8) Conduct traffic engineering studies to establish traffic regulations such as fixed or variable speed limits.

(MTT-SE)

FOR THE COMMANDER:

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APPENDIX A

DEFINITIONS OF TRAFFIC ENGINEERING TERMS

Assignment. The theoretical allocation of design year traffic to a proposed or existing highway network.

Beacon. A bright-flashing traffic warning signal (yellow or red).

Clearance interval. The time during which the signal indication following the green interval is displayed to permit pedestrians or vehicles to clear the intersection (generally yellow).

Capacity. The maximum number of vehicles per hour that can reasonably be expected to pass over a given section of a lane or a roadway in one direction (or in both directions for two- or three-lane highway) under prevailing roadway and traffic conditions. Capacity corresponds to level of service E with speeds about 30 miles per hour and unstable flow with frequent stoppages and long delays.

Capacity, design. A term denoting the traffic volumes that result in level of service C, the level typically associated with urban design practice. At level of service C, stable operation continues although an occasional vehicle backup may develop.

Classification heirarchy. The designation of a system of roadways according to geometric characteristics and traffic served: freeway, expressway, parkway, arterial routes (primary streets), collector streets (secondary), local streets (tertiary), and finally cul-de-sacs. Also called functional classification.

Condition diagram. A schematic drawing of a section of road or parking area showing all dimensions and traffic-control devices.

Delay. The time consumed while traffic (or a specified component of traffic) is impeded in its movement by some element over which it has no control; usually expressed in seconds or minutes per vehicle. A lower delay is observed in off-peak periods than during traffic peaks.

Delineators. Light-reflecting devices, usually in groupings, mounted along the shoulder, to indicate the alignment and direction of the roadway. May also indicate the location of hazard.

Delineators, pavement. Raised, reflective marker disks attached to the pavement surface, usually along the center, lane, or edge line.

Detector. Radar, sonic, magnetic, loop, or road tube devices to indicate or record vehicle presence or passage.

Flow, interrupted. A condition in which a vehicle traversing a roadway is required to stop by a cause outside the traffic stream, such as signs or signals at an intersection or a junction. Stoppage of vehicles by causes internal to the traffic stream does not constitute interrupted flow.

Flow, uninterrupted. A condition in which a vehicle traversing a roadway may be stopped by causes internal to the traffic stream, but is not required to stop by any cause external to the traffic stream.

Highway. The entire width between boundary lines of every publicly maintained trafficway when any part thereof is open to the use of the public for purposes of vehicular travel.

Highway, arterial. A general term denoting a highway primarily for moving large volumes of through traffic; usually on a continuous route.

Highway, limited access. Every highway, street, or roadway in respect to which owners or occupants of abutting lands and other persons have no legal right of access to or from the same except at such points only and in such manner as may be determined by public authority having jurisdiction over such highway, street, or roadway.

Intersection. The general area where two or more highways join or cross, within which are included the roadway and roadside facilities for traffic movements in that area.

Intersection approach. Those lanes of an intersection leg that are used by traffic moving towards the intersection; for example, the northern approach.

Intersection leg. One of the roadways radiating from and forming part of an intersection.

Islands, channelizing. A traffic island located in a roadway area to confine specific movements of traffic to definite channels.

Lane, reversible. A lane where traffic moves in one direction only during some period of time, then in the reverse direction during another period of time.

Level of service. A qualitative measure of the effect of a number of factors, which include speed, travel time, traffic interruptions, freedom of maneuver, safety, driving comfort and convenience, and operational costs. Usually given a letter grade from A to F with A being free-flow; E, capacity; and F, forced-flow.

Line, center. A single or double yellow line painted along the roadway, separating opposing traffic flow. The paint may be reflectorized by the addition of glass beads to the wet paint.

Line, edge. The solid white line that indicates the edge of the roadway.

Line, lane. A solid or dashed white line separating two lanes of traffic moving in the same direction.

Origin and destination study. An analysis of the number, purpose, and mode of trips from various zones of origin to various zones of destination.

Parking, accumulation. The cumulative number of vehicles parked at a facility, at any given point of time.

Parking, demand. The requirement for parking space as indicated by the number of drivers having the study site as a destination; stated in terms of spaces (or space-hours).

Parking, generator. A land use that is a desirable trip-end, and thus creates a demand for parking space.

Parking, need. The difference between parking demand and parking supply; stated in terms of spaces (or space-hours).

Parking, peak-hour. The highest accumulation of parked vehicles during 60 consecutive minutes.

Parking, supply. The total number of spaces (or space-hours) legally available for parking.

Parking, utilization. At a given point in time, the ratio formed when accumulation is divided by supply; stated in terms of vehicles per space, or as a percentage. A peak utilization of 0.85 vehicle/space is sometimes used as a design standard.

Peak-hour factor (PHF). A numerical factor indicating the magnitude of the highest traffic flow observed during the entire peak-hour. The PHF is a number between 0.00 and 1.00, where a smaller number indicates more severe peaking. The peak-hour factor is formed by taking the ratio:

$$PHF = \frac{\text{Peak-hour volume}}{4 \times (\text{highest 15-minute volume})}$$

Planning, transportation. Planning is the effectuation of predetermined goals. Transportation planning is the process by which transportation improvements or new facilities are systematically conceived, tested as to adequacy, and programed for future construction. The planning process is composed of the following elements: organizing, stating the objectives, obtaining the information, preparing and evaluating land use and transportation plans within the framework of the objectives, selecting the best plan, and working for its adoption and implementation.

Roadway. That portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the berm or shoulder. In the event a highway includes two or more separate roadways, the term "roadway," as used herein, refers to any such roadway separately but not to all such roadways collectively.

Sign, guide. A sign used to direct traffic along a route or toward a destination; or to give information concerning places or points of interest.

Sign, regulatory. A sign used to indicate regulations governing use of the highway.

Sign, traffic. A device mounted on a fixed or portable support whereby a specific message is conveyed by means of words or symbols, officially erected for the purpose of regulating, warning, or guiding traffic.

Sign, warning. A sign used to indicate actual or potential hazards to highway users.

Signal, controller. The timing mechanism that determines the phase and cycle length of a traffic signal. May be connected to other controllers to form a signal system, in which case the controller also determines the "offset" between signals.

Signal, cycle. The time period required for one complete sequence of signal indications.

Signal, offset. From a reference point, the time difference from signal-to-signal along a system, which permits progressive traffic flow along a street.

Signal, phase. The portion of the total time cycle allocated to the right-of-way of a given traffic movement, or to any combination of traffic movements that receive the right-of-way simultaneously. Thus the cycle length is divided into two or more phases.

Signal, pretimed. A type of traffic-control signal that directs traffic to stop and permits it to proceed in accordance with predetermined time schedules.

Signal, progressive. A system of synchronized signals that provides a green indication as traffic progresses along a street.

Signal, traffic-actuated. A type of traffic-control signal in which the intervals are varied in accordance with the demands of traffic as registered by the actuation of detectors. Often qualified with the terms: semi-, partially-, totally-, or fully-.

Signal, traffic-control. Any device whether manually, electrically, or mechanically operated by which traffic is alternately direct to stop and permitted to proceed.

Speed, 85-percentile. That speed at or below which 85 percent of vehicles travel. Good engineering practice often picks the 85-percentile speeds as the posted speed limit.

Streets, local. Roadways, the main purpose of which is to provide access to abutting property. Moving traffic is an incidental function of local streets.

Streets, primary. All roads or streets on the installation that serve as the main distributing arteries for traffic originating within or without the installation. They provide access to, through, and between the various functional areas of the installation.

Streets, secondary. All installation roads and streets that supplement the primary highway system by providing access within the various functional areas, as well as travel to and between.

Thoroughfare plan. The proposed physical layout of a network of primary streets and highways. The network may be composed of radial, circumferential, and transverse elements.

Traffic accident. Any event involving a vehicle in motion on a roadway, which results in unintended death, injury, property damage, or loss. A single accident may involve several vehicles. Only vehicles that were originally in contact with the road or sidewalk should be included. (Only those accidents involving loss in excess of $100 are included in this report.)

Traffic-control devices. All signs, signals, markings, and devices placed or erected for the purpose of regulating, warning, or guiding traffic, by authority of a public body of officials having jurisdiction.

Traffic engineering. That phase of engineering that deals with the planning and geometric design of streets, highways, and abutting lands and with traffic operation thereon, as their use is related to the safe, convenient, and economic transportation of persons and goods.

Traffic lane. A strip of roadway intended to accommodate and delimit the movement of a single line of vehicles.

Traffic markings. All lines, patterns, words, colors, or other devices (except signs), which may be set into the surface of, applied upon, or attached to either the pavement, curbing, or objects within or adjacent to the roadway. They are officially placed for the purpose of regulating, warning, or guiding traffic.

Traffic, peak. The maximum traffic flow in a given circumstance, usually stated in vehicles per hour.

Traffic, peak-hour. The highest number of vehicles observed to traverse a section of roadway during 60 consecutive minutes.

Traffic, through. That part of the traffic circulating within a given area, or at a given point in that area, having neither origin nor destination within the area.

Trip, person. A one-way trip from origin to destination by an individual person.

Person trips = Vehicle trips x Vehicle occupancy

Trip, vehicle. A one-way trip from origin to destination performed by a vehicle, regardless of the number of passengers.

Vehicle. Any wheeled device for conveying persons or property upon a roadway, excluding devices moved by human power, or moving upon fixed tracks.

Vehicle occupancy. The number of persons traveling in a vehicle expressed as the ratio of persons per vehicle.

Volume. The flow rate of traffic on a given roadway, usually stated in vehicles per hour.

Warrant. A set of formally stated conditions that have been accepted as minimum justification for installation of traffic-control devices or regulations.

Weaving. The crossing of traffic streams moving in the same general direction, accomplished by merging and diverging along a considerable length of highway.

APPENDIX B

BIBLIOGRAPHY

1. The following publications are considered applicable and provide a valuable source of information on subjects pertinent to this pamphlet:

2. DOD Literature

4270.1-M, Construction Criteria Manual

5160.60, 26 April 1973, Highways for National Defense

3. Joint Regulations

AR 55-80/OPNAVINST 11210.1/AFR 75-88/MCO 11210.2A/ DSAR 4500.19, Highways for National Defense, 2 Aug 1974

AR 190-5/OPNAVINST 11200.5A/AFR 125-14/MCO 511.1A/ DSAR 5720.1, Motor Vehicle Traffic Supervision, 29 Sep 1970

4. Army Regulations

AR 210-4, Car Pooling and Parking Controls

AR 210-20, Master Planning for Permanent Army Installations

AR 385-10, Army Safety Program

AR 385-30, Safety Color Code Markings and Signs

AR 385-40, Accident Reporting and Records

AR 385-41, US Army Accident Codebook

AR 385-55, Prevention of Motor Vehicle Accidents

AR 415-31, Construction, Basic Housing and Space Allocations of Permanent Installations

5. Air Force Regulations

AFR 86-4, Master Planning

6. Technical Manuals

TM 5-803-1, Master Planning Principles and Procedures

TM 5-803-3, Site Planning-General

TM 5-803-6, Planning of Community Centers

TM 5-803-10, Site Planning of Family Housing Areas

TM 5-818-2, Pavement Design for Frost Conditions

TM 5-820-4, Drainage Facilities for Roadways and Builtover Areas

TM 5-822-1, Roads, Streets, and Pavement Generally--Traffic Study Requirements

TM 5-822-2, (AFM 88-7, Chapter 5) Roads, Streets, Walks, and Open Storage Areas--General Provisions and Geometric Design

TM 5-822-3, (AFM 88-7, Chapter 3) Roads, Streets, Walks, and Open Storage Areas--Parking for Non-Organizational Vehicles (Draft Only)

TM 5-822-4, Roads, Streets, Walks, and Open Storage Areas--Soil Stabilization for Roads and Streets

TM 5-822-5, Roads, Streets, Walks, and Open Storage Areas--Flexible Pavement Design

TM 5-822-6, Roads, Streets, Walks, and Open Storage Areas--Rigid Pavement Design

TM 19-251, Traffic Control Studies

7. Air Force Manuals

AFM 86-4, Standard Installations Facility Requirements

AFM 86-6, Air Base Master Planning

AFM 88, Facility Design

8. Field Manuals

FM 19-25, Military Police Traffic Control

FM 19-26, Traffic Accident Investigation

NAVFAC OM-5, Civil Engineering

9. Other Publications

A Policy on Design of Urban Highways and Arterial Streets, American Association of State Highway Officials, Washington, DC (1973).

A Policy on Geometric Design of Rural Highways, American Association of State Highway Officials, Washington, DC (1965).

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Wohl, Martin, and Martin, Brian V., Traffic System Analysis for Engineers and Planners, McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York, NY 10036 (1967).

10. Resource Organizations

American Association of State Highway and Transportation Officials (AASHTO)
341 National Press Building
Washington, DC 20004

American Automobile Association (AAA)
811 Gatehouse Road
Falls Church, VA 22042

Eno Foundation for Transportation
Saugatuck, CT 06880

US Department of Transportation
Federal Highway Administration
c/o FHWA Office of Traffic Operations
400 - 7th Street, SW
Washington, DC 20590

Highway Research Board (HRB)
2101 Constitution Avenue, NW
Washington, DC 20003

Highway Users Federation for Safety and Mobility (HUFSAM)
200 Ring Building
Washington, DC 20036

Illuminating Engineering Society
345 East 47th Street
New York, NY 10017

Institute of Traffic Engineers (ITE)
1815 N Fort Myer Drive, Suite 905
Arlington, VA 22209

Insurance Institute for Highway Safety (IIHS)
2600 Virginia Avenue, NW
Washington, DC 20037

Public Administration Service
American Public Works Association
1313 East 60th Street
Chicago, IL 60637

National Safety Council (NSC)
425 North Michigan Avenue
Chicago, IL 60611

Superintendent of Documents
US Government Printing Office
Washington, DC 20402

APPENDIX C

FEDERAL HIGHWAY ADMINISTRATION REPORTING FORMS FOR TRAFFIC-CONTROL-DEVICE INVENTORY

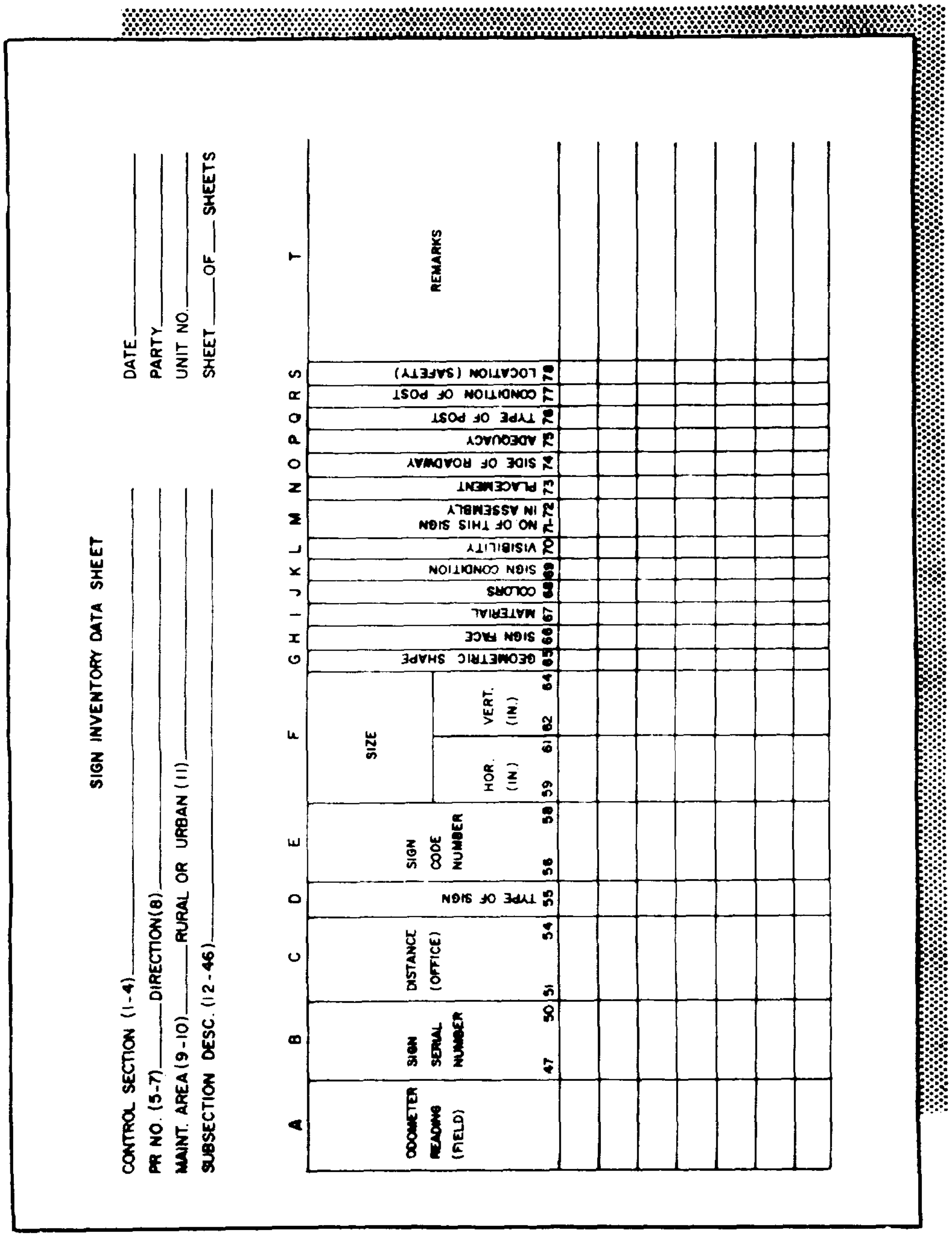

Figure 63. Sign inventory data sheet.

Column	Item	Code
1 - 4	Control section	Number assigned
5 - 7	Project number	Number assigned
8	Direction traveling while recording data	N, S, E, W
9 - 10	Maintenance area	Number assigned
11	Rural or urban	R or U
12 - 46	Subsection description	Describe beginning and ending points as well as route being inventoried. Select easily identified points and abbreviate. Example: W. Co. Line to N. L. St. Cloud for west county line to north limit, St. Cloud. (note: all column spaces may not be needed)
	Odometer reading	Actual mileage recorded - coded as distance from reference point (column C)
47 - 50	Sign serial number	Begin at 0000 for each subsection and number successive signs consecutively
51 - 54	Distance	Computed in office using odometer readings from a reference point noted in the subsection description

Figure 64. ADP coding instructions for sign inventory.

Column	Item	Code
55	Type of sign	0 - warning signs 1 - regulatory signs 2 - route markers, including assemblies 3 - destination, distance and information signs 4 - fixed advertising signs 5 - movable advertising signs 6 - church signs 7 - service signs 8 - signs not on inventory list, note details in remarks column
56 - 58	Sign code number	Use predetermined code listing, example: 010 - Turn symbol (left) 070 - Cross road symbol
59 -61	Horizontal dimension	Code actual dimension in inches
62 - 64	Vertical dimension	Code actual dimension in inches
65	Geometric shape	0 - rectangular 1 - square 2 - diamond 3 - octagon 4 - triangle 5 - circular 6 - shield (specify) 7 - others (specify)
66	Sign face	0 or A* - reflective sheeting 1 or B* - enamel 2 or C* - refl. buttons, nonrefl. background

Figure 64 - cont.

Column	Item	Code
66	Type of sign (cont.)	3 or D* - refl. buttons, refl. background 4 or E* - refl. letters, nonrefl. background 5 or F* - refl. letters, refl. background 6 - internally illuminated * Use when external illumination is provided
67	Material	0 - steel (flat) 1 - steel (embossed) 2 - aluminum 3 - wood 4 - other (fiber-glass, plastic, etc.)
68	Colors	0 - black on white 1 - white on black 2 - white on red 3 - red on white 4 - white on green 5 - green on white 6 - black on yellow 7 - black on orange 8 - white on blue 9 - red, white, and blue A - other (specify)
69	Sign condition	G - good condition B - rusty, bent, or damaged S - needs repair or straightening F - faded R - poor reflectivity L - not legible

Figure 64 - cont.

Column	Item	Code
70	Visibility	0 - easily seen 1 - hidden by official sign 2 - hidden by advertising sign 3 - hidden by parked vehicles 4 - hidden because of curve 5 - hidden because of hill 6 - hidden by other objects (trees, brush, light poles, etc.) 7 - other (specify)
71 -72	Number of signs in assembly	01 - first sign 02 - second sign 03 - third sign, etc.
73	Placement of sign	O - overhead G - ground mount
74	Side of roadway	R - right side L - left side
75	Adequacy	0 - standard as per MUTCD 1 - nonuniform - replace with uniform sign 2 - nonstandard - remove, do not replace 3 - add this sign 4 - other (specify)
76	Type of post	0 or A* - steel channel or U 1 or B* - steel round 2 or C* steel H-beam 3 or D* - steel rectangular 4 or E* - wood 4 x 4 5 or F* - wood 4 x 6 6 or G* - wood 6 x 6 7 or H* - wood round 8 - light or power pole 9 - other (specify) * Use where post is considered breakaway or frangible

Figure 64 - cont.

Column	Item	Code
77	Condition of post	0 - satisfactory 1 - replace 2 - straighten 3 - paint 4 - straighten and paint 5 - sign too low 6 - sign too high
78	Location (safety)	0 - satisfactory 1 - relocate behind existing guardrail 2 - relocate on lighting or power pole 3 - place on support with another sign 4 - relocate on over-crossing structure 5 - move farther away from roadway 6 - move to better location up or down roadway 7 - needs guardrail protection
	Remarks	Use where special information about sign is to be inserted.

Figure 64 - cont.

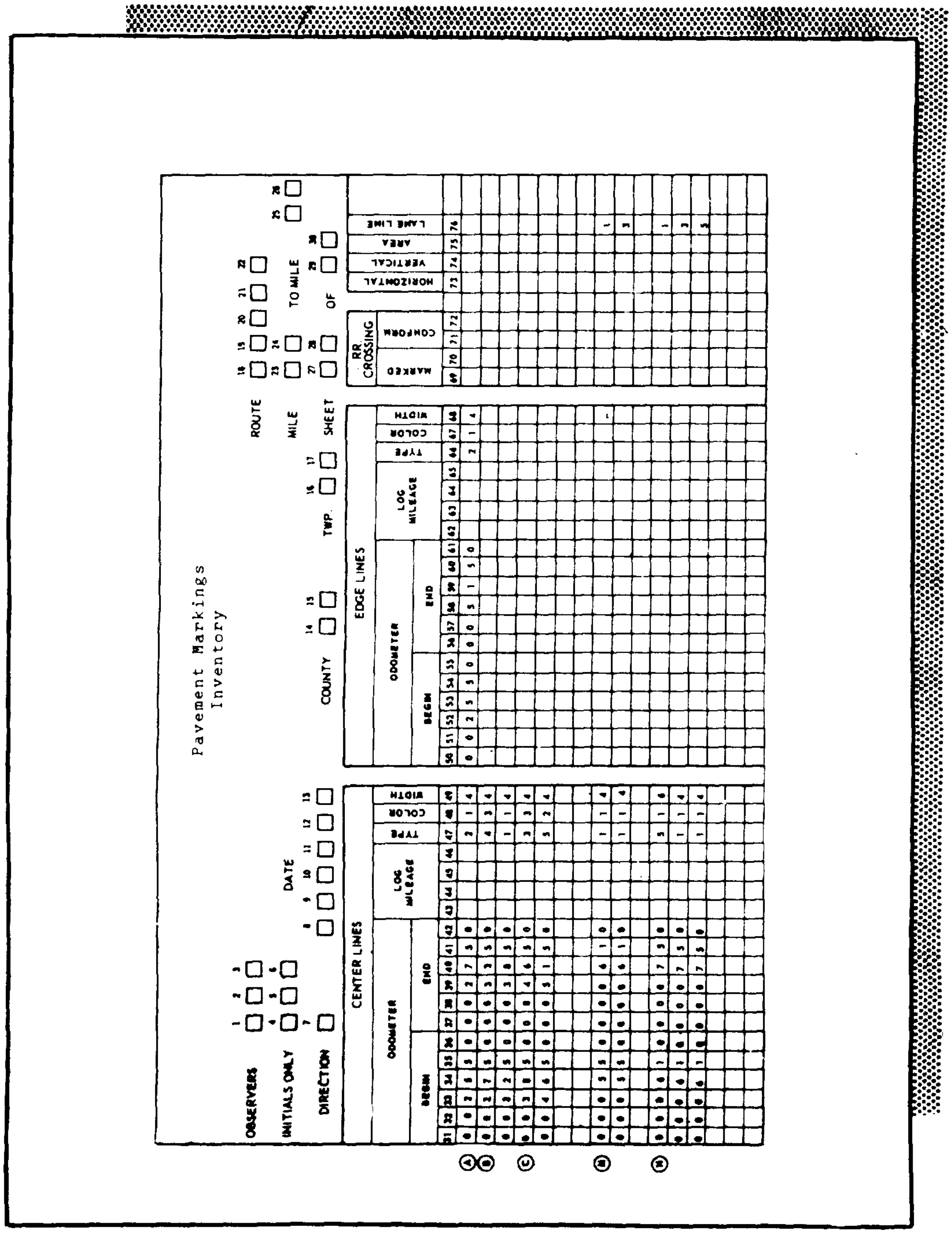

Figure 65. Pavement markings inventory.

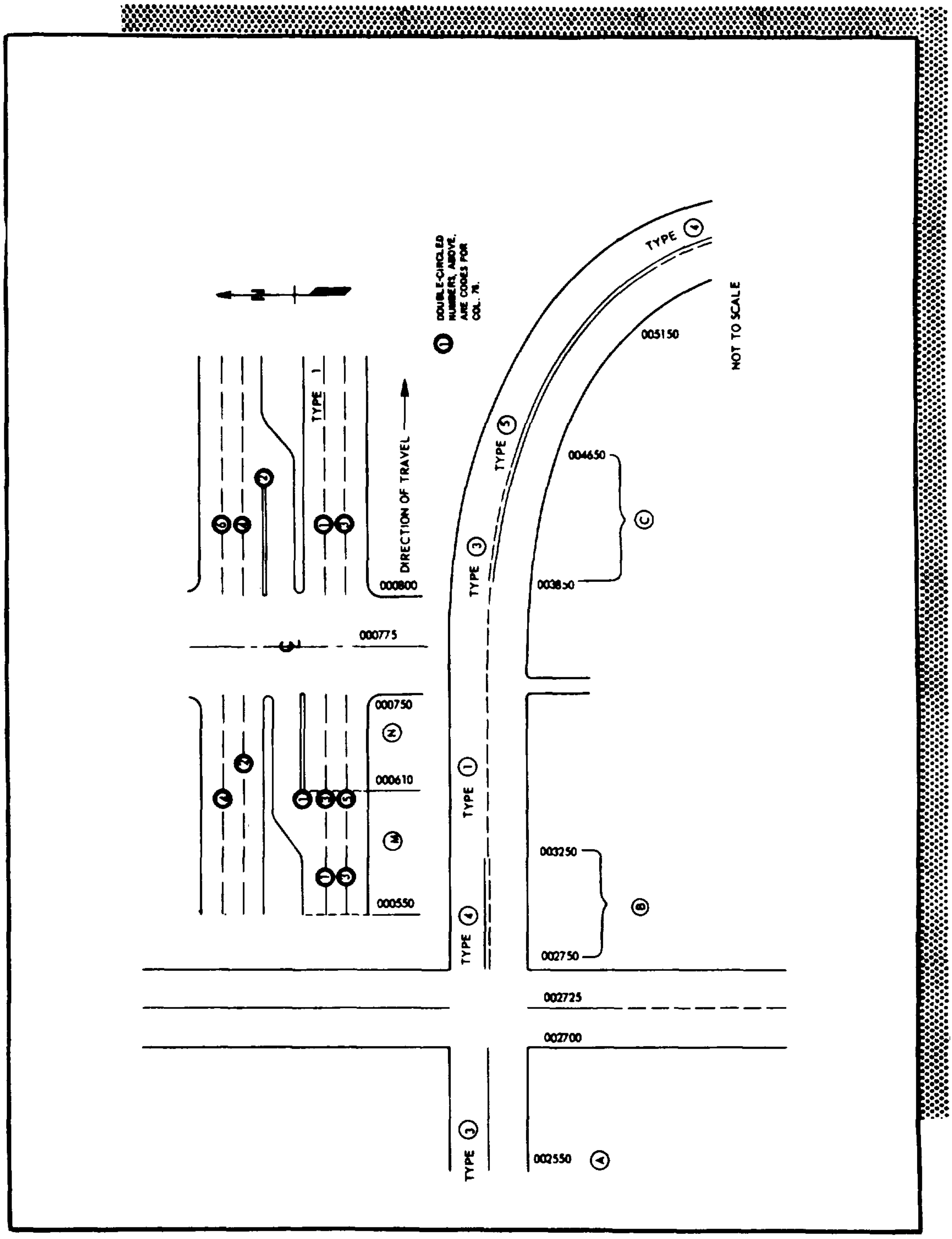

Figure 66. Graphic representation of markings.

Column	Item	Code
1 - 6	Identification of observers	Enter initials
7	Direction traveling while recording	N, S, E, W
8 - 13	Date	Code in numeric form, e.g. June 25, 1967 = 06 25 67
14 - 15	County or equivalent	Use number assigned
16 - 17	Township, if appropriate	Use number assigned
18 - 21	Route	Use number assigned or actual route number
22	Route type	A - alternate B - business S - spur
23 - 26	Length of study section	Code actual miles
27 - 30	Sheet identification	Code number of pages
31 - 36	Beginning of a particular type center line	Code actual odometer reading
37 - 42	End of a particular type of center line	Code actual odometer reading
43 - 46	Mileage of a particular marking	Calculate from odometer readings
47	Marking type	1 - dashed 2 - solid 3 - dashed left, solid right 4 - solid left, dashed right 5 - solid left, solid right 0 - none

Figure 67. ADP coding instructions for markings inventory.

Column	Item	Code
48	Marking color	1 - white, only 2 - yellow, only 3 - white dashed, yellow solid 4 - yellow dashed, white solid
49	Marking width	Code actual width in inches
50 - 55	Beginning of an edge line	Code actual odometer reading
56 - 61	End of an edge line	Code actual odometer reading
62 - 65	Mileage of a section of edge line	Calculate from odometer readings
66	Marking type	As for center lines
67	Marking color	As for center lines
68	Marking width	Code actual width in inches
69 - 70	Railroad crossing markings	1 - crossing marked 2 - crossing not marked
71 - 72	Railroad crossing markings type	1 - markings conform to standard 5 - markings are incomplete 9 - markings do not conform
73	Horizontal curve	1 - curve present
74	Vertical curve	1 - curve present
75	Area type	1 - urban 9 - rural

Figure 67 - cont.

Column	Item	Code
76	Lane line	Record length in center line section Code of lines on right side 1 - first lane from center 3 - second lane from center 5 - third lane from center Code for lines on left side 2 - first lane from center 4 - second lane from center 6 - third lane from center, etc.

Figure 67 - cont.

Column	Item	Code
1 - 5	Intersection Code	Number assigned to each intersection
6 - 9	Date of Coding - Month and Year	01 = Jan., etc. 68 = 1968, etc.
10	Type of Intersection	1 - Four leg or regular 2 - Tee; 3 - Wye; 4 - Irregular; 5 - Jogged 6 - Circle; 7 - 5 legs; 8 - 6 legs; 9 - 7 legs; A - 8 legs; B - other
11	Number of Approaches	Code direct; when number is more than 9; A = 10; B - 11, etc.
12	Approaches with a Single Indication (Nonstandard)	Same as Column 11
13	Approaches - Nonstandard Signal Location or Operation	Same as Column 11
14	Number of Phases	Same as Column 11
15	Leading Protected Left Turn	0 = No; 1 = one approach; 2 = two approaches, etc.
16	Lagging Protected Left Turn	Same as Column 15
17	Leading Protected Right Turn	Same as Column 15
18	Lagging Protected Right Turn	Same as Column 15
19	All Red Clearance	1 = yes; 2 = no
20	Part-Time Flashing Operation	1 = yes; 2 = no

Figure 68. ADP coding instructions for signal inventory.

Column	Item	Code
21	Pedestrian Phases	1 = No pedestrian signals 2 = All walk phase 3 = Flashing "walk" (or blank out) 4 = Steady "walk" for at least one crosswalk 5 = Flashing "walk" and steady "walk," at least one crosswalk
22	Type of Controller	1 = Pretimed; 2 = pretimed with actuated demand 3 = Semiactuated 4 = Fully actuated 5 = Volume density; 6 = Volume density with actuated minor movement units; 7 = Special unit in a computerized system
23	Solid State	1 = yes; 2 = no
24	Controller Manufacturer	Code manufacturers signal number i.e. -1 = Eagle; 2 = Automatic signal, etc.
25	Location of Controller	1 = NW corner; 2 = NE corner; 3 = SE corner; 4 = SW corner; 5 = Center in intersection 6 = Northerly; 7 = Easterly; 8 = Southerly; 9 = Westerly
26 - 27	Year Installed	Last two digits of year
28	Number of Intersections Controlled by this Controller	Code direct; when number is more than 9; A = 10; B= 11, etc.
29	Type of Interconnection	1 = telephone wire; 2 = cable; 3 = radio; 4 = cable & decoder; 5 = radio & cable; 6 = coordinated noninterconnected synchronous system; 7 = isolated

Figure 68 - cont.

Column	Item	Code
30	Number of Dials Installed	Code direct
31	Number of Dials in Use	Code direct
32	Number of Dials Possible	Code direct
33	Number of 1 Section Signal Faces	Code direct
34 - 35	Number of 3 Section Signal Faces	Code direct
36 - 37	Number of 4 Section Signal Faces	Code direct
38	Number of 5 Section Signal Faces	Code direct
39	Number of 6 Section Signal Faces	Code direct
40 - 41	Number of Arrow Indications	Code direct
42 - 43	Number of 12-inch lenses	Code direct
44	Number of 12-inch Arrow Indications	Code direct
45 - 46	Number of Tunnel Visors	Code direct
47	Number of Louvers	Code direct
48	Number of Backplates	Code direct
49	Number of Incandescent Pedestrian Signals	Code direct
50	Number of Neon or Blank Out Pedestrian Signals	Code direct
51	Number of Illuminated "NO LEFT TURN," or "NO RIGHT TURN"	Code direct

Figure 68 - cont.

Column	Item	Code
52	Number of Vehicle Detectors	Code direct; when number is more than 9; A = 10, B = 11, etc.
53	Number of Radar Detectors	Code direct
54	Number of Inductive Loop Detectors	Code direct
55	Number of Magnetic Loop Detectors	Code direct
56	Number of Pressure Pad Detectors	Code direct
57	Number of Ultrasonic Detectors	Code direct
58	Number of Pedestrian Detectors	Code direct
	Post and Poles on Which Signals are Mounted	
59 - 60	Number of Metal Street Light Poles	Code direct
61 - 62	Number of Pedestal Signal Posts	Code direct
63	Number of Mast Arm Mountings	Code direct
64	Number of Span Wire Mountings	Code direct
65	Number of Wood Poles	Code direct
66	Number of Exclusive Left Turn Lanes	Code direct
67	Number of Exclusive Right Turn Lanes	Code direct
68 -69	Posted Speed Limit - Major Street (if practical to record)	Code direct
70 - 71	Posted Speed Limit - Minor Street (if practical to record)	Code direct

Figure 68 - cont.

Column	Item	Code
72 - 75	Nearest Traffic Signal - Major Street - in feet - (if less than 10,000 feet)	Code direct
76 -79	Nearest Traffic Signal - Minor Street - in feet - (if less than 10,000 feet)	Code direct
80	Blank	

Figure 68 - cont.

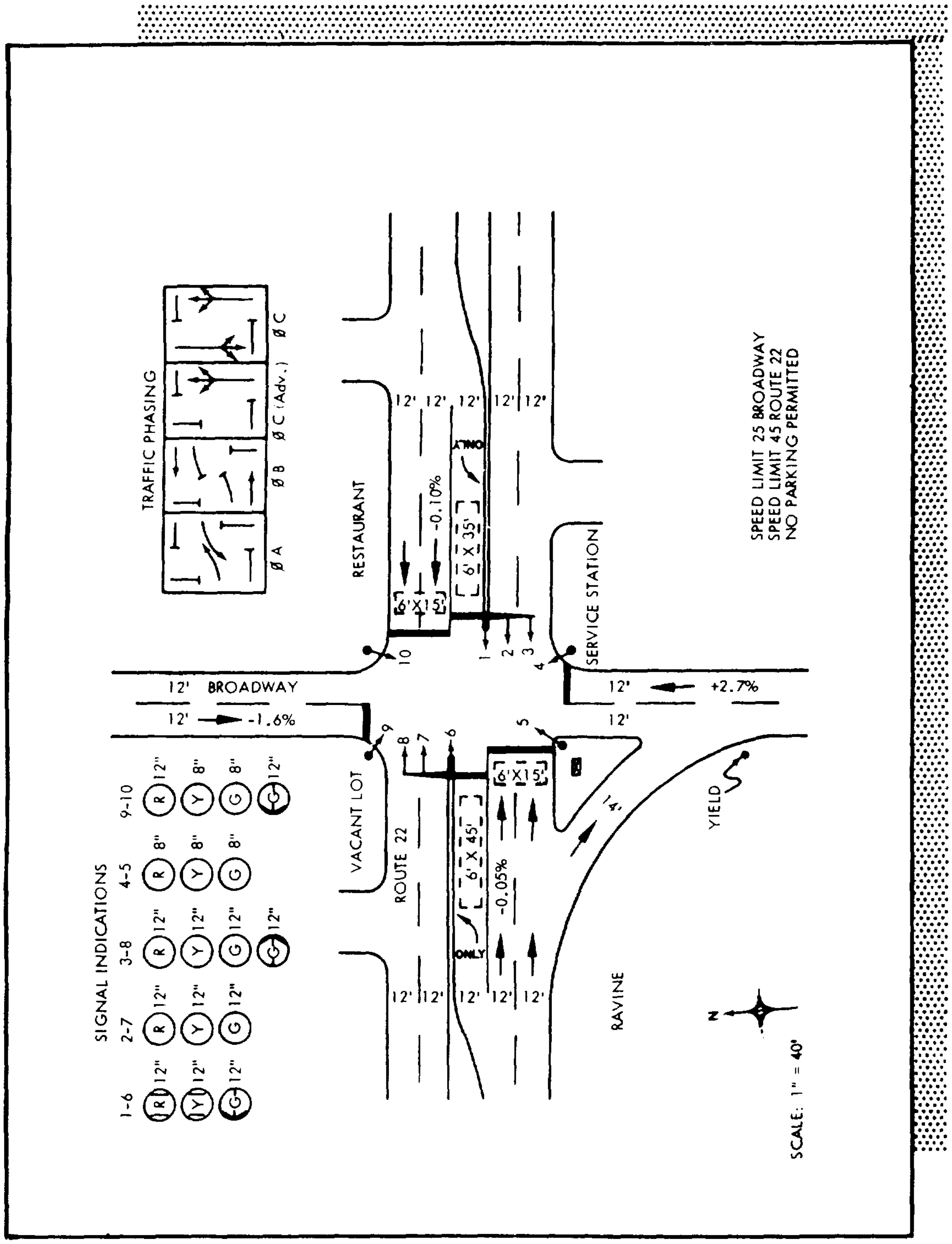

Figure 69. Signal location sketch.

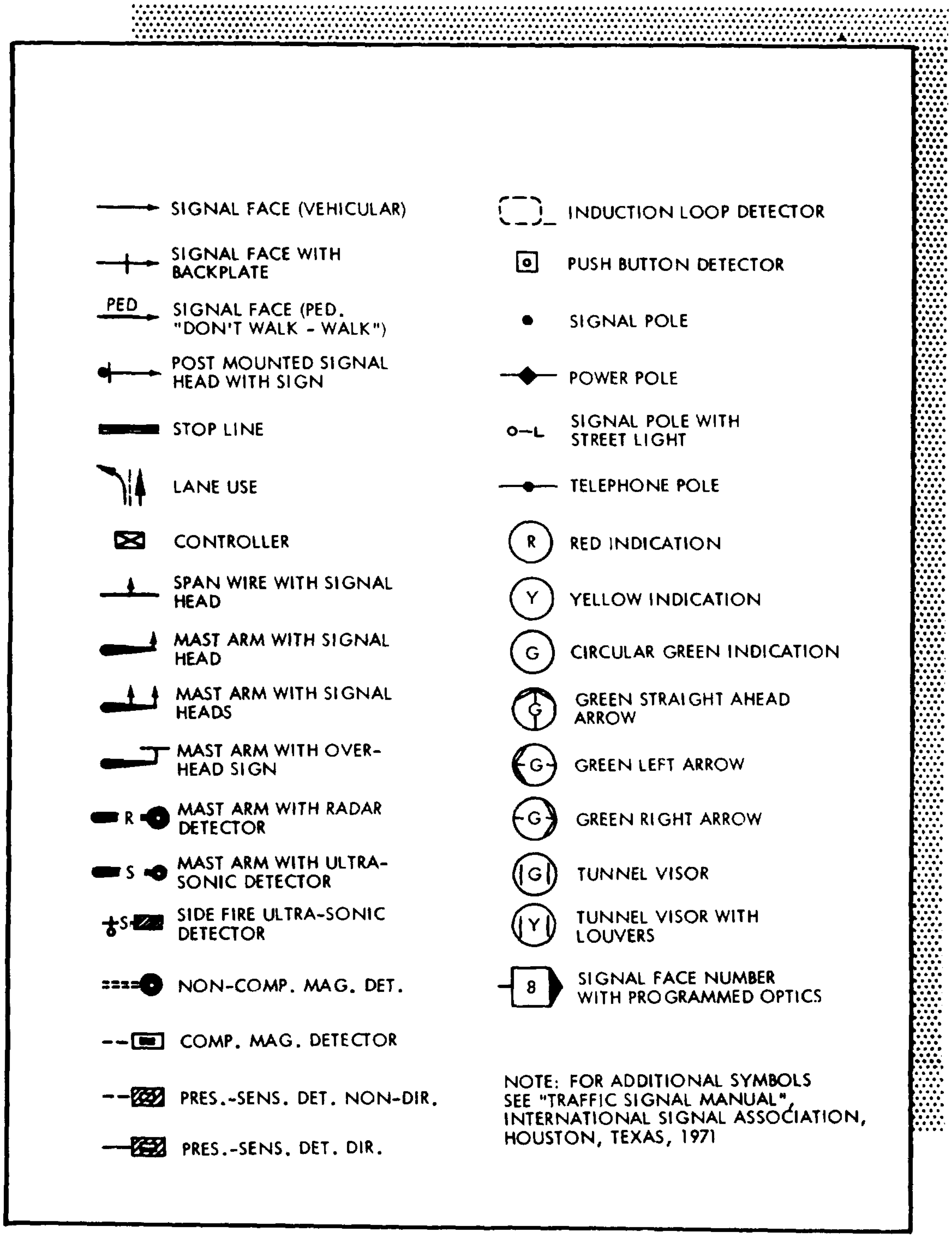

Figure 70. Traffic signal symbols.

APPENDIX D

SAMPLE TRAFFIC SIGN INVENTORY FIELD DATA SHEET

TRAFFIC SIGN INVENTORY

AREA A SHEET NO. 1

DATE 26 July 1975 OBSERVER A. Black

SIGN TYPE	SIGN SIZE 1/ (INCHES)	NO. OF EACH SIGN	BAD FACE 2/	BAD BLANK 3/	BAD LOCATION 4/	BAD MOUNTING 5/ (HI-LO)	BAD POST 6/
	30x30	210	30	12	6	14	6
	24x24	10	0	1	4	1	0
	36x36x36	70	12	8	4	6	3
	48x48x48	2	0	0	0	0	0
	36x12	40	10	5	2	15	3
	36x12	46	5	3	6	15	3
	30x30	35	5	7	12	20	2
	36x24	4	0	0	3	1	0
	24x24	36	0	0	12	0	2
	24x18	36	0	0	12	0	2
	24x24	20	2	1	3	2	1
	24x18	20	1	0	3	2	1
	24x24	6	0	0	2	0	1
	24x18	6	0	0	2	0	1
	24x24	14	6	2	4	5	6

1/ Standard sizes must occur in multiples of 6 inches.
2/ Face is non-reflective, worn-out, damaged, non-standard, wrong message, bad size.
3/ Sign base (wood or metal) is bad, damaged, broken, bent, holes.
4/ Sign is too close/far from road edge 2' 6' 12'; from intersection; or from problem.
5/ Sign (on its post) is too high, or too low. (5 ft rural, 7 ft urban min.)
6/ Post is bent, twisted, broken, rotted, or leaning.

Figure 71

APPENDIX E

PROJECT PRIORITY AND BENEFIT/COST

1 General. To insure the proper expenditure of installation funds, it will be necessary to assign priorities to roadway construction projects. First, the need for every project must be determined by application of standard traffic engineering techniques. Second, the time frame of the various projects must be decided. Long-term and short-term projects must be identified, together with the desired completion date. Suitable project lead-time must be allowed. Third, the cost of the project should be estimated. Fourth, the expected benefits from the project should be computed. Fifth, the standard benefit/cost ratio should be calculated. And finally, the projects should be listed by priority.

2. Cost. Project cost may be estimated by using any of the convenient costing guides published by DOD or civilian concerns. Up-to-date material should be used and should include the cost of design, labor, material, equipment, and, where applicable, right-of-way. Principles of engineering economics should be followed when applicable. The impact of the project upon the environment, air pollution, noise, socioeconomic human factors, and energy usage must be determined.

3. Benefits.

a. Accident costs. The benefits of any valid highway project include reduced travel time, decreased driving expense, and improved highway safety. The computation of the first two is covered in several of the references presented in appendix B. The computation of the benefits due to improved traffic safety is discussed in HSPM 13 (see part two, sec XIV of this pamphlet). HSPM 13 contains a formula for estimating the benefits of accident reduction. It calculates the dollar benefit by using an after/before ratio, which includes the averaged cost per accident. The basic accident costs recommended by the FHWA are:

Property Damage Only (PDO)- $	300
Injury (I)-	7,300
Fatality (F)-	200,700

When more accurate state or local accident costs are available, they should be used instead of the above.

b. Fatal accidents. Statistically speaking, a fatal accident is a rare occurrence. The event of a fatal accident at some particular intersection may cause that intersection to be assigned to priority far out of proportion with what it deserves. Therefore, the FHWA benefit formula includes a weighting factor "Q" that tends to bring individual computations into agreement with the ratio of injury/fatal accidents observed statewide.

c. Project benefits. The dollar accident benefits of a traffic project, which causes accidents to decrease from state "b" (before) to state "a" (after), is estimated by -

$$B_{B-a} = \frac{ADT_a}{ADT_a}\left[Q \ (A_{FI}) \ P_{FI} + 300 \ (A_{PDO}) \ P_{PDO} \right]$$

where: B = Benefits ($) resulting from project

A_{FI} = Accidents; yearly average number of fatalities plus injury

P_{FI} = Percent reduction in A_{FI} expected due to project

A_{PDO} = Accidents; yearly average number of property damage only

P_{PDO} = Percent reduction in A_{PDO} expected due to project

To prevent biasing the results because of rare fatal occurences, a weighting factor is used, given by:

Q = Average cost of non-PDO accidents;

$$= \frac{200,700 + (I_S/F_S)\ 7,300}{1 + (I_S/F_S)}$$

where: I_S/F_S = State or local ratio of injury to fatal accidents on that particular class of road (two-lane rural, four-lane urban, and so forth)

4. Benefit/cost ratio. This ratio should be computed for each project. The projects may then be ranked in order of priority. Again, it is emphasized that concern must be shown for the environment, air quality, noise, socioeconomic factors, and energy usage.

5. Documentation. Sufficient accident and cost data must be maintained. An after/before study should be performed for each major project. It is only by this method that the validity of various traffic engineering techniques may be proven and future projects may benefit.

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