To the Graduate Council:

I am submitting herewith a thesis written by William A. Ellis entitled "A Systems Engineering Analysis of Traffic." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

John N. Snider, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

B

A SYSTEMS ENGINEERING ANALYSIS OF TRAFFIC

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee

William A. Ellis

August 1974

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An enormous amount of credit is due others. First, the greatest credit should go to my professors at the University of Tennessee for giving me greater insight into what engineering is all about. Second, I want to thank Air Force Major Donald F. Schermerhorn for assisting me in obtaining the data used here. Next, I want to thank those many personnel at Eglin Air Force Base that participated in the traffic counts, accident tabulations, origin-destination survey, and other data gathering tasks that are required on a study of this magnitude. Unfortunately, space does not permit mentioning them by name, but I am greatly indebted to them for a job well done.

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August, 1974 William A. Ellis

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ABSTRACT

Very often a traffic safety improvement project is disapproved because the administrators aren't sure that the improvement will reduce accidents and is cost effective.

This study shows a systems engineering analysis approach to traffic safety problems that can be used by any traffic planning group to plan and program safety improvements based on forecasted accident reductions and cost effectiveness.

The study was conducted on a large U.S. Air Force base and consisted of traffic volume counts, capacity analysis of the major signalized intersections, traffic accident analysis, an origin-destination study, and a traffic oriented data system.

The major part of the study involved the traffic accident analysis. Traffic accident information were coded and a computer program written to break out the accident data by location of occurrence. These data were then used in a statistical test, the rate quality-control test, to determine hazardous locations. The test assured at the 0.90 probability level that the hazardous location was not hazardous by chance. Once knowing where the hazardous locations were and the condition of all the accidents that occurred there, remedial improvements were selected. Each improvement selected had a corresponding accident reduction probability. These probabilities along with the direct cost of accidents were used to determine the cost effectiveness of the selected improvements. In the cost analysis, benefit-to-cost ratios were calculated. The benefit used was the total annual dollar savings based on the expected accident reduction given an improvement. The

cost used was the total annual cost of the improvement including the time value of money. The hazardous locations were then ranked by benefit-to-cost ratios to determine the order of making the improvements. This analysis showed that the main roadway on the base should be upgraded from a three lane, center reversible lane highway to a four lane, median divided highway with left turn lanes at the major intersections. The recommended improvements were shown to more than pay for themselves in lower costs due to accident reductions.

Intersection capacity analysis showed that two of five intersections analyzed required major construction in order to relieve traffic congestion.

Origin-destination data showed that the major driver irritants were too few parking places and too few traffic lanes on the main roadway of the base.

The data system used as a data base information obtained from vehicle registration forms administered by the base Air Police. When the regulation governing the registration of vehicles was changed and registration was no longer required, the data system was abandoned since the data base no longer existed.

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CHAPTER I

INTRODUCTION

I. STATEMENT OF THE PROBLEM

Enormous resources of money, material, and human energies are involved in the construction and operation of new traffic facilities. The major problems that face the administrator responsible for allocating these resources for the construction of a new facility are: "Will the new facility reduce the traffic problem for which it was designed?" ---- "Will it be cost effective?"

II. PURPOSE OF THE STUDY

The purpose of this study is to devise a systems engineering analysis program than can be used to effectively plan and program traffic improvements on an economic basis.

III. NEED FOR THE STUDY

Historically, the approach to traffic engineering on U.S. Air Force bases has been fragmentary. Air Force regulation (1) requires commanders, staff members, military and civilian supervisors to be the responsible agents for the management and implementation of programs for motor vehicle accident prevention.

The Civil Engineering group on each base is primarily responsible (2) for on-base roadway engineering and planning, correcting physical traffic hazards, and liason with local and state highway engineering officials on mutual engineering problems.

Still another area of responsibility concerning traffic engineering belongs to the Air Force Security Police. This groups responsibility includes detecting, correcting, and reporting (3) physical hazards related to on-base traffic routing and flow in addition to its regular job of traffic supervision and motor vehicle administration.

Finally, the Ground Safety group is responsible (1) (4) for investigating on-base traffic accidents, assisting in the evaluation of traffic engineering efforts, hazard identification systems that relate to the reduction or elimination of accidents, and for conducting driver improvement training programs.

With this fragmentary responsibility, very little system analysis can be accomplished due to the lack of central authority for accomplishing such a task; therefore, outside agencies are usually contacted to accomplish traffic studies.

As an example, in 1966 (5), Eglin Air Force Base contracted the updating of the "Eglin Air Force Base Master Plan" to Daniel, Mann, Johnson and Mendenhall, an architectural and engineering firm. A part of the updated plan included recommendations for traffic engineering improvements. In 1969, Eglin officials requested the U.S. Army Transportation Engineering Agency (6) to conduct a traffic study. The results from both these studies were used on several occasions as justification to higher headquarters for requested funds to accomplish traffic improvements needed to reduce accidents and expedite traffic flow. Each time funding was denied because the Air Force administrators were not convinced that the recommended improvements were cost effective or accident reducing. Neither study contained cost effectiveness analysis or accident reduction forecast.

The main thrust of this study is to devise a systems engineering program that can be used by administrators to plan and program traffic improvements on an economic basis.

IV. HYPOTHESIS

A systems engineering analysis of traffic program can be developed and used to effectively plan and program traffic improvements on an economic basis.

V. DELIMITATIONS

While a system engineering analysis of traffic program will be ascertained and used in this study, it will not be possible due to time, cost, and resource limitations to prove that it is the only or even the best method available. The analysis will, of necessity, limit itself to the traffic problems found at Eglin Air Force Base, Florida, although the same principles and methods should be equally applicable to any community where like traffic problems exist.

VI. TECHNIQUE OF INVESTIGATION

This thesis involves the development and use of a systems analysis method that can be used to plan and program traffic improvements.

In developing the method, a thorough examination of books, periodicals, and U.S. Air Force documentation was conducted. This investigation did not reveal any previous studies similar to this thesis. Studies in this area have historically been directed toward large urban areas and conducted on the state level; not for a large military installation, which is quite like a city.

CHAPTER II

REVIEW OF THE LITERATURE

I. INTRODUCTION

Literature abounds on the subject of traffic studies. No attempt will be made to cover any part of the literature in great detail or to survey the field; time and resources do not permit. What will be presented is a typical approach to a traffic study that would normally be taken by a traffic engineering consulting firm or the traffic engineering department in a medium sized city.

II. EXISTING CONDITIONS

In the development of a traffic study, it is first necessary to know what is taking place on the present transportation systems. To obtain the information there is a data collection phase of the traffic study which includes various types of individual studies (7) designed to obtain the desired information.

Present Traffic Volume Counts

Traffic volume counts are taken to determine traffic trends and average traffic flows (7) over specified periods of time. The ways of counting vary from manual counts to costly infrared detection systems (8) which sense and record the presence of vehicles as well as moving traffic.

The types of information collected and tabulated also varies. In some cases, the objective may be to obtain the peak hour of traffic; other

objectives such as determining the relationship of average weekday to the average daily traffic or seasonal variations may require a count period of one week at three month intervals.

There are several characteristics of vehicular traffic flow that can be observed using volume count data. Usually traffic volumes increase as the center of the city is approached; certain streets which are more attractive (9) to the drivers are used to cross the area; and roads that circle the areas of heaviest traffic congestion are used as by-passes. To show volume count results, flow maps are drawn of the area under study. On the maps the volume of traffic is represented by a band width (10) related to a traffic scale. A wide band represents large volumes of traffic and a narrow band indicates little traffic. Volumetric measures of traffic movement are generally accepted as a true (10) measure of the relative importance of any given traffic route in a given area.

Signalized Intersection Studies

Signalized intersection studies are part of a complete traffic study. In urban areas, they are the controlling factor (11) on capacity of the roads. Intersectional volumes usually reach a peak during the hours of greatest traffic movement. As vehicular conflicts arise from stopping, starting, and turning maneuvers in and near the intersection, traffic flow capacity through the area can be seriously affected (8) by the conditions at the intersection.

Seldom are all approaches to an intersection utilized to full capacity simultaneously. Even in peak hours only one or two approaches may (12) operate at capacity. It is these highly utilized approaches that must be evaluated and improved if need be to provide an acceptable level of service for the user of the roadway.

Factors affecting intersection capacity. Factors which effect the capacity of signalized intersection fall under four main headings and are described (12) in the following paragraphs.

Physical and operating conditions. These following conditions involve the geometrics of the intersection and the manner in which the traffic is handled on that pavement.

(1) Width of approach - The width in feet of the approach to an intersection has the most significant bearing on the approach capacity. Generally, the wider the approach is the more traffic that approach can handle.

(2) Parking - Parked vehicles reduce the effective width of an approach more than the physical width the parked cars occupy. This is because of the passing driver's cautious reaction due to fear of a car pulling out from parking or a door opening into the traveled lane. The effective loss of roadway width due to parking is from 12 to 14 feet.

(3) One-way or two-way operation - One-way operation of a street increases the capacity of a roadway by reducing turning movements and simplifying signalization and is considered superior to two-way operations for these reasons.

Environmental conditions. Environmental conditions represent those characteristics of the traffic demand, as reflected in the traffic stream, that cannot be readily altered by engineering design or control measures.

(1) Load factor - Represents the percentage of green signal phases fully utilized by traffic. One green phase is fully "loaded" when it is continuously used; therefore, this factor represents the ratio of those green phases that are loaded, or fully utilized, to the total number of green phases available in a given time period, usually the peak hour. Its range is 0.0 to 1.00.

(2) Peak hour factor - This factor is the ratio between the number of vehicles counted during the peak hour to four times the number of vehicles counted during the highest consecutive 15 minutes of the peak hour. A separate peak hour must be calculated for each intersection approach. The peak hour factor measures peaking during the peak hour. Its range is 0.25 to 1.00.

(3) Metropolitan area population - This factor reflects the finding that the capacity of a given approach in a large metropolitan area is greater than a like geometric approach to an intersection in a small city.

(4) Metropolitan area characteristics - This factor reflects the peculiar characteristics of that section of the metropolitan area in which the intersection is located; i.e., central business district, fringe area, outlying business district, or residential area.

Traffic characteristics. Intersection capacity is greatly influenced by the characteristics of the traffic flows being accommodated.

(1) Turns - Left and right turns can hinder other traffic if turn lanes are not provided or can help traffic flow if they are provided. This factor measures turn characteristics.

(2) Trucks - The effect of the percentage of trucks in the traffic flow is measured by this factor. In general, trucks take up more space and are slower moving than passenger cars. Pickups, panel trucks, and other light trucks with four tires are considered passenger cars.

(3) Buses - Have an influence on traffic due to their stops and slow pace compared to passenger cars. This factor measures their effect.

Control measures. The control measure that is used on most studies is a signal timing factor or G/C factor. This factor is the ratio of the available green time on an approach phase to the total cycle time of the signal light.

Levels of service. All of the above factors or characteristics determine the level of service of an intersection. The particular levels of service for intersections are described in terms of load factor, which is considered to be closely related to driver satisfaction with the roadways. The six levels of service, the load factor and the traffic description pertaining (7) to the levels are listed below:

LEVEL A - Has a load factor of 0.0 and traffic is free flowing.

LEVEL B - Has a load factor of 0.0 to 0.1 and traffic is stable.

LEVEL C - Has a load factor of 0.1 to 0.3 and flow remains stable.

LEVEL D - Has a load factor of 0.3 to 0.7 and flow is approaching instability.

LEVEL E - Has a load factor of 0.7 to 1.00 and the roadway has reached capacity.

LEVEL F - The load factor is undefined - forced flow (stalled traffic are present).

Data collection. In order to accomplish capacity calculations (13) for an intersection, data in addition to the regular traffic volume counts had to be collected. These are:

Turn counts. Traffic turning movements are obtained by personnel located at the apex of two approaches to an intersection. Figure 1 shows the position of two observers and the turns each observer is responsible for recording.

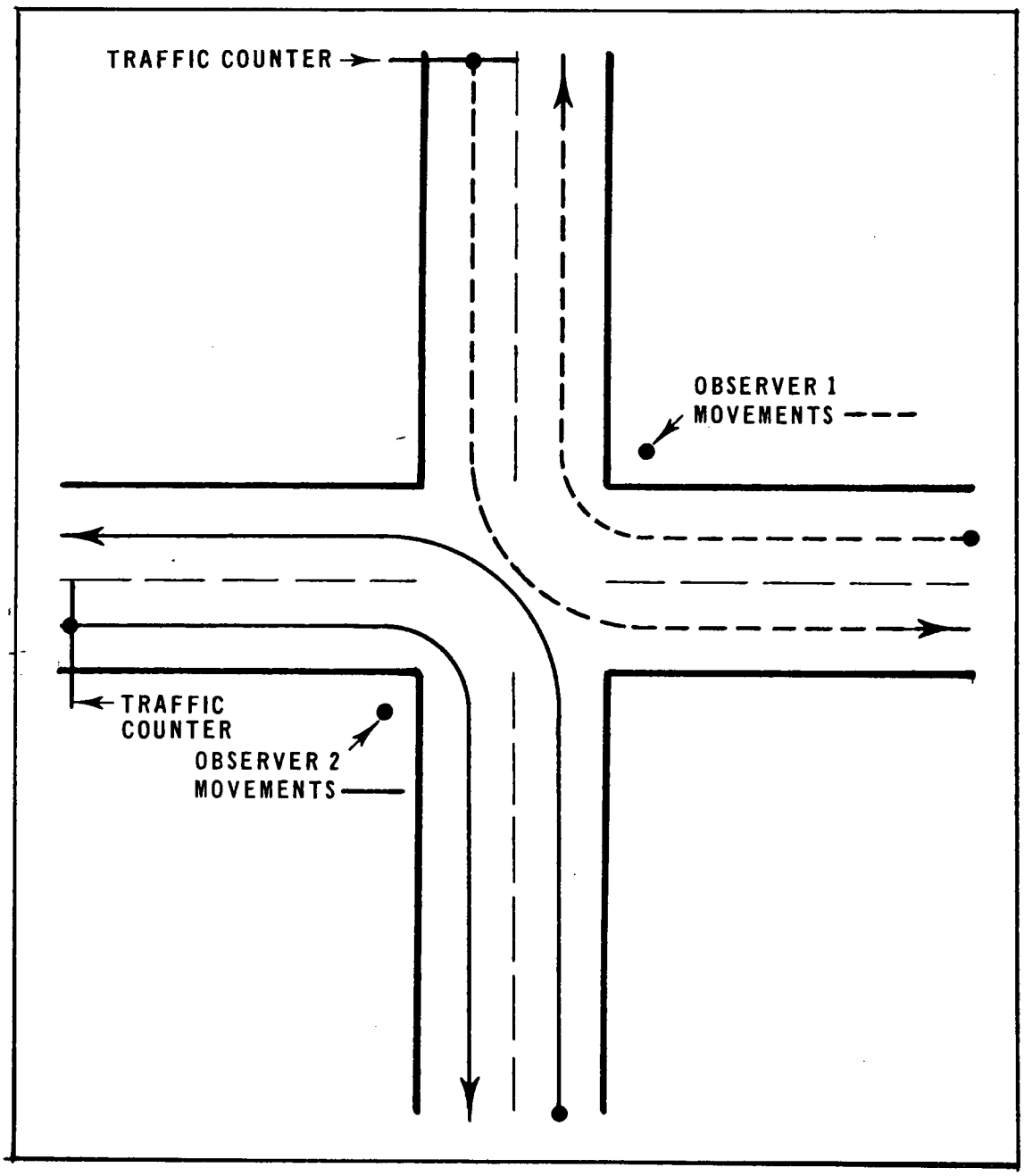


Figure 1. Turning Movements - Position of Observers

The observers record the number of turns left or right on a form like that shown in Figure 2. Tally marks are used to record the turns. Turns are recorded in consecutive 15-minute intervals throughout the peak hour. The time of start and stop for each interval is logged in the time column of the tally sheet.

Truck and bus count. Trucks and buses are counted for each approach at the same time that turning movement counts are taken. Each observer uses a hand held counter to accomplish this count. The total peak hour truck and bus count is logged at the bottom of each approach turning movement form sheet.

Signal timing. Signal timing is needed for each approach of the intersection. To obtain the timing an observer uses a log sheet and a stop watch. With the stop watch the observer records the length of green phases and the total cycle time of the traffic signal. From these data the G/C ratio is calculated. For example: The green cycle on an approach was found to be 20 seconds. The total cycle time including green time, amber caution time, and red time was found to be 60 seconds. The green time, 20 seconds, divided by the total cycle time, 60 seconds, is the G/C ratio. In this example, the G/C ratio is equal to 0.333.

Total traffic and peak 15-minute count. Total traffic counts and peak 15-minute counts are obtained using traffic counters on each approach to the intersection.

III. TRAFFIC ACCIDENT STUDY

Traffic accidents are the most dramatic and terrifying of all traffic problems. In recent years approximately 53,000 persons are killed (14)

TURNING MOVEMENTS
AT
INTERSECTION OF _____

AND _____

TIME		LEFT TURNS		RIGHT TURNS	
START	END	FROM		FROM	
		TO		TO	

CHECKER: _____

DATE: _____

Figure 2. Form for Recording Turning Movements at Intersections

annually on our nation's highways. To emphasize the serious need for accident reduction and to show how costly accidents are, a simple comparison (14) can be made: The estimated annual cost of motor vehicle accidents in the United States is $10,000,000,000. By comparison, the funds used each year to construct new and safer roads is $8,645,000,000. Less money is being spent on improvements that reduce accidents than is being spent on accidents! Since safe and efficient traffic movement is the major objective of most traffic studies, the study of traffic accidents (10) is essential.

Accident causes are numerous and very often difficult to determine. Most accidents occur when the weather is clear and involve a driver with no previous record (8) of an accident. On the other hand, many collisions involve adverse weather conditions and other hazards to driving safety, (10) such as wet and slippery pavement, poorly lighted roadways, inadequate traffic control, excessive speed, and vehicles with defective equipment.

Accident reports from the driver and police department provide the necessary basic data (7) for traffic accident analysis. Accident reports vary, but generally contain information on the accident concerning location, time, number of vehicles, number of persons, roads, actions, violations, and the conditions and circumstances (10) of the accident. From these data, periodic summaries are sorted electronically or manually. Since accidents are usually sorted by accident location, high frequency accident locations are readily detected for detailed analysis.

The sorted data are used to draw collision diagrams, Figure 3. Collision diagrams illustrate graphically, by means of directional arrows and symbols, the paths of the vehicles just prior to the accident occurring. The location, date, and time period is usually given (8) in

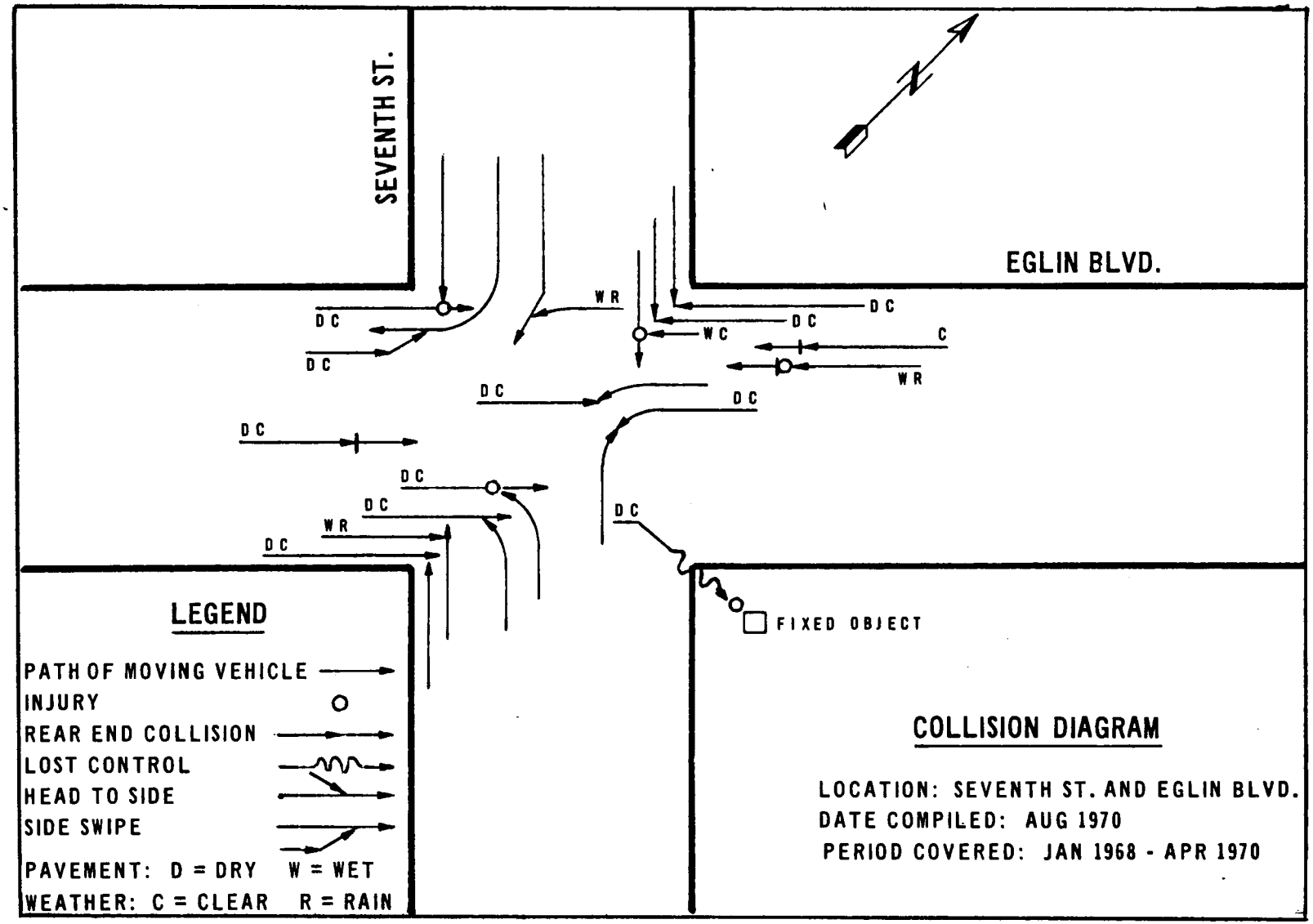


Figure 3. Collision Diagram

addition to a legend showing the meaning of the coded symbols used. The diagrams are used, along with a visit to the accident location, as a means of determining the type of remedial actions required to reduce the type of accidents occurring. Collision diagrams are also used to show the accident reductions produced after the improvements are made (10) to the accident location.

Accident data are also analyzed to summarize accidents by type (7) and severity; to determine hourly, daily, and monthly variations of accidents by type and severity; and to identify the relationship between accident causes, drivers involved, and locations and contributing roadway deficiencies.

IV. ORIGIN-DESTINATION STUDY

In order to formulate travel patterns for the future, it is necessary to know what the existing traffic conditions are as well as where the motoring public desires to travel.

Origin-destination studies are commonly used throughout the United States and are recommended (13) by the United States Bureau of Public Roads. They are used in the planning, design, and operation of highways and streets as they indicate the preferred location of traffic facilities.

An origin-destination study is begun by taking a map of the urban area and drawing a line (8) completely around it. This line should closely follow the limits of the urban area or city. At each intersection of this line with a major roadway an origin-destination interview station (7) is set up. The origin-destination stations, or O-D stations, are operated during the highest traffic volume hours in the morning and afternoon. Usually traffic moving in the outbound direction, leaving the city, is interviewed.

The interviewers are instructed to question the motorist as to the origin and destination of his trip. Street addresses, building numbers, and establishment names are obtained when the trips originated in the urban area under study. In the event that the trip required the road user to pass completely through the area, the interviewer will ask the driver if he stopped within the area (10) and if so, where, and for what reason. If a stop was made for a significant reason, the address is recorded along with the reason for the trip. Motorists making through trips are also questioned (7) as to which route they entered the city in order to trace their movements through the study area.

Simultaneously with the operation of the O-D stations, a vehicle classification count is made. All vehicles are counted manually and classified by type in the inbound and outbound directions. The type indicates whether the vehicle is a (8) passenger car, pickup truck, truck, bus, tractor-trailer combination, and the like.

To check the completeness and accuracy of the O-D station interviews and classification count a portable traffic recording machine is placed (8) at the station site. This machine records the traffic and transfers the volume counts to a tape at the end of each hourly period. By comparing the interview card count, classification count, and machine count, a representative sample of each individual hour of the interview period can be obtained.

The information received by questioning the motorist at the various interview stations is used to determine the travel desires (8) of all trips entering and leaving the study area. It is also used in choosing and developing arterial streets, relocating routes, determining street improvements (7) and organizing one-way streets.

Prior to the O-D survey, the urban area within the cordon line is grouped into specific areas called zones. These zones are surrounded by imaginary lines determined by field inspection and coordinated with the zoning and planning maps of the urban area. The major factor used to determine the zone (14) boundaries is land use -- that is, how the land is being used, whether it is industrial, commerical, residential, or agricultural, with the central business district isolated as a zone by itself.

The O-D interview data are then coded using the zoning maps and then key-punched for machine processing and sorting. The trip movements are then depicted on desire line maps. Desire lines (14) represent the shortest distance of travel between origins and destinations and also show the volume of traffic desiring to travel between these points. This volume is also illustrated by band width, where a wide band represents a large volume of traffic.

CHAPTER III

METHODOLOGY

The traffic engineering tools discussed in Chapter II will be used to accomplish this study; however, the various processes described will be tailored to fit the problems experienced at Eglin Air Force Base, Florida.

A systems approach (15) will be used, whereby the traffic problems will be defined, data will be obtained, evaluated and organized, relationships will be discovered, hypothesis formulated and evaluated, and solutions applied. The main thrust of the study will be to demonstrate a scientific method of accident analysis that will provide officials with an assessment of traffic improvements in terms of cost benefits as well as reduced accidents.

Traffic count study. A traffic count study will be initiated to evaluate the traffic volume characteristics of the "main base" area of Eglin Air Force Base. These data will be compared with volume data obtained (6) in 1968. In addition, the data will be used to compute accident exposure rates (accidents per million vehicles and accidents per million vehicle miles) needed to accomplish the accident analysis phase of the study.

Intersection capacity studies. The major intersections on the base will be evaluated to determine their capability to handle present traffic loads. In order to do this, basic data will be collected for each intersection approach. This includes the turns to and from the approach, traffic signal timing, the number of trucks and buses in the

traffic stream during the peak period, the peak hour, and the peak 15-minute traffic count. These data will then be used in a computer program (CAPINT) (13) to determine the adequacy of each approach of the major Eglin intersections to handle traffic.

Traffic accident study. A traffic accident file will be established for Eglin Main Base. To accomplish this, an accident map will be designed breaking out sections, intersections, spots, parking lots, and miscellaneous areas. A data code sheet will be designed to code all information available from an accident report relative to where the accidents occurred. Data will be coded and key-punched for a 28-month period (1 January 1968-30 April 1970). A computer program will then be written to break out the data in tabular form by location of occurrence. These data will be used in a statistical test to determine extremely hazardous locations. The test, the rate-quality control method, assures at the .90 probability level that the hazardous location is not hazardous by chance. Once knowing where the hazardous locations are and the condition of all the accidents that occurred there, remedial improvements can be selected. Each improvement to be made will have a corresponding accident reduction probability. These probabilities along with the direct cost of accidents will be used to cost analyze the various recommended improvements. In the cost analysis, benefit-cost ratios will be calculated. The benefits to be used will be the annual dollar savings based on expected accident reduction given a certain improvement. The cost will be the total annual cost of the improvements including the time value of money. The hazardous locations will then be ranked by benefit-cost ratios to determine the order in which the hazardous locations should be

improved. Using this method of benefit-to-cost will assure getting the maximum safety benefit for the dollars invested.

Origin-destination survey and study. An origin-destination survey will be initiated by a questionnaire instead of stopping traffic at interview stations as is normally done. This is necessary since base officials will not allow traffic to be stopped.

The questionnaire will be designed to be administered by the base Air Police and will be used to determine:

a. The distribution of work trips throughout the day

b. The work trip generation centers

c. Parking adequacy

d. Walking distances from parking

e. Other related traffic information.

Traffic data system. Since a traffic oriented data base does not exist, one will be developed. The purpose of the data system will be to provide data for this study, to provide a data base for future studies, to provide information for use by a number of other base organizations, and to provide a central source for information regarding personnel and their vehicles. The main objective of this data system will be to satisfy traffic analysis requirements in a single system which will include data collection, information and accident analysis subsystems. In addition, by using automated data processing techniques, the speed, accuracy, and comprehensiveness necessary for effective control and analysis of the base traffic problems will be made available for use by management.

CHAPTER IV

DATA COLLECTION AND ANALYSIS

I. TRAFFIC VOLUME COUNTS

Traffic counts were taken during July and August of 1970. Ten visual count pneumatic recorders and four printed tape pneumatic recorders were used to take the counts. The recorders were placed in position on Tuesdays, Wednesdays, and Thursdays to obtain a representative weekday traffic count since Monday, Friday, Saturday, and Sunday traffic had been found to vary significantly (6) from mid-week traffic on earlier count studies.

In most cases, two separate 24-hour counts were obtained for each segment of roadway counted. This was done to assure that no large deviations were obtained in the counts due to counter malfunctions or changes in travel patterns. On several occasions, large deviations were observed between separate counts due to wrecks, road resurfacing, bad weather, poor placement of recorders, etc.; but in all cases where abnormal deviations occurred, the counts were taken again.

Prior to using any readings from an individual recorder, that recorder was placed in position and checked by manually counting the same vehicular traffic with hand counters. The two counts were then compared. If any deviation was observed, the recorder was adjusted and checked again for accuracy. These checks were made several times during the period that the recorder was in place. In addition, the recorder was checked for damage each time readings were taken and was replaced if found defective. Counter readings were logged on the form shown in Figure 4.

EGLIN TRAFFIC STUDY

DATE: _____ 1970 CHECKER _____

NUMBER	TIME	LOCATION	BEGIN	END	ADJ.

READ COUNTERS AT - 1200 HRS
1500 HRS
1800 HRS
0600 HRS
0800 HRS
1200 HRS

Figure 4. Traffic Counter Readings Form

In short, great care was taken to obtain as accurate a count record as the recorders could be expected to provide.

Table 1 shows the 24-hour average daily traffic for each gate on the main base. The counts are for traffic entering and leaving the base. In addition, the 1970 traffic counts are compared directly with the traffic counts taken by the U.S. Army Transportation Engineering Agency (6) in October of 1968.

Table 1 reflects that only 1,605 more counts were recorded in 1970 than in 1968, and that the traffic using the gates has only slightly increased; the actual change being a 4.4 percent increase for 1970. The largest increase, 6.4 percent, occurred at the West Gate. This increase is attributed to the new occupied base housing located south of the hospital area, and additional contracting work in progress to develop more new housing, and other new facilities in the same area.

Table 2 depicts the traffic volume counts on the major main base roadways. Figure 5 shows the Eglin main base traffic volume flows. Table 2 shows many changes in traffic patterns around the base for 1970 relative to 1968. Largest increases in traffic occurred on Hatchee Road (West), up 84.6 percent; Boatner Road, up 83.1 percent; Eglin Boulevard between Fifth Street and Sixth Street, up 47.0 percent; and on Choctawhatchee Avenue just west of Seventh Street, up 25.0 percent. Again, the increases in traffic on Hatchee Road and Boatner Road are due to new occupied base housing and new construction in the area. The increase on Eglin Boulevard between Fifth and Sixth Streets is due to the influx of employees from other areas of the base to a new building, Building 13, at the northwest corner of Eglin Boulevard and Seventh Street. With the new parking lot across the street from Building 13, one would expect

Table 1. 24-Hour Traffic Volume by Gates. (1968 and 1970)

Gate	Number of Vehicles 1970	Percent of Total Gate Traffic 1970	Number of Vehicles 1968	Percent of Total Gate Traffic 1968	1970 Increase Over 1968
West Gate	22,344	58.3	21,000	57.2	6.4
East Gate	13,000	34.0	12,900	35.1	0.8
TAC Gate	1,800	4.7	1,800	5.0	0.0
North Gate	1,161	3.0	1,000	2.7	1.6
Totals	38,305	100.0	36,700	100.0	

Total Increase All Gates (Percent) = $\frac{38,305 - 36,700}{36,700}$ X 100 = 4.4 Percent

Traffic Increase All Gates = 1,605 Counts

Table 2. Traffic Volumes on Major Base Roadways (1968 and 1970)

Roadway	Location	24 Hr Volume 1970	24 Hr Volume 1968	Percent Change + or -
Eglin Blvd	Between Chinquapin Dr and Second Street	24,900	25,100	-0.8
Second St	N.W. of Eglin Blvd	16,745	18,100	-7.5
Eglin Blvd	Between Seventh St and Eighth St	12,000	11,000	+9.1
"F" Ave	Between Third St and Fourth St	10,695	11,000	-2.8
Daytona Rd	N.W. of Seventh St	9,233	10,400	-11.2
Eglin Blvd	Between Fifth St and Sixth St	14,700	10,000	+47.0
Seventh St	North of Eglin Blvd	7,000	9,200	-13.0
Barrancas Ave	South of "A" Ave	5,901	8,600	-31.4
Choctawhatchee Ave	West of Seventh St	10,000	8,000	+25.0
Seventh St	South of Eglin Blvd	7,376	7,100	+3.9
Hatchee Rd (West)	South of Eglin Blvd	12,740	6,900	+84.6
Boatner Rd	Hospital Area	9,153	5,000	+83.1
West Side Rd	North of Eglin Blvd	1,749	4,000	-56.3
Eighth St	North of Eglin Blvd	3,333	3,300	+1.0
Third St	South of Georgia Ave	1,582	2,650	-40.3
Boatner Rd	Between Hospital and Plew	5,186		
Hatchee Rd	South of Gaffney Rd	4,952		
Gaffney Rd	South of BX	1,671		
Hatchee Rd (East)	South of Eglin Blvd	4,784		
Chinquapin Dr (West Branch)	South of Eglin Blvd	766		
Chinquapin Dr (East Branch)	South of Eglin Blvd	1,860		
Eglin Blvd	Rear of Climatic Hangar	6,670		
Eglin Blvd	Between Sixth St and Seventh St	17,000		

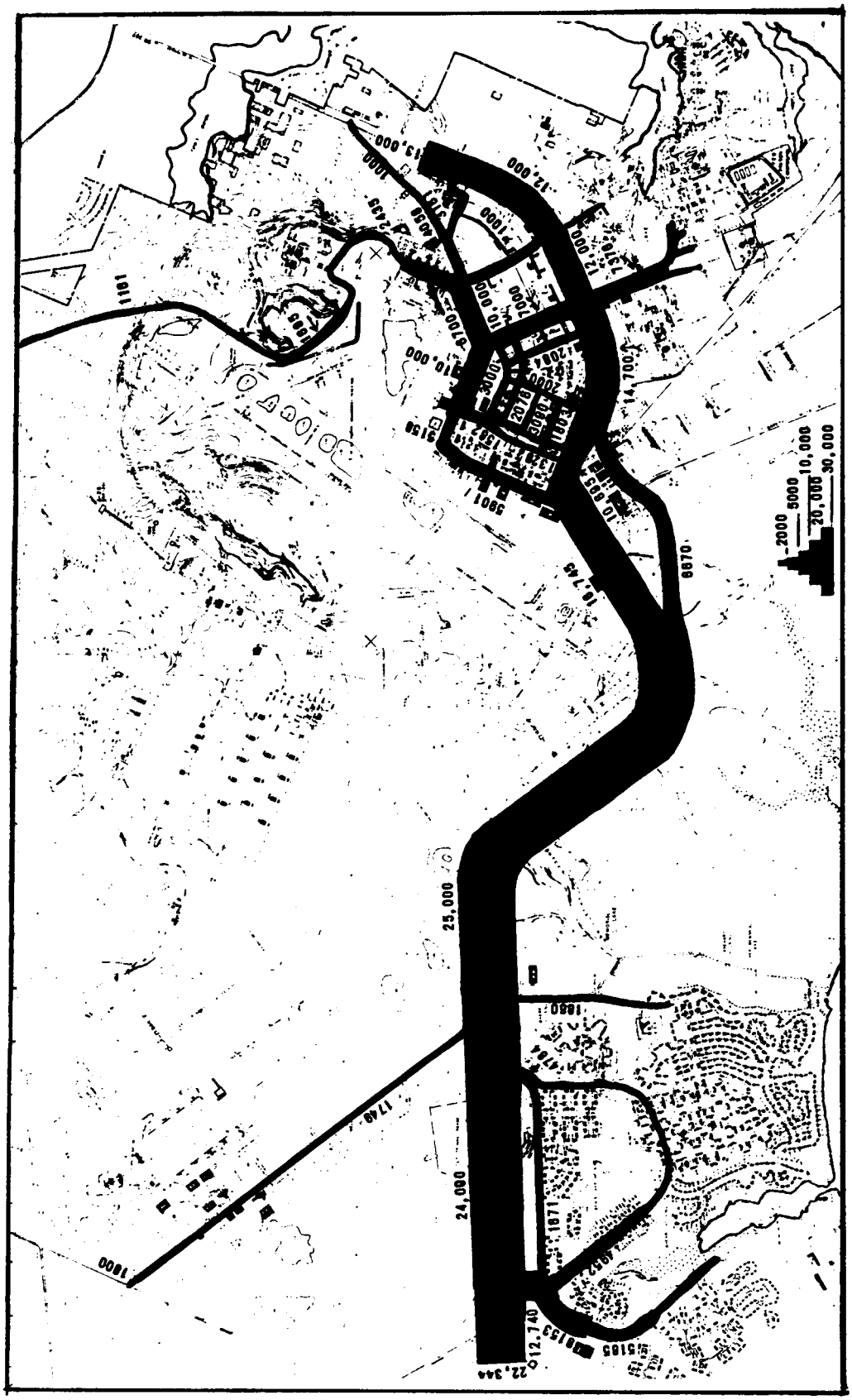


Figure 5. Eglin Main Base Traffic Volume Flows

more than normal traffic counts due to the traffic flow pattern for parking in this block. Choctawhatchee Avenue traffic has increased due to the increased use of Daytona Road as a continuous route around the major part of the base.

Marked decreases were noted in traffic movements on West Side Road, down 56.3 percent; Third Street, down 40.3 percent; and Barrancas Avenue, down 31.4 percent. West Side Road traffic is down due to the decrease in personnel in the TAC area. Third Street traffic has decreased because it is now a one-way street toward "F" Avenue. At the time of the 1968 traffic count study, it was a two-way street. Barrancas Avenue traffic has decreased due to the movement of people to other buildings. Other changes occurred but were of a less significant nature.

In summary, the mass moves of people from one area of the base to another area of the base are readily reflected in the traffic flow counts. Also, new base housing and construction in the Hatchee Road (West) area has increased traffic markedly in that locale. Gate traffic has increased because of additional personnel living on base and using off-base facilities.

II. INTERSECTION CAPACITY STUDIES

Data Collection

Data were collected on five intersections using the methods described in Chapter II, Signalized Intersection Studies. The data used for analysis are compiled on Figures 6, 7, 8, 9, and 10.

Capacity Analysis

Intersection capacity analysis was accomplished using the Signalized Intersection Capacity Program (CAPINT) (13) of the Urban Transportation

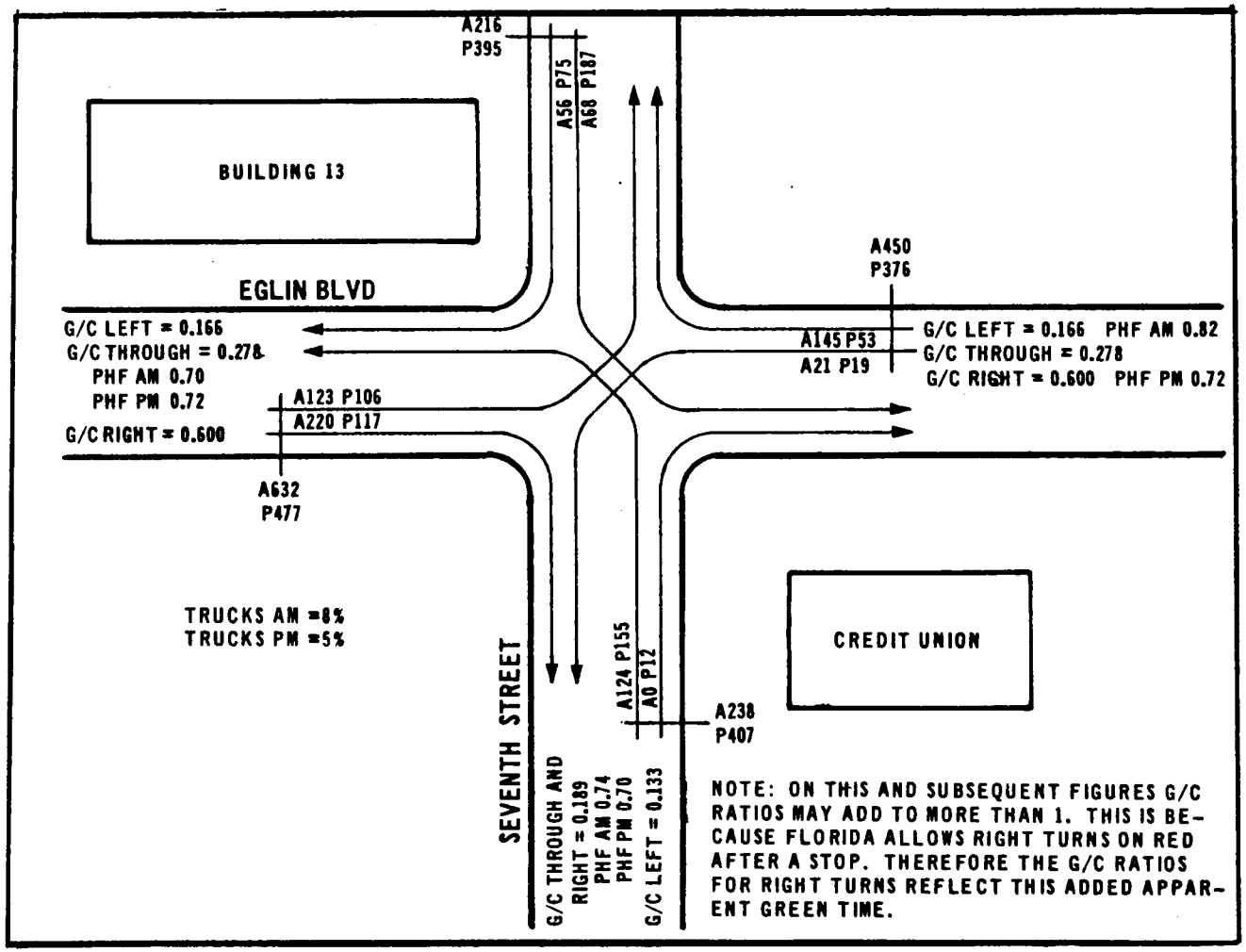


Figure 6. Capacity Analysis - Seventh Street and Eglin Boulevard

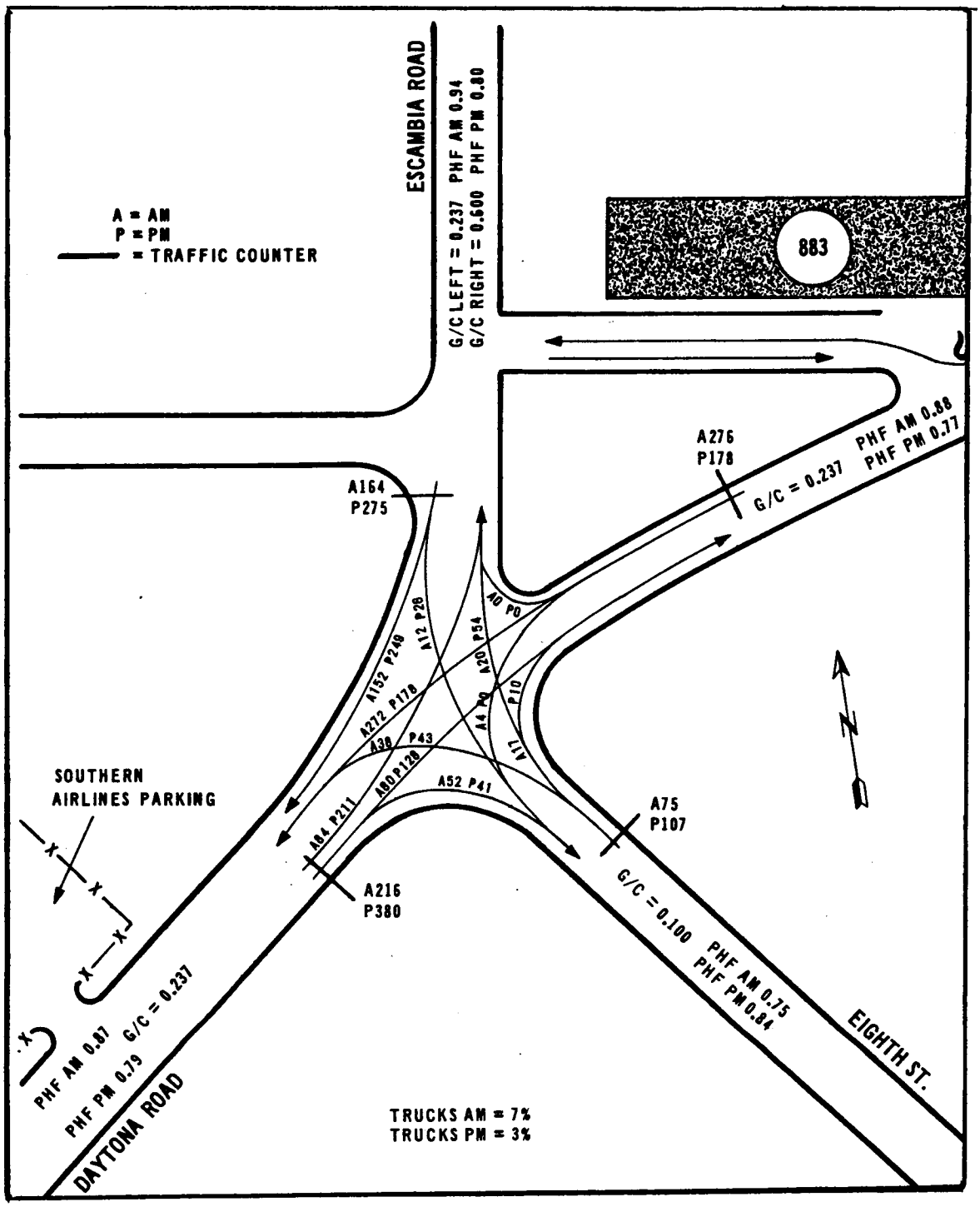


Figure 7. Capacity Analysis - Daytona Road, Eighth Street and Escambia Road

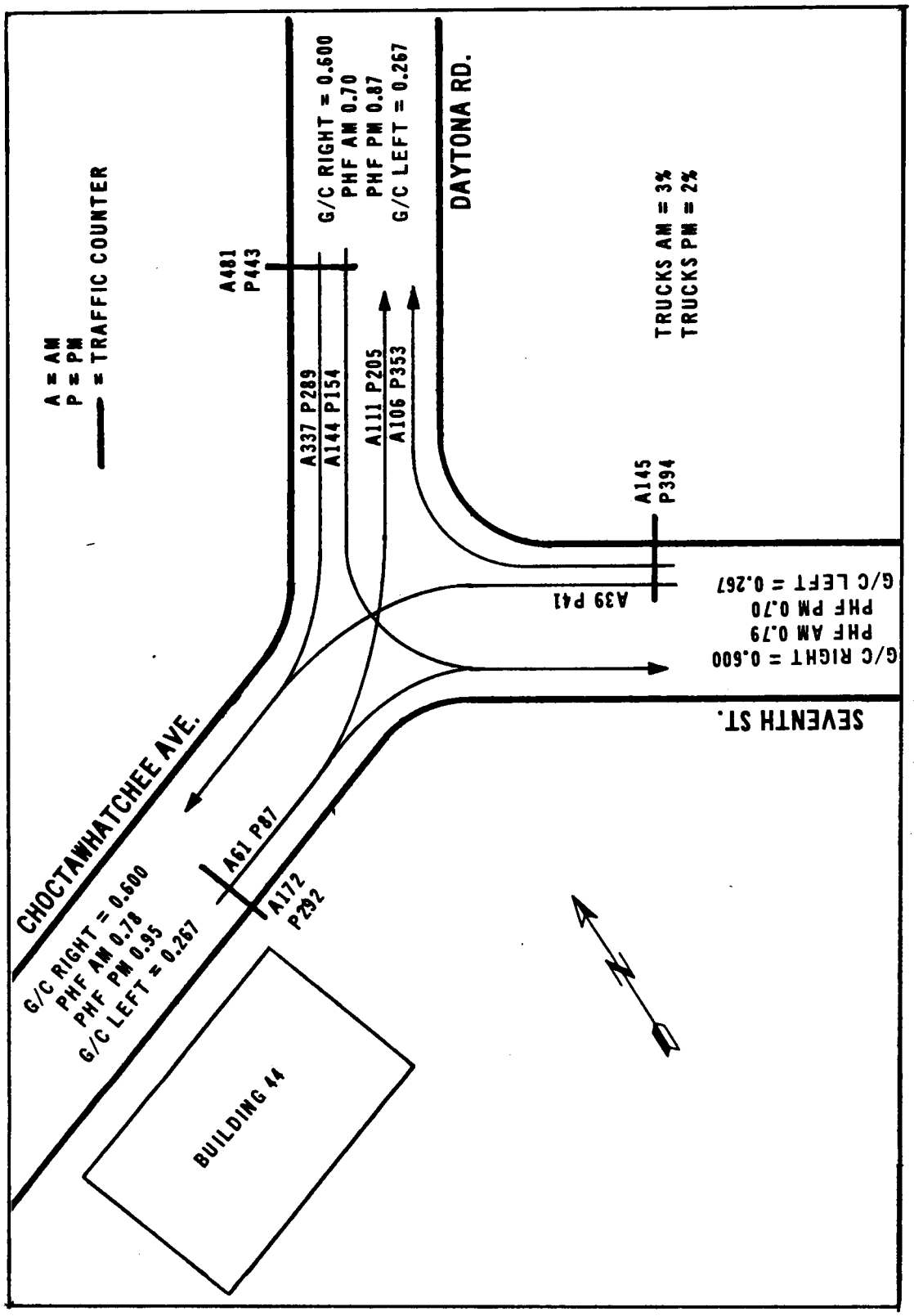


Figure 8. Capacity Analysis - Choctawhatchee Avenue, Daytona Road and Seventh Street

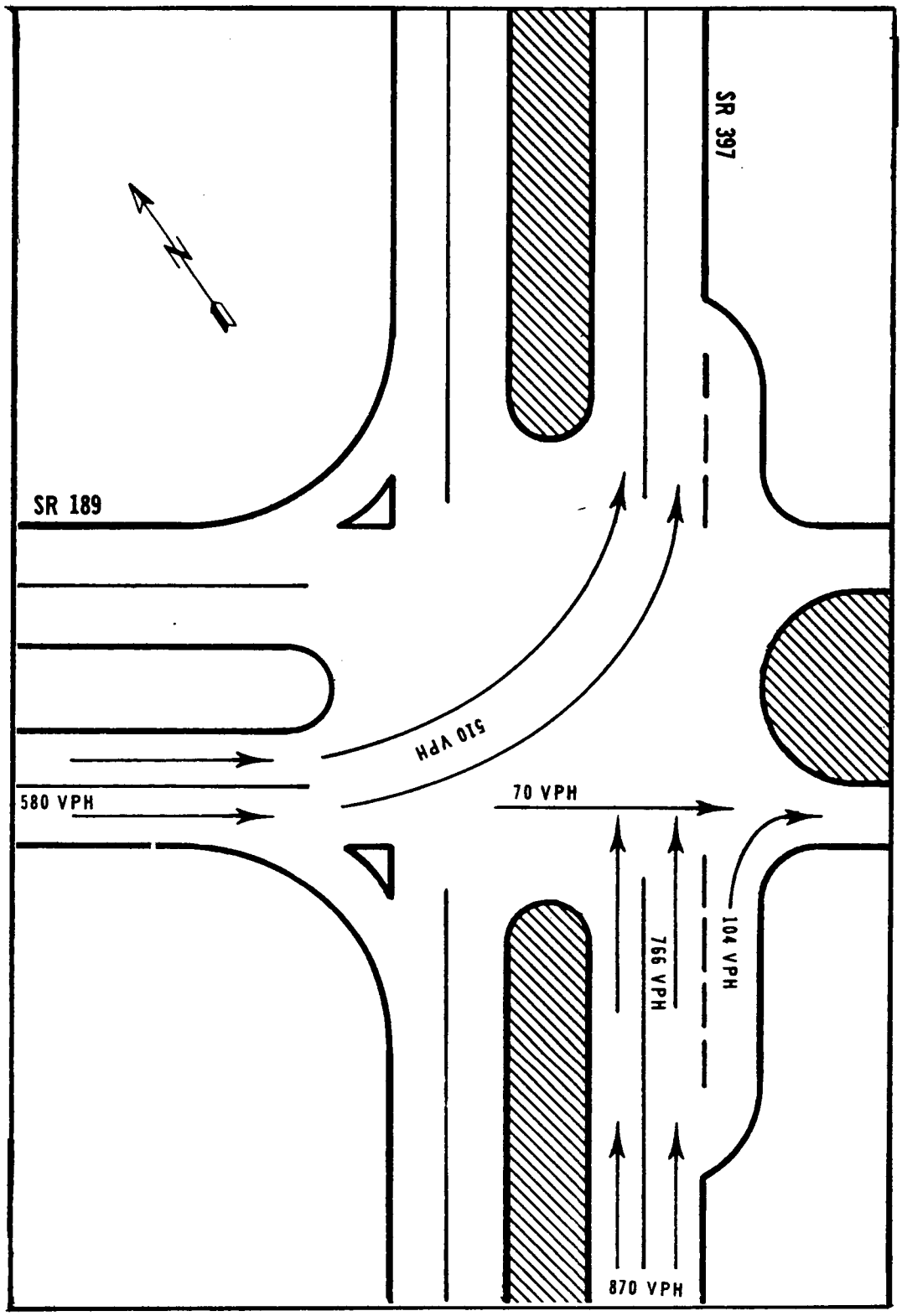


Figure 9. SR 397 and SR 189 Intersection at the West Gate

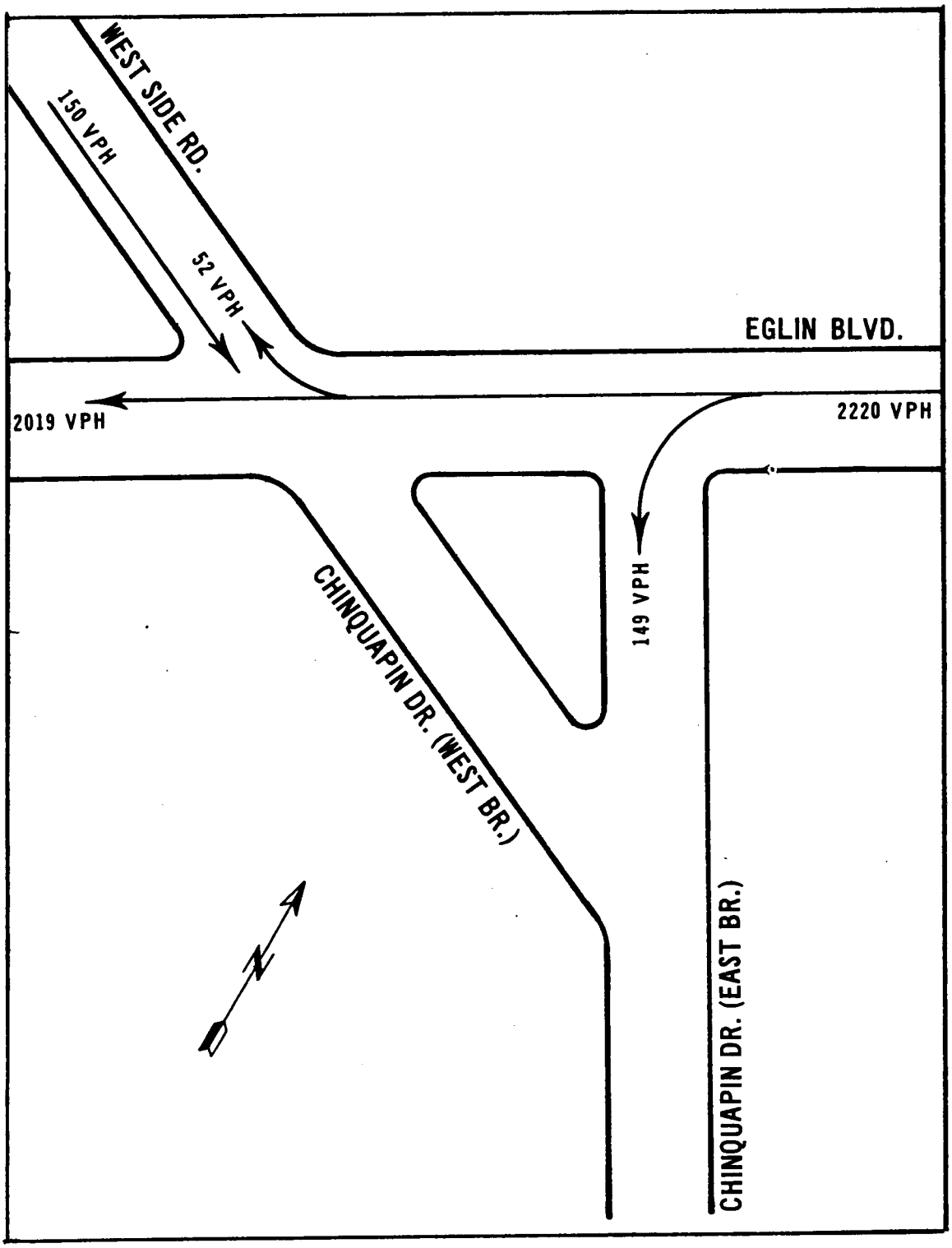


Figure 10. Eglin Boulevard and West Side Road Intersection (P.M.) (Peak Hour)

Planning System 360. CAPINT is one program of a battery of computer programs furnished by the Federal Department of Transportation, Bureau of Public Roads. The collection of programs are furnished to federal and state governmental bodies at no cost other than the computer tape on which the programs are placed. The purpose of the battery is to assist those responsible for traffic engineering in the manipulation and handling of large amounts of traffic data and in solving the transportation problems quickly with the use of an electronic computer. The CAPINT program computes either service volume, approach width, load factor or the G/C ratio required for a given approach to an intersection.

The criterion used for capacity analysis in this study was the capability to adequately handle present traffic at the most important signalized intersection of the main base. For clarity each approach and the various movements thereof will be handled separately in the analysis.

Seventh Street and Eglin Boulevard. The Seventh Street intersection is the most overloaded intersection on the base, particularly during the evening peak hour (Table 3). During the evening both approaches on Seventh Street are operating at forced flow for all movements. In addition, the through lane on East Eglin Boulevard proceeding west is operating in forced flow conditions and the through lane from west to east is operating in a condition approaching unstable flow.

Table 4 shows that the morning peak hour volumes are less than the evening. Two lanes are overloaded during the morning. These are the north left-turn and through lane on Seventh Street and the west-through lane on Eglin Boulevard.

The basic problem at this intersection is caused by the large number of turns off Seventh Street during the peak hours. These

Table 3. Seventh Street and Eglin Boulevard (P.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
North Seventh St. (thru & right)	208	148	Above Graph Line 1.0	F
North Seventh St. (left)	187	160	Above Graph Line 1.0	F
South Seventh St. (thru & right)	252	185	Above Graph Line 1.0	F
South Seventh St. (left)	155	142	Above Graph Line 1.0	F
West Eglin Blvd. (thru)	254	---	0.54	D
West Eglin Blvd. (right)	117	---	0.00	A
West Eglin Blvd. (left)	106	---	0.00	A
East Eglin Blvd. (thru)	304	302	Above Graph Line 1.0	F
East Eglin Blvd. (right)	53	---	0.00	A

Table 4. Seventh Street and Eglin Boulevard (A.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
North Seventh St. (thru & right)	148	142	Above graph line 1.0	F
North Seventh St. (left)	68	---	0.00	A
South Seventh St. (thru & right)	114	---	0.00	A
South Seventh St. (left)	124	---	0.62	D
West Eglin Blvd. (thru)	289	288	Above Graph line 1.0	F
West Eglin Blvd. (right)	220	---	0.00	A
West Eglin Blvd. (left)	123	---	0.14	C
East Eglin Blvd. (thru)	239	---	0.27	C
East Eglin Blvd. (right)	145	---	0.00	A

turns with their required signal time plus the narrow approach widths throw the intersection into forced flow easily.

There is no direct solution at the present time to eliminate the problem at Seventh Street. However, when Eglin Boulevard is made into a four-lane divided highway, the Seventh Street approaches should then be widened to provide the capacity needed due to these heavy turns.

One indirect approach to improve the Seventh Street intersection now is to improve Daytona Road so that more personnel can use that road to enter and leave the base. Daytona Road would require resurfacing, some widening, and new lane striping.

The effect of the above would be to reduce the high number of left turns from Seventh Street north of Eglin Boulevard. Once Daytona Road is improved, the Seventh Street traffic light will need retiming so that additional green signal time will be available for other approaches.

Daytona Road, Eighth Street and Escambia Road Intersection. Tables 5 and 6 depict the present condition of the Daytona Road, Eighth Street, and Escambia Road intersection. This intersection is operating very well except for the Eighth Street approach morning and evening and the Daytona Road (East) approach in the morning. The Eighth Street approach is working at forced flow morning and evening while Daytona East is operating at capacity during the morning peak.

To eliminate this problem, the signal light requires retiming to give additional time to Eighth Street. Also, additional time should be allocated to the Daytona Road (East) approach in the morning, especially if Daytona Road is improyed as an access-egress gate for the base.

Table 5. Daytona Road, Eighth Street, and Escambia Road Intersection (A.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
Eighth St. (thru & right)	107	104	Above Graph Line 1.0	F
Daytona East (thru)	178	---	0.0	A
Escambia Rd. (thru & right)	249	---	0.0	A
Daytona West (thru & right)	169	---	0.0	A
Daytona West (left)	211	---	0.29	C

Table 6. Daytona Road, Eighth Street, and Escambia Road Intersection (P.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
Eighth St. (thru & right)	75	50	Above Graph Line 1.0	F
Daytona East (thru)	276	--	0.92	E
Escambia Rd. (thru & right)	152	--	0.00	A
Daytona West (thru & right)	132	--	0.00	A
Daytona West (left)	84	--	0.00	A

Choctawhatchee Avenue, Daytona Road and Seventh Street Intersection. This intersection is working well on all approaches. No deficiencies were noted. The a.m. and p.m. peak hour load factors and service volumes are shown on Tables 7 and 8.

SR 397 and SR 189 Intersection at the West Gate. The data for this intersection were obtained from the Origin-Destination Questionnaire which is described later in this chapter. The reason the O-D data were used is because this intersection was not in existence; it was in the process of being built. What is now SR 189, a four-lane divided highway, was then a hazardous and rough two-lane roadway.

One group of questions on the O-D questionnaire queried individuals filling out the forms as to their intended use of SR 189 after it was completed. If their answer was yes, they were asked to designate the gate they would use going to and from the base via SR 189.

These basic data, with inbound traffic counts listed in Table 9, enable analysis and prediction of the proper signal timing needed at the intersection to handle expected traffic loads.

Figure 9 shows the intersection and the predicted morning loads on the two main approaches after SR 189 is opened. Table 10 shows the signal timing that will be required to handle the traffic loads. Also shown are the predicted levels of service, load factor, and approach volumes for two main approaches. Comparing these predictions with the 1968 Army Report shows that SR 189 will have a traffic increase of over 55 percent at the intersection. In 1968, SR 397 carried 82 percent of the morning peak hour traffic entering the West Gate while SR 189 carried the remaining 18 percent. The predicted figures show that SR 397 will carry 60 percent of the morning peak hour traffic and SR 189 the remaining.

Table 7. Choctawhatchee Avenue, Daytona Road, and Seventh Street Intersection (A.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
Choctawhatchee Ave. (right)	61	--	0.00	A
Choctawhatchee Ave. (left)	111	--	0.00	A
Seventh St. (right)	106	--	0.00	A
Seventh St. (left)	39	--	0.00	A
Daytona Rd. (right)	337	--	0.00	A
Daytona Rd. (left)	144	--	0.00	A

Table 8. Choctawhatchee Avenue, Daytona Road, and Seventh Street Intersection (P.M.) (Peak Hour)

Approach	Service Volume (VPH)	Capacity (VPH)	Load Factor	Level of Service
Choctawhatchee Ave. (right)	87	--	0.00	A
Choctawhatchee Ave. (left)	205	--	0.00	A
Seventh St. (right)	353	--	0.00	A
Seventh St. (left)	41	--	0.00	A
Daytona Rd. (right)	289	--	0.00	A
Daytona Rd. (left)	154	--	0.00	A

Table 9. Inbound Traffic - West Gate

Time	Vehicles
0630-0645	557
0645-0700	466
0700-0715	239
0715-0730	187
Total	1,449

Table 10. SR 397 and SR 189 Intersection at the West Gate - Signal Timing for Morning Peak Hour

Approach	Approach Volume (VPH)	Load Factor	Level of Service	G/C[a] Ratio
SR 397 (West to East)	870	0.0	A	0.44
SR 189 (North to South)	580	0.0	A	0.33

[a] 90 Second Cycle in the Morning:

40 seconds Eglin Boulevard (SR 397) approach

30 seconds SR 189 approach

11 seconds Hospital area approach

9 seconds Three amber caution lights

Signal timing was evaluated only for the two critical approaches. Also, these figures are good only for the morning peak hour.

Eglin Boulevard-West Side Road Intersection. Analysis shows that this intersection is overloaded with traffic during the afternoon peak hour. Figure 10 depicts the westbound Eglin Boulevard traffic and the traffic out of West Side Road during the afternoon peak hour.

After further analysis, it was concluded that this intersection must be upgraded to a four-lane system complete with adequate left-turn lanes in order for it to accommodate the required vehicle loads at a reasonable level of service. This intersection and the improvements required will be discussed at length in the traffic accident analysis section of this chapter.

III. TRAFFIC ACCIDENT ANALYSIS

This section shows how the historical data contained in accident records were used as a tool in designing, conducting, and recommending an accident reduction program. Although developed for Eglin AFB, the methodology can be applied to any community that desires to improve traffic safety.

There were four basic steps used in the study of accident experience at Eglin AFB:

A. An accident data bank was established.

B. Hazardous locations were determined.

C. Improvements to these hazardous locations were recommended.

D. The recommended improvements were analyzed as to cost effectiveness.

In the traffic accident records systems design, considerable attention was given to data requirements not only for the roadway safety improvements but also for all other purposes for which accident data may be utilized. As a result, some of the data gathered are not essential to accident analysis. Possible other uses of these data are discussed in the section titled Data System.

Establishing an Accident Data Bank

To make analyses of accident data for identifying hazardous locations, the individual accidents must be identified with their specific location. Locations were assigned four character alpha/numeric codes with the alpha character designating a specific type:

A - Section of roadway $\geq$ .1 mile long.

B - Section of roadway (spot) $<$ .1 mile long excluding intersections.

C - Intersections of two or more roadways.

D - Parking lots.

E - Areas including A, B, C, and D.

The last three characters of the code are numeric permitting 1,000 different codes per type location; e.g., possible section codes range from A000-A999.

The Bureau of Public Roads, Federal Department of Transportation (DOT) recommends (16) that a section of roadway be limited by geometric homogeneity. A section of roadway is considered homogeneous if:

1. The cross-section dimensions are constant.
2. The surface type remains constant.
3. The number of lanes is constant.
4. The access control remains constant.

5. The environment - urban or rural - is constant.

In order to divide the roadways into homogeneous geometric sections, a visual survey was conducted throughout Eglin AFB and a coded map developed, Figure 11.

The next step in establishing the data bank was to catalogue accident information by location using the above location codes, in a form adapted to computer analysis. Using the Accident Data Instruction Code Sheet (Appendix B), data from the Motor Vehicle Accident Investigation Reports (Appendix A), on file with the local Security Police, were transcribed onto punch cards for computer input. The computer was programmed for a routine sort of the data card deck and also to summarize accident data relative to accident location. Now the data were in suitable form for identifying hazardous locations.

Determining Hazardous Locations

The purpose of accident analyses is to detect and correct highway locations which have been identified as hazardous. The method if identifying the hazardous locations (17) employs the rate quality-control technique.

By this method, accident data are analyzed to provide rates: accidents per vehicle for spots and intersections and accidents per vehicle mile for sections of roadway. Locations are eliminated by statistical tests (16) if rates are not significantly greater than a mean accident rate. The remaining locations are considered hazardous. The statistical tests applied are based on the commonly accepted assumption that accidents fit the Poisson distribution. The mathematical basis of this method is described in Appendix C.



Figure 11. Accident Code Map - Eglin Air Force Base.

The procedures involved in determining the hazardous locations on Eglin AFB are discussed next.

Input. The parameters required for the identification of these hazardous locations are:

a. Number of accidents by location (A).

b. Average annual daily traffic (ADT).

c. Length of section or spot under consideration (L).

d. Time period of study (1 January 1968 to 30 April 1970 - a total of 850 days).

e. Average accident rate for the type of roadway under consideration (R_a).

(1) Accidents per million vehicles for spots and intersections.

(2) Accidents per million vehicle miles for sections of roadways.

f. Level of statistical significance.

Average annual daily traffic (ADT) for each section or spot was taken from the traffic volume counts taken earlier. Lengths of sections were taken from scaled area maps.

Average accident rates. Accident rates and average numbers of accidents vary (16) with the nature of the roadway. Each section and location was assigned a roadway category designation defined by roadway type; for example, rural or urban, number of lanes, etc. These designations are needed so that average accident rates can be calculated for roadways of like characteristics.

Average accident rates were computed using equations (1) and (2) below:

Sections:

$$R_a = \frac{\sum_{n}^{n} A_i \ (10^6)}{T \sum_{n} (ADT_i \ M_i)} \qquad (1)$$

Where:

R_a = Average accident rate (per million vehicle miles)

A_i = Number of accidents occurring on the ith roadway section during the time period T.

T = Time period of data collected

ADT_i = Average annual daily traffic for the ith section

M_i = Length in miles of the ith section

n = Number of sections.

Intersections:

$$R_a = \frac{\sum_{n}^{n} A_i \ (10^6)}{T \sum_{n}^{n} ADT_i} \qquad (2)$$

Where R_a = Average accident rate (per million vehicles)

Data for the State of Florida (18) were available for roadway sections comparable to Eglin Main Base and were used in determining the average accident rate, R_a.

ADT at intersections includes the cross street ADT. Number of accidents (A) also includes those cross street intersection approach accidents that were designated as intersection accidents; i.e., that occur within .025 miles (132 feet) of the center of the intersection.

Rate quality-control method. The minimum criteria used for testing accident locations by the rate quality-control method is (17) the critical accident rate. It is a function of average accident rate, average daily

traffic, time period of study, and section length for the category of roadway being tested. Roadways with an existing accident rate in excess of the critical rate are hazardous. The critical rate, R_c, is computed as follows:

$$R_c = R_a + K \sqrt{\frac{R_a}{M}} - \frac{1}{2M} \qquad (3)$$

Where:

R_c = critical accident rate.

R_a = average accident rate for that roadway category.

M = average vehicle exposure for a specific location.

K = constant.

(For sections, R_c and R_a are accidents per million vehicle miles and M is million vehicle miles.)

(For intersections, R_c and R_a are accidents per million vehicle miles and M is million vehicles.)

For a specific location, all the terms of the above equation are from data on the specific location except for the value of K which is determined by the level of statistical significance deemed important. Therefore, the value of K determines the length of the hazardous location list. The 90 percent confidence level with a corresponding value of K = 1.282 was used for determining hazardous locations.

Identification. Whenever the location accident rate is greater than the critical accident rate, the location is considered hazardous. Seventeen Eglin AFB locations were found hazardous. Table 11 shows an example of the critical accident rate tabulations for roadway sections. A similar list was generated for intersection locations.

Table 11. Critical Accident Rates - Eglin Boulevard Roadway Sections

Location		Number of Accidents	Average Daily Traffic	Length in Miles	Million Vehicle Miles	Accident Rates (Accidents per MVM)	
						Existing	Critical
Name	Code	A	ADT	L	M=ADT x L x 850 x 10-6	$R = \frac{A}{M}$	C.L.=90% R_c
Barrancas Ave	A106	5	7300	100	.621	8.052	9.948
Barrancas Ave	A107	3	7300	.125	.776	3.866	9.669
Barrancas Ave	A108	1	7300	.150	.931	1.074	9.451
Barrancas Ave	A109	6	7300	.165	1.024	5.859	9.341
7th St	A113	5	7400	.125	.786	6.361	9.653
7th St	A114	4	7000	.109	.649	6.163	9.892
7th St	A115	6	7000	.160	.952	6.303	9.425
Choctawhatchee Ave	A116**	14	6000	.250	1.275	10.980	9.100
Choctawhatchee Ave	A117	5	6500	.101	.558	8.961	10.086
Daytona Rd	A118	2	9200	.115	.899	2.225	9.492
8th St	A121	1	3300	.116	.325	3.077	10.810
8th St	A122	4	2400	.210	.428	9.346	10.438
Daytona Rd	A123	0	4000	.100	.340	-----	10.749
8th St	A125	1	1700	.120	.173	5.780	11.596
Escambia Rd	A126	2	5600	.120	.571	3.503	10.056
Escambia Rd	A127**	4	2400	.125	.255	15.686	11.131
7th St	A128	3	4000	.125	.425	7.059	10.448
Cypress Rd	A129	1	2300	.175	.342	2.924	10.741
Georgia Rd	A130	5	8000	.149	1.013	4.936	9.354
5th St	A131	0	2100	.250	.446	-----	10.383
6th St	A132	2	2100	.300	.536	3.731	10.139
4th St	A133	2	2000	.250	.425	4.706	10.448
2nd St	A134	2	1000	.250	.213	9.390	11.358
"A" Ave	A136**	3	2100	.135	.241	12.448	11.204
"A" Ave	A137	0	1700	.125	.181	-----	11.547
"D" Ave	A138/139	4	2400	.240	.490	8.163	10.257
TOTALS		85	1.19×10^5	4.19	14.875	R_a = 6.58 ACC/MVM	

**Hazardous Locations

Methods to Determine Safety Improvements

The hazardous locations identification summary pinpointed the high accident rate locations which required detailed analysis in an effort to determine accident causes so that remedial improvements could be recommended.

To assist in analyzing these accidents, collision diagrams and/or accident summaries were prepared by researching the accident data bank for each hazardous location.

Collision diagrams. Collision diagrams, although not drawn to scale, show graphically the nature of all accidents that occurred at the location. The direction of movement of each vehicle is shown by arrows. The legend in Figure 12 explains additional symbols used.

Accident summaries. Summaries (Table 12) provided another means of assembling the facts pertaining to accidents occurring at the hazardous locations. They show the total number of each type of accident, such as head-on, rear end, etc.; the number of property damage only, injury, and fatal accidents, and the number of accidents that occurred during a particular season or time of day.

On-site observations. In addition to preparing collision diagrams and accident summaries, on-site observations were conducted at the 17 hazardous locations to arrive at the final analysis of accident causes. Then improvements were recommended based on these causative factors.

Example of Hazardous Location Analysis

As an illustration of the procedures involved in the analysis of high accident rate locations, the following example is submitted. It

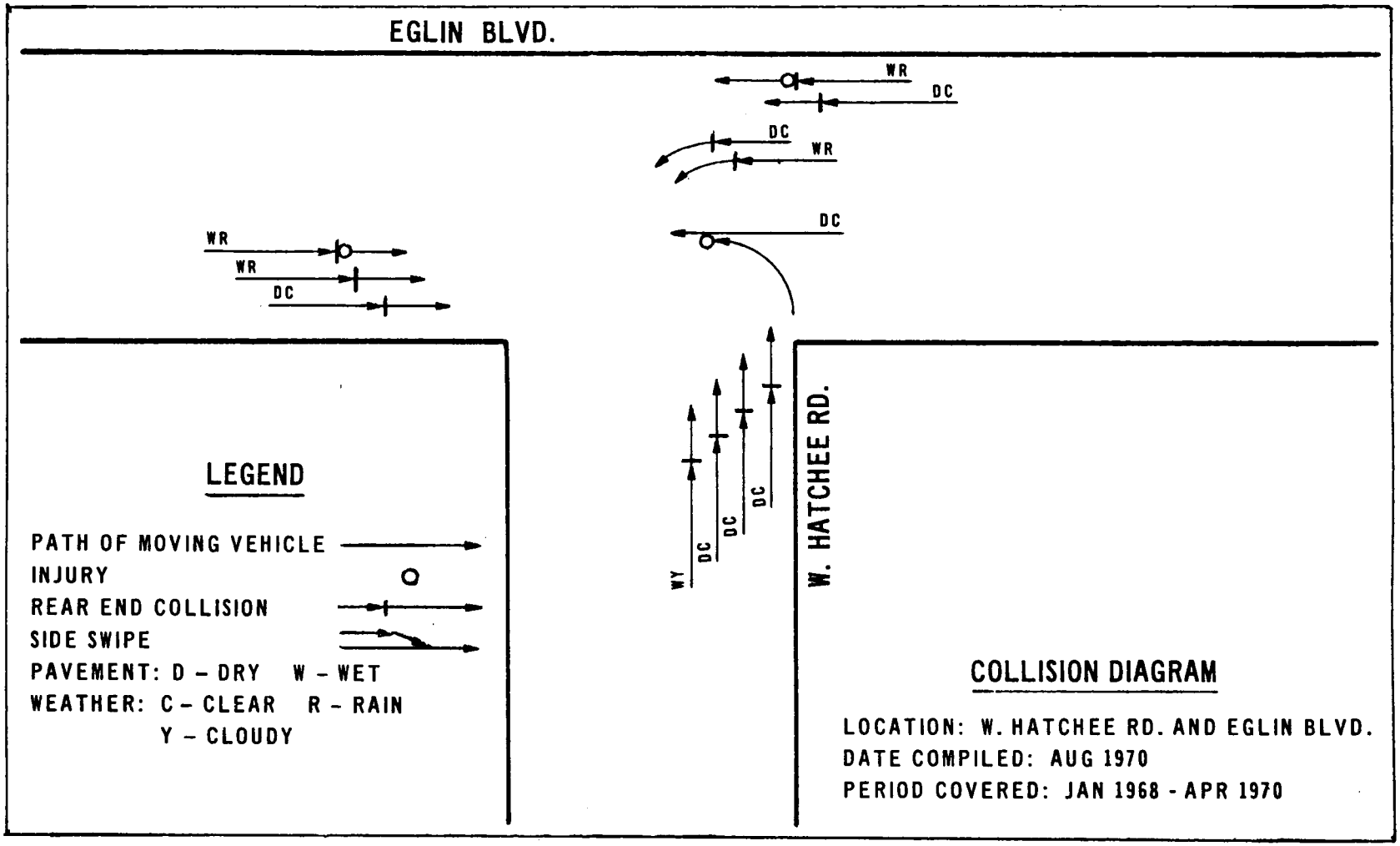


Figure 12. Collision Diagram - West Hatchee Road and Eglin Boulevard

Table 12. Accident Summary - West Hatchee Road and Eglin Boulevard

Variable	No. of Accidents	Variable	No. of Accidents No. of Vehicles
Time of Year		**Time of Day**	**Accidents**
Winter (Dec-Feb)	4	0001-0600	0
Spring (Mar-May)	4	0601-1200	6
Summer (Jun-Aug)	4	1201-1800	6
Fall (Sep-Nov)	1	1801-2400	1
	13		13
Pavement		**Type of Vehicle**	**Vehicles**
Dry	8	Government	4
Wet	5	Private	22
	13		26
Weather		**Accident Severity**	**Accidents**
Clear	8	Property Damage Only	11
Fog	0	Injury	2
Raining	4	Fatality	0
Cloudy	1		13
Strong Wind	0		
	13		
Type of Accident		**Direction of Travel**	**Vehicles**
Head-on	1	North	0
Head-to-Side	0	Northeast	6
Rear End	11	East	0
Backing	0	Southeast	0
Side Swipe	1	South	0
Lost Control	0	Southwest	9
Fixed Object	0	West	0
Pedestrian	0	Northwest	9
Other	0		24
	13		

concerns the West Side Road and Chinquapin Drive intersections on Eglin Boulevard. The existing lane delineation of this area is seen in Figure 13. This example includes a discussion of pertinent facts found from a study of the collision diagrams and accident summaries as supplemented by other information obtained during several on-site observations.

Collision diagram and accident summary analysis.

West Side Road. The collision diagram is shown in Figure 14 and summarized in Table 13. Examination of this information indicates the following:

(1) The majority of vehicles involved in accidents were approaching the intersection from the northeast. A majority of these were involved in rear end collisions on wet pavement.

(2) All 9 right angle collisions occurred on dry pavement in clear weather.

(3) More collisions occurred in winter months than any other season.

(4) Accidents were equally divided between the morning and afternoon "work-hours".

(5) Rear end and head-to-side collisions were more numerous than other types.

Chinquapin Drive. The collision diagram is shown in Figure 15 and summarized in Table 14. (Included in Figure 15 are the accidents that occurred in the three-tenths mile section of Eglin Boulevard approaching the intersection from the northeast.) The following facts are revealed by referring to these figures:

(1) Nine out of ten accidents were rear end collisions that occurred on wet pavement during rainy weather.

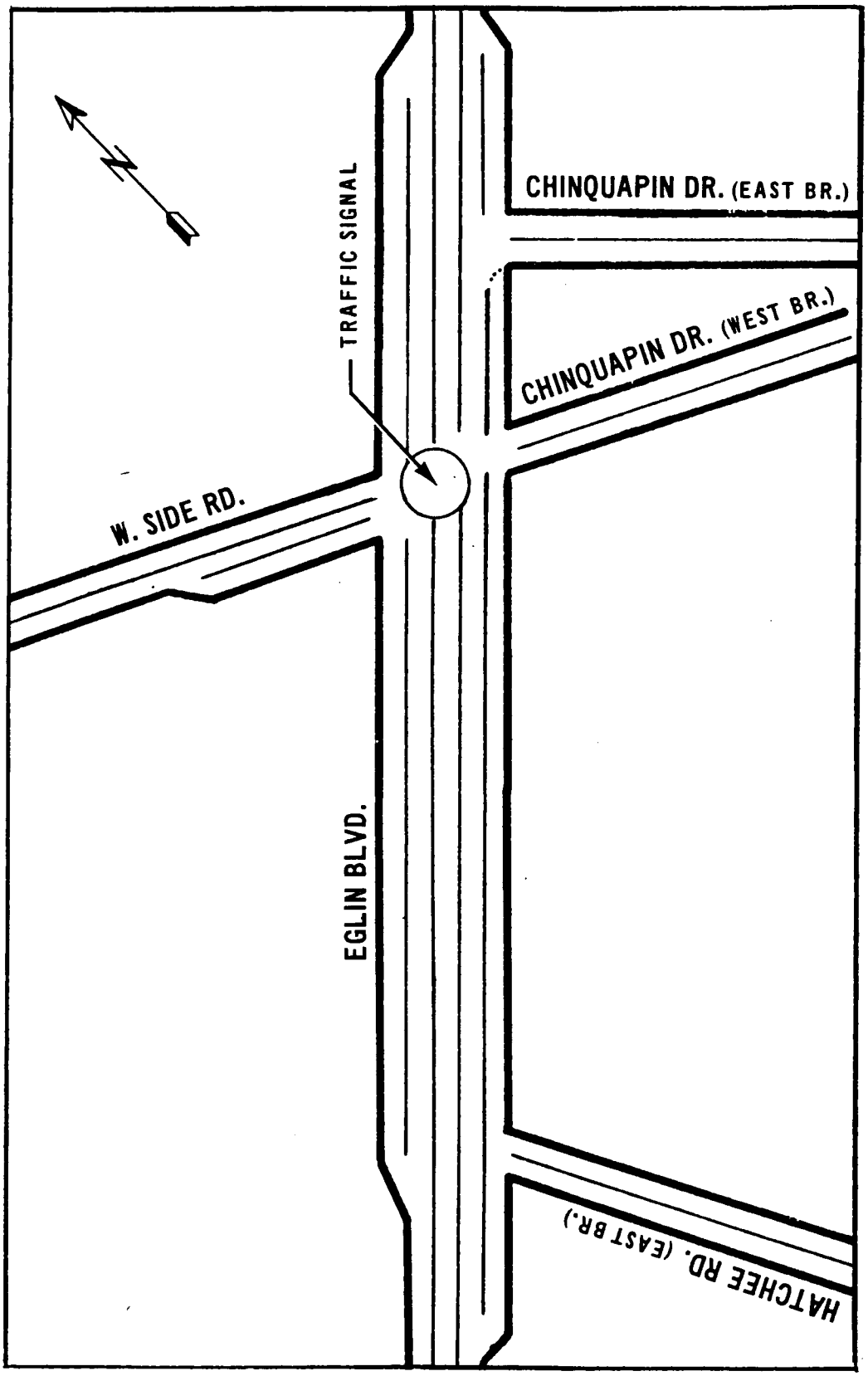


Figure 13. Existing Lane Delineation - West Side Road and Chinquapin Drive Intersections on Eglin Boulevard.

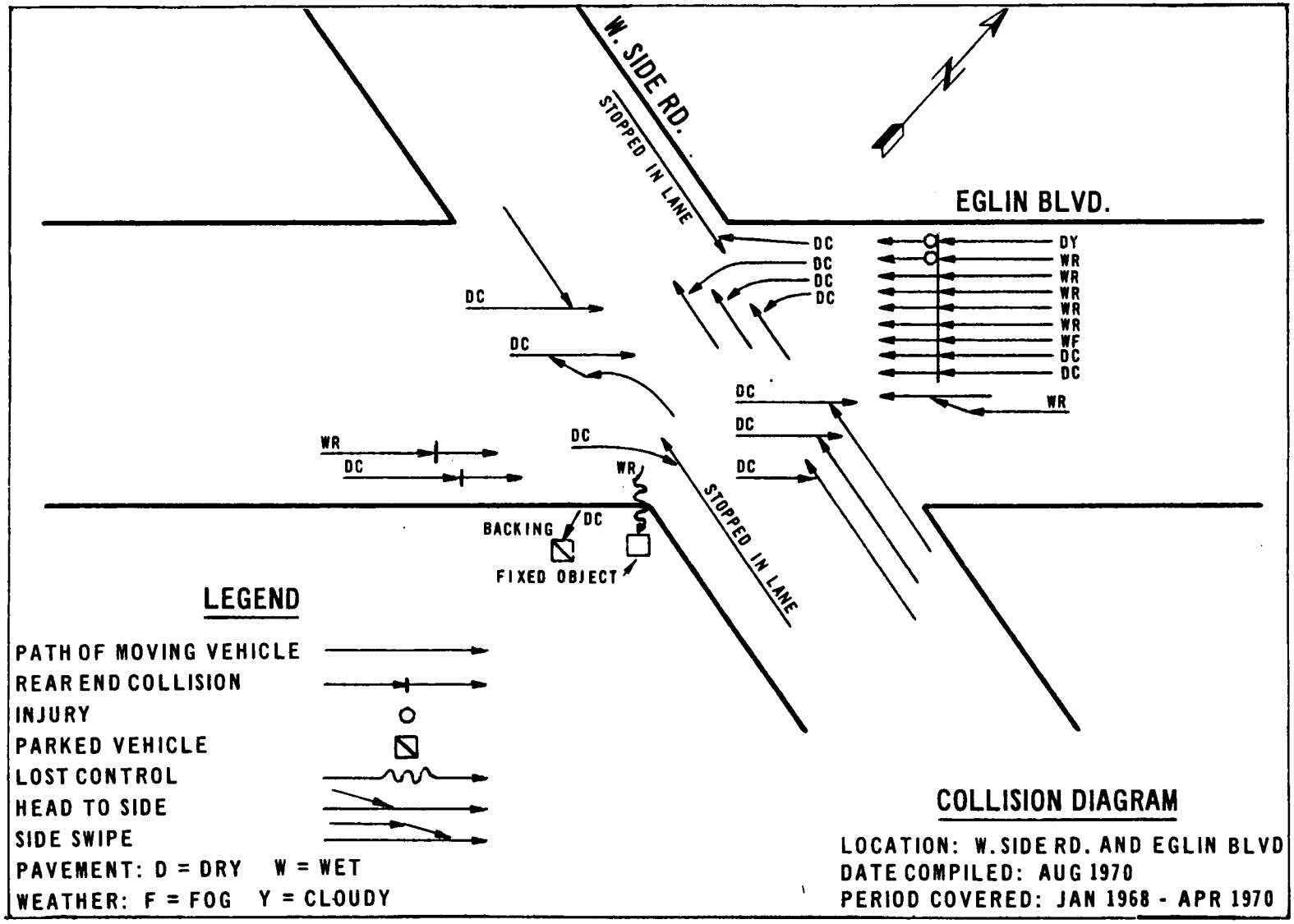


Figure 14. Collision Diagram - West Side Road and Eglin Boulevard.

Table 13. Accident Summary - West Side Road and Eglin Boulevard.

Variable	No. of Accidents	Variable	No. of Accidents No. of Vehicles
Time of Year		Time of Day	Accidents
Winter (Dec-Feb)	12	0001-0600	1
Spring (Mar-May)	5	0601-1200	10
Summer (Jun-Aug)	5	1201-1800	10
Fall (Sep-Nov)	2	1801-2400	3
	24		24
Pavement		Type of Vehicle	Vehicles
Dry	15	Government	10
Wet	9	Private	37
	24		47
Weather		Accident Severity	Accidents
Clear	14	Property Damage Only	22
Fog	1	Injury	2
Raining	8	Fatality	0
Cloudy	1		24
Strong Wind	0		
	24		
Type of Accident		Direction of Travel	Vehicles
Head-on	0	North	0
Head-to-Side	9	Northeast	10
Rear End	11	East	0
Backing	1	Southeast	2
Side Swipe	2	South	2
Lost Control	0	Southwest	24
Fixed Object	1	West	0
Pedestrian	0	Northwest	8
Other	0		46
	24		

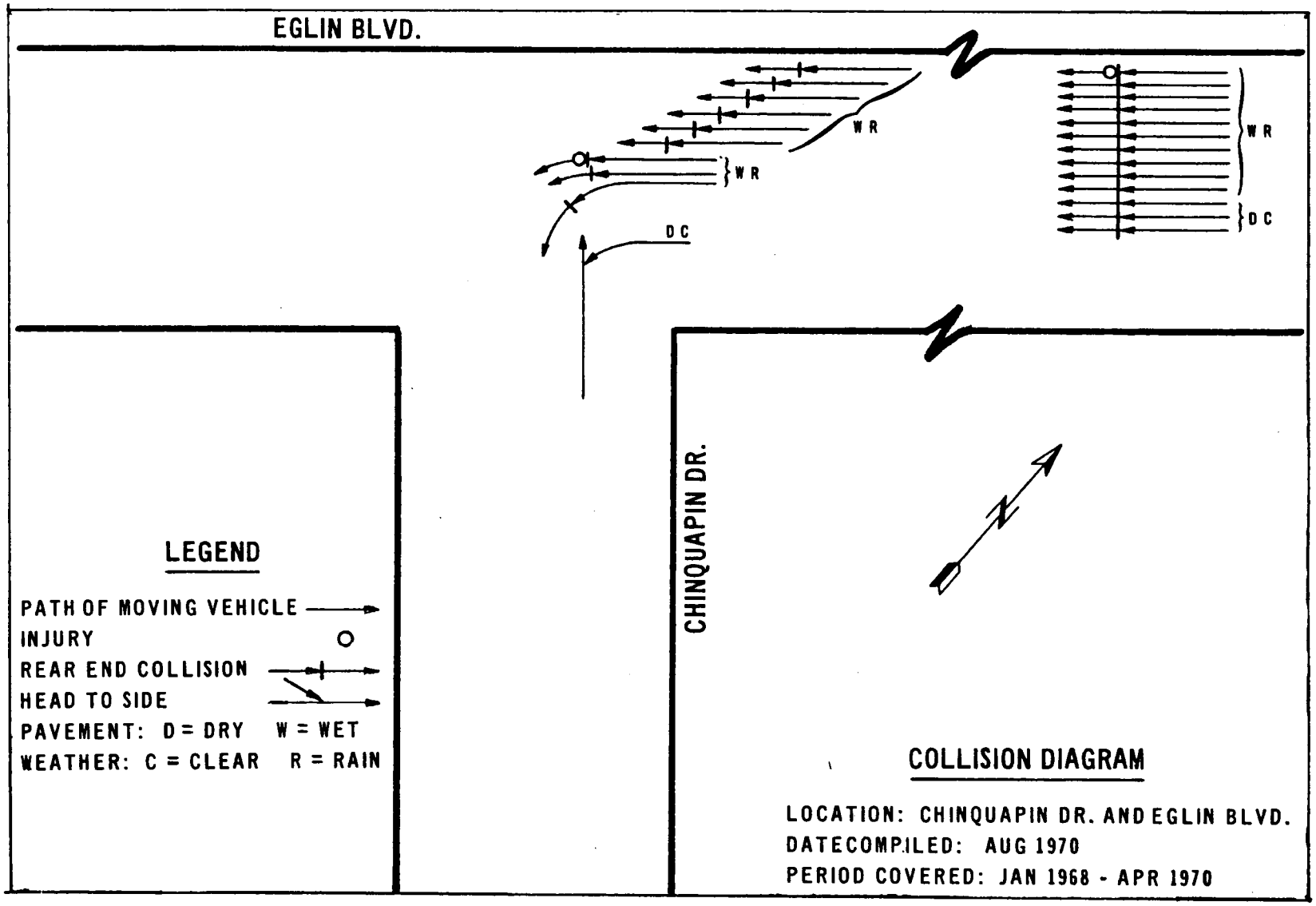


Figure 15. Collision Diagram - Chinquapin Drive and Eglin Boulevard.

Table 14. Accident Summary - Chinquapin Drive and Eglin Boulevard.

Variable	No. of Accidents	Variable	No. of Accidents No. of Vehicles
Time of Year		**Time of Day**	**Accidents**
Winter (Dec-Feb)	5	0001-0600	0
Spring (Mar-May)	3	0601-1200	2
Summer (Jun-Aug)	1	1201-1800	7
Fall (Sep-Nov)	1	1801-2400	1
	10		10
Pavement		**Type of Vehicle**	**Vehicles**
Dry	1	Government	1
Wet	9	Private	19
	10		20
Weather		**Accident Severity**	**Accidents**
Clear	1	Property Damage Only	9
Fog	0	Injury	1
Raining	9	Fatality	0
Cloudy	0		10
Strong Wind	0		
	10		
Type of Accident		**Direction of Travel**	**Vehicles**
Head-on	0	North	0
Head-to-Side	1	Northeast	0
Rear End	9	East	0
Backing	0	Southeast	0
Side Swipe	0	South	0
Lost Control	0	Southwest	19
Fixed Object	0	West	0
Pedestrian	0	Northwest	1
Other	0		20
	10		

(2) Approaching the intersection from the northeast 12 rear end collisions occurred. Nine of these were during rain showers.

(3) All accidents involved vehicles as they approached the intersections from the northeast.

(4) The majority of accidents occurred in the afternoon.

(5) Property damage only accidents predominated.

On-site observations. Field visits to this area indicated the following:

a. Any redesign of the West Side Road intersection should include the Chinquapin Drive and East Hatchee Road intersections.

b. Southwest bound traffic on Eglin Boulevard was permitted left turns onto the west branch of Chinquapin Drive.

c. All approaches to the intersections were clear; i.e., the vehicle operator had an unobstructed view.

d. Approaching from the northeast, the motorist could be deceived by the confusion created with the overhead lane light's close proximity to the traffic signal.

e. During wet weather, the roadway surface was very slick making controllable rapid decelerations difficult.

f. Vehicles making a left turn onto Chinquapin Drive impeded traffic flow in the center lane of Eglin Boulevard.

g. In the winter season and during the afternoon "rush-hour", the sun angle is such as to shine directly into the driver's eyes when he approaches from the northeast. It was apparent that only when the driver is close to the intersecting street could he observe the traffic signal clearly.

Recommended improvements. The recommended engineering improvements at the TAC Light area including Chinquapin Road and East Hatchee Road intersections are illustrated in Figure 16. The safety improvements depicted are:

a. Constructing left turn lanes at Chinquapin and East Hatchee Roads for southwest bound traffic and at West Side Road for northeast bound traffic to provide a sheltered holding area for turning traffic.

b. Widening the traffic lanes to the standard twelve foot width.

c. Adding an additional lane to permit smooth flow of thru traffic.

d. Provide a painted median and other pavement markings to include stop lines and lane delineation to allow adequate separation between opposing lanes of traffic and better control of approaching traffic.

e. Resurfacing the roadway to improve coefficient of friction for better vehicle control.

Like analysis was used to recommend safety improvements on the remaining sixteen hazardous locations on Eglin AFB.

Cost Analysis

In previous sections of this chapter (1) accident locations which experienced high accident rates were identified, and (2) an example of analysis which led to recommended improvements was shown.

Now, the economic aspects of the improvements will be evaluated. This is accomplished by (1) determining the economic feasibility of each improvement on a cost basis and (2) determining the order in which to

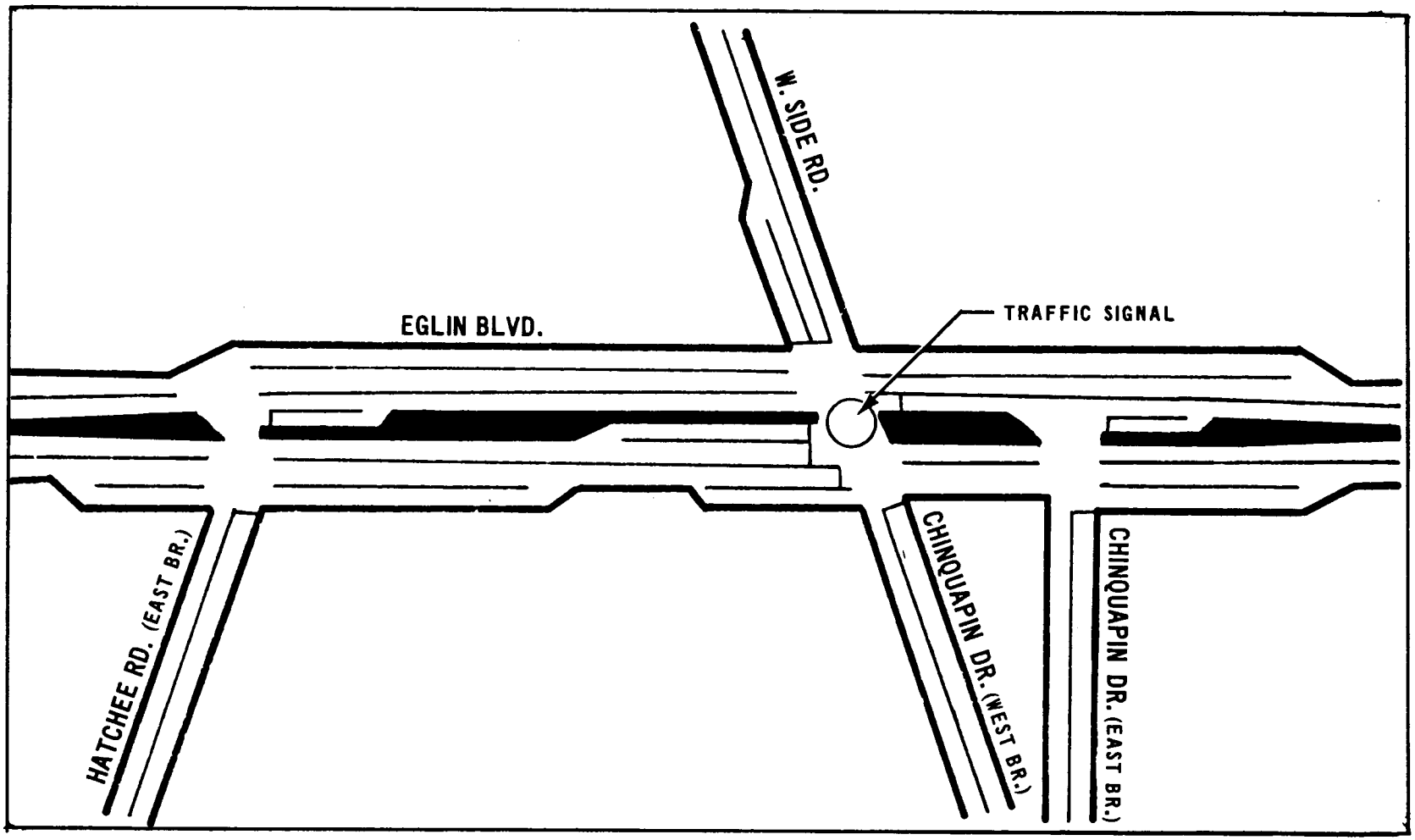


Figure 16. Recommended Improvements - West Side Road and Chinquapin Drive Intersections on Eglin Boulevard.

treat hazardous locations on a basis of benefit - cost ratios.

Background. Determining cost per accident is the basic step in this cost analysis. Several states have conducted cost studies. California conducted a study on costs of accidents (19) occurring in 1964. The California report used data generated by a 1958 Illinois study (20) which measured direct costs of accidents. The Illinois report defined direct costs as,

> ...the money value of: Damage to property, ambulance use, hospital and treatment services, doctor and dentist services, loss of use of vehicle, value of work time lost, legal and court fees, damage awards and settlements, and other miscellaneous items. . . Such items as loss of future earnings of persons killed or permanently injured in accidents were excluded from the direct cost phase of the studies, except to the extent that damage awards or settlements made either in or out of court might have compensated for such losses. Expenditures also excluded from the direct cost phase of the studies were those made by public and private agencies in the interest of accident prevention or to mitigate the economic burden of accidents and the overhead cost of automobile and certain other types of insurance.

The direct costs can be summarized as the dollar expenditures, including the value of work time lost, by people as the result of a traffic accident.

The 1958 Illinois accident involvement costs were updated (21) to 1969 prices. These calculations appear in Appendix D. Medical care expenses have increased somewhat more than other prices. This fact was reflected in the revised price indexes for fatal and injury accidents; however, an average price increase of 28 percent for 1969 was used in further calculations.

The involvement costs, adjusted for 1969 prices by applying the 28 percent increase to the Illinois involvement costs were:

	Cost Per Vehicle Involved		
	Fatal	Injury	PDO
Illinois	$4,215	$ 910	$144
Illinois + 28 percent	5,395	1,165	184

The Illinois costs reflect the average number of persons killed and injured per vehicle in Illinois. It was assumed that approximately the same ratios held for Eglin AFB.

An involvement is defined (19) as one vehicle involved in an accident. Therefore, the above costs have to be converted to a per accident basis.

For this conversion, the average number of vehicles involved per reported accident for non-freeway urban roadways for California (19) for 1965 were assumed to be the same as Eglin's.

Multiplying the vehicles involved per accident by the cost per vehicle involved gave the following accident costs:

Accident Type	Vehicles per Accident	Cost per Vehicle Involved	Cost per Accident
Fatal	1.67	$5,395	$9,010
Injury	2.03	1,165	2,365
PDO	2.02	184	372

The National Safety Council (NSC) calculated accident costs for 1964 as (7):

Fatal (each person killed) - - - - - -$34,400

Injury (each person injured) - - - - -$ 1,800

Property Damage Only - - - - - - - - -$ 310

In addition to direct costs, the NSC estimates included indirect costs which are mainly the loss of future earnings of persons killed

or permanently disabled. Therefore, the cost per accident figures used in this study are very conservative.

Improvement justification. Many accident reduction studies have been conducted in recent years in which before and after accident experiences have been compared for a specific type improvement. The results were then consolidated and presented (17) (19) in various reports as accident reduction probabilities.

When safety improvements are applied judiciously to a hazardous location, very substantial accident reductions can be realized. Later it will be shown by an example that many improvements will more than pay for themselves in savings over a period of a few years due to reduced accident costs. This is accomplished by comparing the savings in accident costs to the cost of the improvements.

When accident reduction measures are applied to hazardous locations there is a probability (17) (19) of a corresponding accident reduction. This accident reduction projected over the service life of the improvement (assumed to be 20 years for all improvements except warning/control signs whose service life is assumed to be 5 years) and divided into the cost of construction gives the construction cost per accident prevented during the lifetime of the improvement.

To determine if an improvement is justified on accident reduction alone, the average cost of accidents in the past is calculated using cost values like those shown in Table 15. Then, if the average cost per accident exceeded the construction cost to prevent an accident, the improvement is considered justified.

Table 15. Cost Analysis - Eglin Boulevard and Eglin Main Base.

	LOCATION		Accident Experience -28 months-			Accident Reduction Probability	Improvement Cost	IMPROVEMENT JUSTIFICATION: Average No. Accidents Per Year	Accidents Prevented In 20 Years	Construction Cost/Acc. Prevented	Existing Avg. Cost/ Accident	Is Improvement Justified?	BENEFIT - COST RATIO: Annual Accident Reduction			Average Annual Benefit	Avg. Annual Construction Cost	Benefit To Cost Ratio
	Name	Code	Fat	Inj	PDO	Percent	Dollars	Acc/Year	Accidents	Dollars	Dollars	Yes/No	Fat	Inj	PDO	Dollars	Dollars	
EGLIN BLVD	7th St.- Wacissa Rd.*	A119	0	7	13	51	7,353	8.57	87.41	84	1,070	Yes	0	1.53	2.84	4,674	641	7.29
	Tac Light Area *	A009	0	5	34	51	10,859	16.71	170.49	64	627	Yes	0	1.09	7.43	5,342	947	5.64
	East Gate *	B110	0	1	5	57	2,895	2.57	29.30	99	704	Yes	0	0.24	1.22	1,022	252	4.06
	Cobbs' Overun	A014	1	5	16	63	21,363	9.43	118.80	180	1,218	Yes	0.27	1.35	4.32	7,232	1,863	3.88
	East of Tac Light	A010	0	4	14	59	25,772	7.71	91.00	283	815	Yes	0	1.01	3.54	3,706	2,247	1.65
	Loop-Blvd, 2nd St., "F" Ave	----	0	6	30	33	25,375	15.43	102.86	247	704	Yes	0	0.86	4.29	3,630	2,213	1.64
	W. Hatchee Rd.*	A001	0	2	11	44	13,440	5.57	49.00	274	679	Yes	0	0.38	2.07	1,669	1,172	1.42
	Wacissa Rd.- 6th St.*	A120	0	0	10	43	9,784	4.29	36.89	265	372	Yes	0	0	1.84	684	853	0.80
	East of Memorial Lake	A013	0	1	11	65	26,907	5.14	66.86	402	538	Yes	0	0.28	3.06	1,800	2,346	0.77
	6th-7th St.*	B104	0	0	5	57	7,669	2.14	24.40	314	372	Yes	0	0	1.22	454	669	0.68
	Gas Station Area	A003	0	1	3	59	14,906	1.71	20.23	737	870	Yes	0	0.25	0.76	874	1,300	0.67
	"F" Ave-6th St.	A112	0	1	3	50	13,605	1.71	17.10	796	870	Yes	0	0.21	0.64	735	1,186	0.62
	Chapel #3 Area	A002	1	2	9	30	47,049	5.14	30.86	1,525	1,424	No	0.13	0.26	1.15	2,214	4,103	0.54
	8th St.- Danner Club	B108	0	0	2	30	3,473	0.86	4.99	696	372	No	0	0	0.25	93	303	0.31
	Danner Club-Foster	B109	0	0	2	30	4,342	0.86	4.99	870	372	No	0	0	0.25	93	379	0.25
	West Gate	B001	0	0	2	20	6,368	0.86	3.44	1,857	372	No	0	0	0.17	64	555	0.11
	E. Hatchee Rd.	A004	0	0	2	30	13,009	0.86	5.14	2,530	372	No	0	0	0.26	96	1,134	0.08
	Memorial Lake Area	A011	0	0	1	30	14,011	0.43	2.58	5,431	372	No	0	0	0.13	48	1,222	0.04
	Foster- McCarthy Ave.	A124	0	0	1	30	19,820	0.43	2.49	7,960	372	No	0	0	0.12	45	1,728	0.03
	EGLIN BOULEVARD SYSTEM		2	35	174	48	288,000	90.42	868.83	331	784	Yes	0.40	7.46	35.56	34,475	25,113	1.37
MAIN BASE	2nd St./"D" Ave.*	C274	0	0	2	32	50	0.86	5.51	9	372	Yes	0	0	0.27	100	4	25.00
	3rd St./"D" Ave/*	C263	0	0	4	32	90**	1.71	2.74	33	372	Yes	0	0	0.55	204	14	14.57
	Flagler/ Lido Rds.*	C252	0	0	2	37	81**	0.86	1.59	51	372	Yes	0	0	0.32	118	19	6.21
	Choctawhatchee Ave.*	A116	0	2	21	73	18,275	9.86	143.96	127	545	Yes	0	0.63	6.57	3.924	1,594	2.46
	"A" Ave.*	A136	0	2	13	62	19,260	6.43	79.73	242	638	Yes	0	0.53	3.45	2,542	1,679	1.51
	7th/Wacissa/ Biscayne *	C219	0	0	3	76	4,260	1.29	19.61	217	372	Yes	0	0	0.98	365	371	0.98
	Escambia Rd.*	A127	0	0	4	56	11,600	1.71	19.14	605	372	No	0	0	0.96	357	1,012	0.35

*Hazardous Location
**5 Year Service Life of Improvement

Determination of order of treatment of hazardous locations. To determine the order in which the hazardous locations should be improved requires computing the benefit-cost ratio for each location.

The benefit is the total annual dollar savings based on expected accident reduction probabilities. The reduction probability is applied uniformly to the existing accident experience according to severity and multiplied by the corresponding cost per accident to arrive at the total annual safety benefit.

The cost is the total annual cost of the improvement and should include the time value of money. (Calculations in Table 15 use a rate of six percent.) The capital recovery factors[1] at six percent interest for service lives of 20 years and 5 years are .0872 and .2374, respectively. These capital recovery factors are then multiplied by the cost of construction to give the total annual cost of the improvement.

By ranking the locations in order of the benefit-cost ratios, from the highest to the lowest, the order of treatment is determined.

Using this method of benefit to cost assures getting the maximum safety benefit for the dollars invested.

The cost analyses for improvement justifications and order of treatment of the hazardous locations for Eglin AFB are summarized in Table 15. From a safety viewpoint, it is not advisable to upgrade one section of roadway to a high level and maintain the remaining sections at that of a lower grade roadway. Therefore, roads were cost analyzed for their entire length as reflected by the table. The upper half of

[1]Capital recovery factor represents the fraction of the initial net capital investment which would be recovered each year if the investment were put into an annuity at a given interest rate. In this sense, the capital is recovered.

the table lists locations for Eglin Boulevard and are ranked according to benefit-cost ratios. The lower half of the table contains the hazardous locations for Eglin Main Base and are also ranked according to benefit-cost ratios. The middle entry includes a road used in conjunction with Eglin Boulevard. This shows that on the basis of accident reduction alone, the improvement of Eglin Boulevard is justified. Assuming funds are insufficient to improve all of the hazardous locations worthy of improvement, treatment should start at the locations with the greatest benefit-cost ratio; i.e., 7th Street to Wacissa Road for Eglin Boulevard and 2nd Street and "D" Avenue for Eglin Main Base.

Example of cost analysis. Data regarding location A119 from Table 15 will be used to illustrate the procedures involved in the cost analysis. The accident record shows:

	Number of Accidents				
Time Period	Total	Fatal	Injury	PDO	Avg. Per Year
28 months	20	0	7	13	8.57

The accident reduction probability for the recommended improvements at this location is 51 percent and the service life is assumed to be 20 years. Improvement cost is $7,353.

The accidents prevented in 20 years are:

Accidents prevented = 8.57 acc/year x .51 x 20 years
= 87.41 accidents.

So the construction cost per accident prevented is:

$$\text{Construction cost per accident prevented} = \frac{\$7353}{87.41} = \$84.$$

Using the cost per accident values on Page 60, the average cost per accident is:

$$\text{Average cost/accident} = \frac{(0)\ \$9010 + 7(\$2356) + 13(\$372)}{20} = \$1070.$$

Since the cost of the improvement to prevent an accident is less than the existing cost of each accident, the improvement is justified.

With the accident reduction probability applied equally to each accident severity, the average annual benefit due to accident reduction is:

$$\text{Average Annual Benefit} = (0)\ (\$9010) + (1.53)\ (\$2356) + (2.84)\ (\$372) = \$4674.$$

The average annual cost of construction over the lifetime of the improvement and including the time value of money is:

$$\text{Average Annual Cost} = (.0872)\ (\$7353) = \$641.$$

The calculated benefit-cost ratio is:

$$\text{Benefit-cost ratio} = \frac{\$4674}{\$\ 641} = 7.29.$$

Additional Accident Information

Accident statistics form the nucleus for traffic engineering analysis. Some of the information gathered and not used heretofore in the analysis are presented in Appendix E.

Figure 17 shows the average number of accidents as related to the month of the year. The Kolmogorov-Smirnov test was used to determine if, in fact, the expected number of accidents were the same for each month, or that accidents were uniformly distributed. Results of the test, at the .01 level of significance, show that the distribution of accidents per month is uniform. This is pictorially represented in Figure 18. The application of this test to the data is explained in Appendix F.

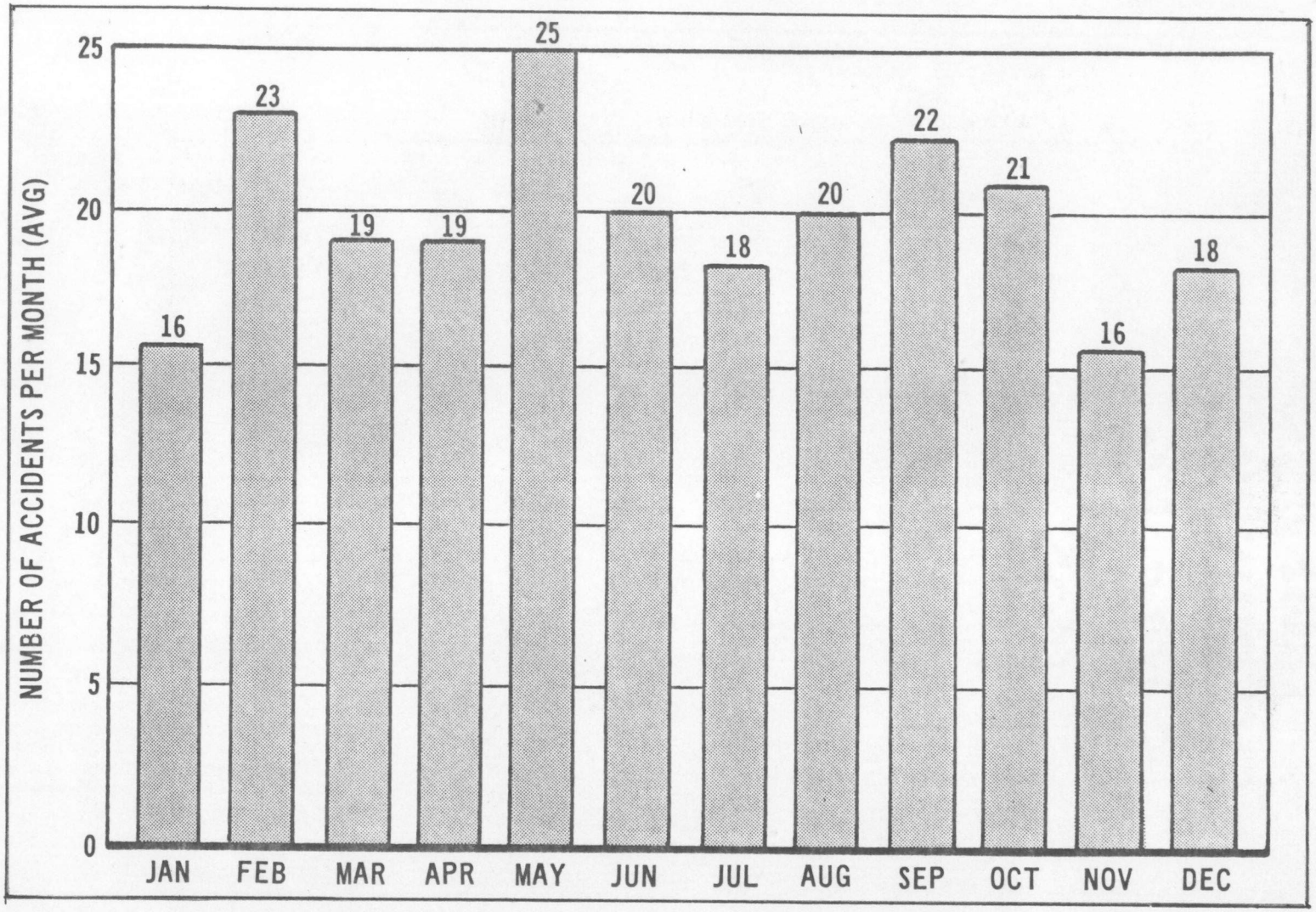


Figure 17. Average Number of Accidents Per Month.

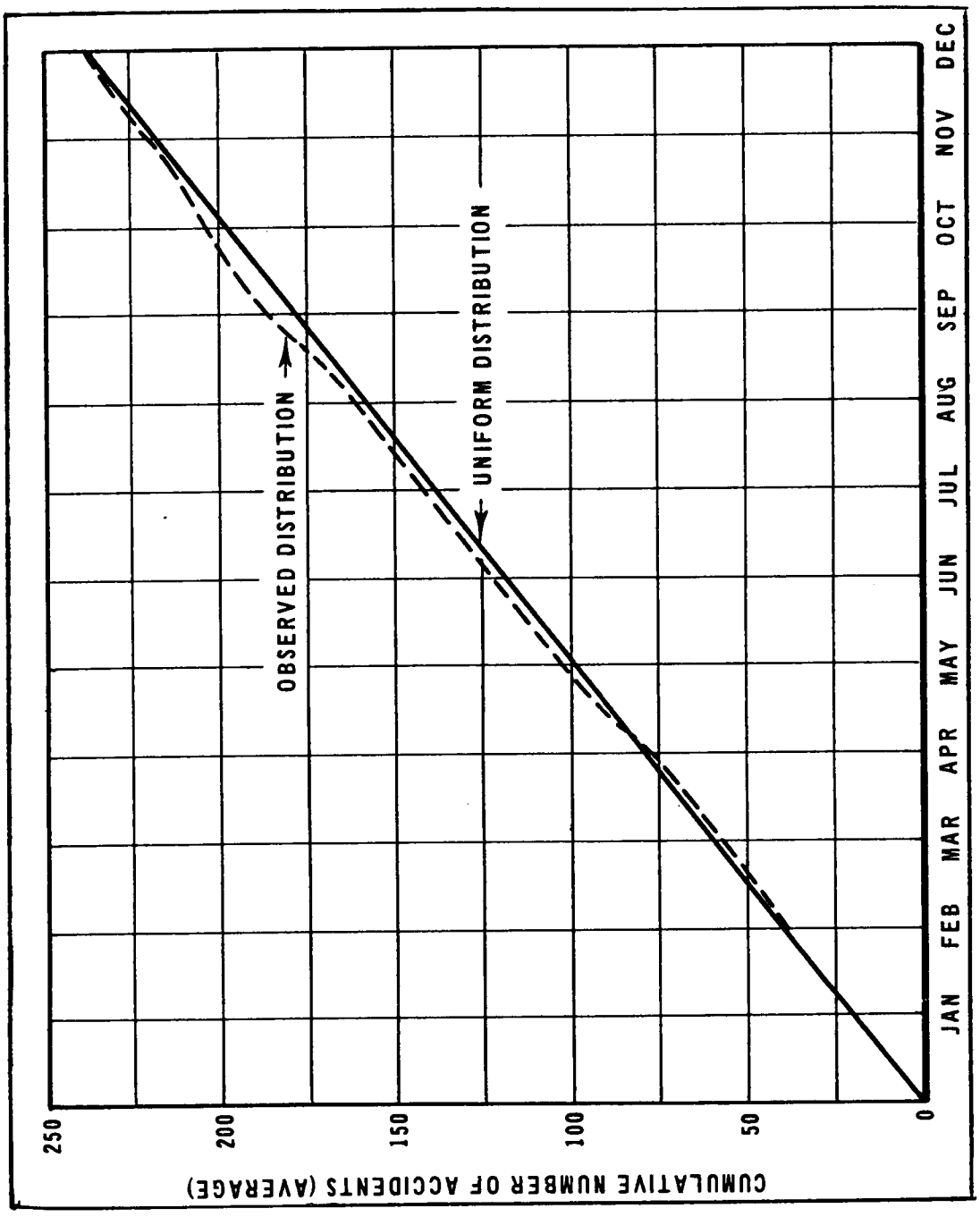


Figure 18. Cumulative Average Number of Accidents by Month.

IV. ORIGIN-DESTINATION SURVEY AND STUDY

Origin-Destination Questionnaire

Since base officials would not permit traffic to be stopped to obtain origin-destination information, an origin-destination questionnaire was designed to take the place of roadway interview stations.

Figure 19 shows the finalized O-D questionnaire. Figure 20 shows the answer sheet used with the questionnaire. The O-D questionnaire was designed to obtain data on the origin and destination of work trips, the mode of transportation, the times people came to work, traffic annoyances, blocks walked and blocks willingly walked, gates used, and a section to determine how on base facilities are used by people living off base that work on Eglin Main. In addition, two questions were included to determine the future use of SR 189. This information provided the basic data needed to determine the signal timing for the new traffic light at the intersection of SR 397 and SR 189.

The O-D questionnaire was administered by the base Air Police. Questionnaires were given to every fourth person requesting a base sticker that worked on Eglin Main.

Zone Maps and Coding

District or zone maps were drawn of the Fort Walton Beach and Eglin AFB areas. These zones were given numbers and used to code the "District" block on the answer sheet, Figure 20. The origin-destination codes are shown in Figure 21.

Prior to coding, each answer sheet was scanned to determine completeness and to detect answers that were ambiguous. If a form was incomplete

ORIGIN/DESTINATION QUESTIONNAIRE

(Do not write on these pages. Answer all questions on ADTC Form 0-303.)

DUTY BLDG NO. Enter the number of the building in which you work.

HOME ADDRESS. Self-explanatory. LCC Hc

SECTION I

(To be completed by all personnel employed/assigned on Eglin Main)

A. By what means do you get to work? (Circle one)

1. Drive own car
2. Ride as passenger
3. Ride in car pool
4. Air Force bus
5. Taxicab
6. Motorcycle or bicycle
7. Other (specify in space provided)

B. What time does your normal duty day begin? (Circle one)

1. 0615
2. 0630
3. 0645
4. 0700
5. 0715
6. 0730
7. 0745
8. 0800
9. Other (specify in space provided)

C. What time does your normal duty day end? (Circle one)

1. 1530
2. 1545
3. 1600
4. 1615
5. 1630
6. 1645
7. 1700
8. 1715
9. Other (specify in space provided)

D. Would you be in favor of a base transit system, to run throughout the day, between a central base parking lot and the main base to provide transportation from vehicle to place of work? (Circle one)

1. Yes
2. No

E. What is annoying about Eglin traffic conditions? (Circle as many as you find annoying.)

1. Too many traffic lights
2. Not enough traffic lights
3. Bad placement of lights
4. Lack of left-turn lanes
5. Narrow roads
6. Speed limits too low
7. Planes stopping traffic to take off or land
8. Three-lane traffic on Eglin Blvd
9. Trucks in peak traffic periods
10. Inadequate parking spaces
11. Too few lanes on Eglin Blvd
12. Too many reserved parking spaces
13. Other (specify; use reverse side of ADTC Form 0-303 if more space is needed)

SECTION II

(To be completed by personnel who drive to work on Eglin Main)

A. How many blocks do you walk to work after parking your vehicle? (Circle one)

0 1 2 3 4 5 or more

Page 1

Figure 19. Origin-Destination Questionnaire

B. How many blocks are you willing to walk to work after parking your vehicle? (Circle one)

0 1 2 3 4 5 or more

C. How many people ride with you to work? (Circle one)

0 1 2 3 4 5 6 7 8 9 or more

SECTION III

(To be completed by personnel living off base and working on Eglin Main)

A. Which gate do you regularly use in going to and from work? (Circle one)

1. West Gate 2. East Gate 3. North Gate 4. TAC Gate

B. If you now use Eglin Parkway or Beal Parkway-Camp Pinchot Road to come to work, will you use Florida 85A (4-lane Camp Pinchot Road) when completed? (Circle one)

1. Yes 2. No 3. Do not use either road now

C. If you plan to use Florida 85A upon completion, by which gate will you enter and leave? (Circle one)

1. West Gate 2. TAC Gate 3. North Gate

SECTION IV

(To be completed by personnel living off base and who make trips to Eglin Main ~~primarily~~ to use base services (hospital, commissary, BX, etc.)

A. During a normal two-week period, how many trips to the base do you and/or your family make primarily to use base services? (Circle one)

0 1 2 3 4 5 6 7 8 9 10 11 12 or more

B. Of these trips, how many are made to the following areas? (If one trip is made to two areas, such as BX and commissary, count only the area which was the primary reason for making the trip.)

(1) Main BX area (BX stores and concessions, barber shop, bowling alley, theater, beauty shop, bank). (Circle one)

0 1 2 3 4 5 6 or more

(2) Commissary area (commissary, gas station, clothing sales store, NCO Club, Thrift Shop, outdoor shop, Southern Airways). (Circle one)

0 1 2 3 4 5 6 or more

(3) Ben's Lake area (Ben's Lake BX, gas station, hospital, beauty shop, ball fields). (Circle one)

0 1 2 3 4 5 6 or more

Figure 19. (continued)

ORIGIN/DESTINATION QUESTIONNAIRE
ANSWER SHEET

DUTY BLDG NO. (1-4)

HOME ADDRESS

STREET NO. AND NAME (5-14)	CITY (15-16)	STATE (17-19)	ZIP CODE (20-24)	DISTRICT (77-79) *(Leave blank)*

SECTION I														
A. (Circle one)	(25)	1	2	3	4	5	6	7						
B (Circle one)	(26)	1	2	3	4	5	6	7	8	9				
C. (Circle one)	(27)	1	2	3	4	5	6	7	8	9				
D. (Circle one)	(28)	1	2											
E. (Circle applicable ones)	(29–41)	1	2	3	4	5	6	7	8	9	10	11	12	13
SECTION II														
A. (Circle one)	(42)	0	1	2	3	4	5							
B. (Circle one)	(43)	0	1	2	3	4	5							
C. (Circle one)	(44)	0	1	2	3	4	5	6	7	8	9			
SECTION III														
A. (Circle one)	(45)	1	2	3	4									
B. (Circle one)	(46)	1	2	3										
C. (Circle one)	(47)	1	2	3										
SECTION IV														
A. (Circle one)	(48–49)	0	1	2	3	4	5	6	7	8	9	10	11	12
B(1) (Circle one)	(50)	0	1	2	3	4	5	6						
B(2) (Circle one)	(51)	0	1	2	3	4	5	6						
B(3) (Circle one)	(52)	0	1	2	3	4	5	6						

ADTC FORM JUL 70 0-303 ONE-TIME

Figure 20. ADTC Form 0-303, Origin-Destination Questionnaire Answer Sheet.

EGLIN 01			
0101		COUNTIES	
0102			
0103		Bay	0300
0104			
0105		Escambia (North)	0400
0106			
0107		Escambia (South)	0401
0108			
0109		Holmes	0500
0110			
0111		Okaloosa (North)	0600
0112			
0113		Santa Rosa (North)	0700
0114			
0115		Santa Rosa (South)	0701
0116			
0117		Walton (North)	0800
0118			
		Walton (South)	0801
FT WALTON BEACH 02			
		Washington	0900
0201			
0202		Florida (Other)	1000
0203			
0204		South Central Alabama	1100
0205			
0206		South Western Alabama	1200
0207			
0208			
0209			
VALPARAISO - NICEVILLE	1300		
WRIGHT	1400		
MARY ESTHER	1500		
SHALIMAR	1700		
DESTIN	1800		

Figure 21. Origin-Destination Location Codes.

because of a lack of address or work area, it was discarded. After the answer sheets were checked, they were then coded. The answer sheets were then sent to key punch. Three thousand and seventy-one cards were punched. This represents a statistical sample of 21.9 percent of all the people working on Eglin.

The punch cards were then computer sorted to determine the origin-destination of each work trip, the mode of travel, the gate used to get to the base, and the future distribution of trips when SR 189 is opened. These data were then used to construct desire line maps and future trip maps.

Desire Lines

Desire lines are used to determine where new roads should be located or to determine if existing roads are located on a main travel corridor. The lines are straight lines drawn from the center of one zone to the center of another zone of a zone map. The lines are proportional in width to the number of "desired" trips involved. Figure 22 shows a work trip desire line map for Eglin AFB. The map depicts all the work trips occurring during a 24 hour period. The work trips terminate in the central business area of the base.

Figure 23 shows a desire line map of work trips generated within the confines of the main base. This map is also for a 24 hour work period. These charts were used to support the argument for new roads on Eglin AFB.

Future Trips

Section III of the O-D questionnaire provided the additional data needed to construct maps predicting future work trips. Figure 24 shows the use of area roads by the Eglin AFB work force when SR 189 is opened.

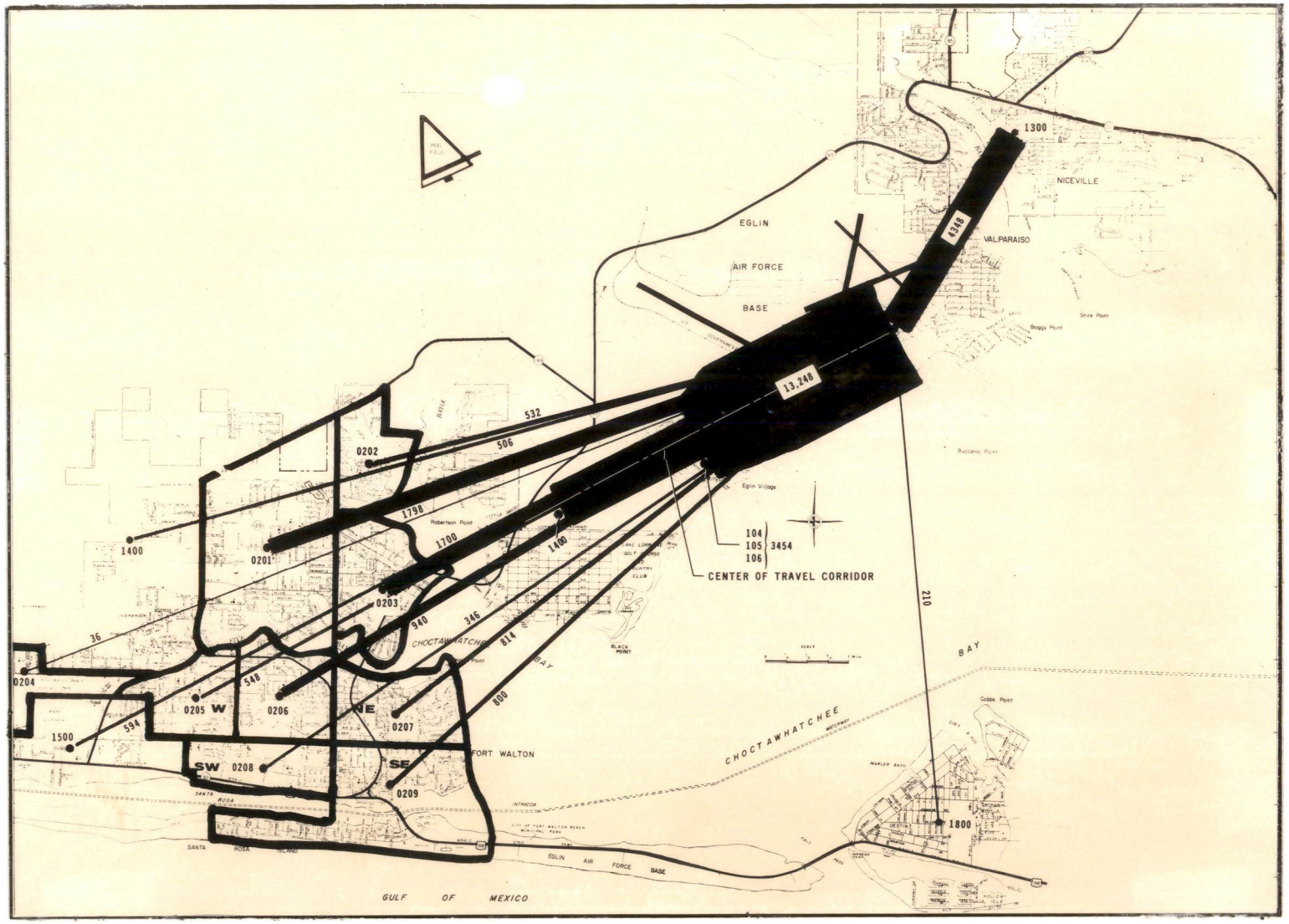


Figure 22. Desire Lines for Work Trips - Eglin AFB (24 Hours).

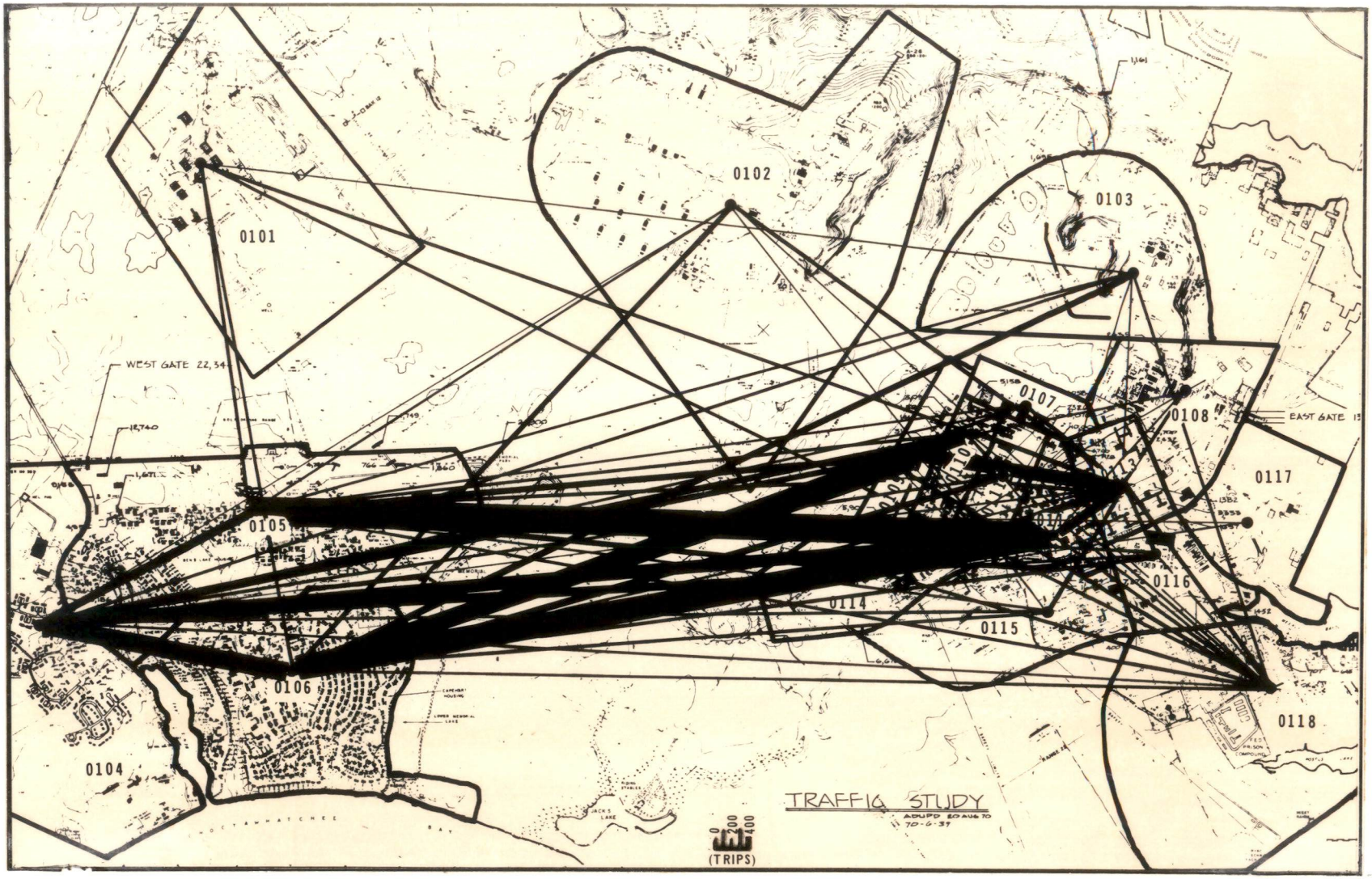


Figure 23. Internal Desire Line Work Trips (24 Hours).

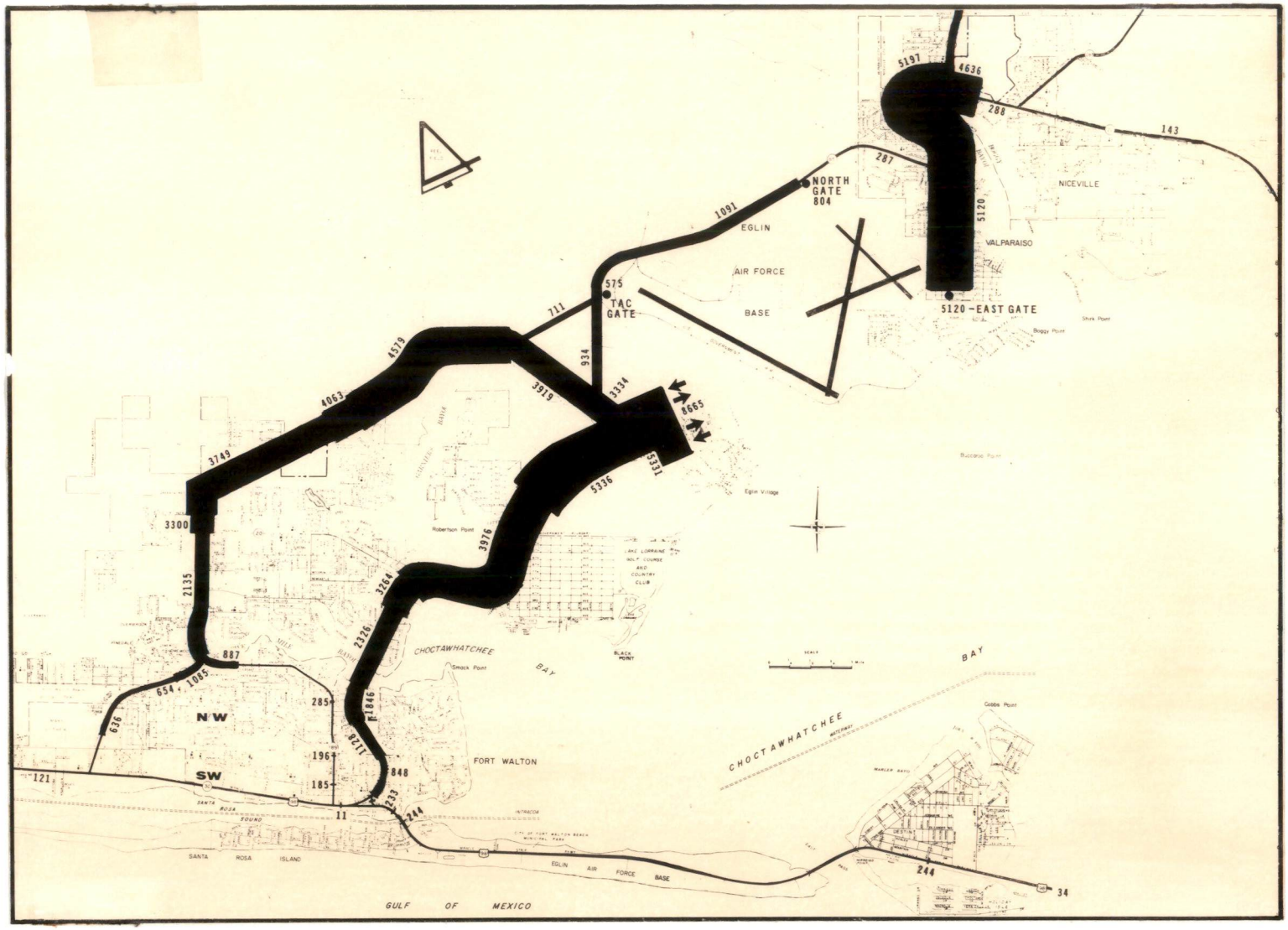


Figure 24. Future Work Trips when SR 189 is Opened (Off-Base).

Figure 25 shows the same future trips distributed about the main base. These maps were used for planning future roadways as they indicate where and how much traffic must be accommodated.

Other Questionnaire Data

These data showed that:

1. 71 percent of the base drivers were not in favor of a base transit system to ferry them to work from a central parking lot.

2. Inadequate parking, too many reserved parking spaces, three traffic lanes on Eglin Boulevard, and too few lanes on Eglin Boulevard were the major driver irritants.

3. The average blocks walked after parking for all districts was less than one block. Table 16 shows the tabulated data for the "blocks walked" analysis. Mean blocks walked for all districts is shown at the bottom of the table. Each district was tested statistically to determine if personnel from any district walked a significantly higher number of blocks than the overall mean number of blocks walked. Two districts were found significantly high at the "three sigma" level.

District 0112 contains large buildings which create high parking demands. Due to the large number of cars involved, this district requires large parking lots removed some distance from the work areas. District 0114 contains large hangar areas and miscellaneous shops. These work areas are located on ramp areas which prohibit private vehicle parking, thus the longer walking distance to the work areas.

Much other data were available for analysis, but will not be discussed here.

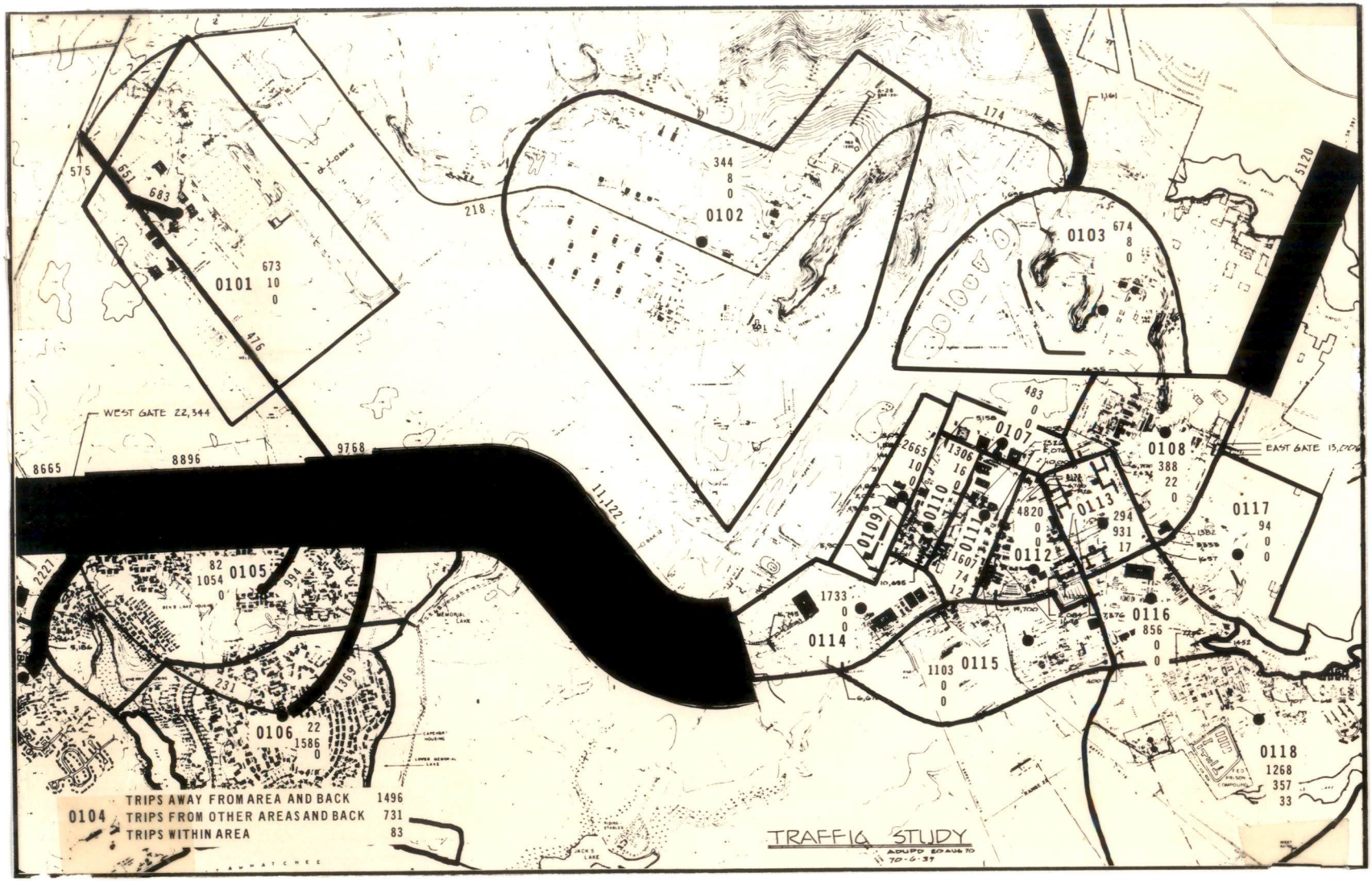


Figure 25. Future Work Trips when SR 189 is Opened (On-Base).

Table 16. Average Number of Blocks Walked.

DESTINATION	TRIPS	BLOCKS	AVERAGE BLOCKS PER TRIP	SIGNIFICANTLY HIGHER THAN OVERALL MEAN
0101	116	60	0.517	
0102	55	19	0.345	
0103	106	39	0.368	
0104	210	145	0.690	
0105	11	0	0.000	
0106	3	0	0.000	
0107	65	50	0.769	
0108	56	16	0.286	
0109	368	182	0.495	
0110	185	75	0.405	
0111	236	133	0.564	
0112	684	636	0.930	Yes
0113	46	28	0.609	
0114	238	194	0.815	Yes
0115	149	65	0.436	
0116	121	38	0.314	
0117	14	2	0.143	
0118	172	71	0.413	
TOTALS -	2,835	1,753		
Overall mean blocks walked = 0.618				

V. DATA SYSTEM

Data System Design

The data system was designed as illustrated in Figure 26. Once data collection was accomplished, the old file would be established. The information contained in the old file would consist of personal files on military kept by the central base personnel office, a supplement to the military information collected at vehicle registration, and personal files on civilian personnel collected at vehicle registration time. The information would be periodically updated, processed, and analyzed which would produce a new master file and periodic reports.

The steps in the design of the data system were:

1. Survey existing systems.
2. Establish output requirements.
3. Identify processing and storage requirements.
4. Data collection techniques.

Survey of existing equipment. A computer system survey was conducted on Eglin to determine what computer facilities were available for a data system. A Burroughs 3500 computer used for personnel records, accounting and finance functions, and civil engineering records was found to have the capacity to handle a much greater load.

The decision was made to determine the feasibility of automating the traffic study to the maximum extent possible, and the Burroughs 3500 was chosen as the ADP facility for this operational evaluation.

Establishing output requirements. The basic steps in accident analysis as discussed earlier were (1) determining hazardous locations, (2) applying accident reduction probabilities, (3) and cost analyzing

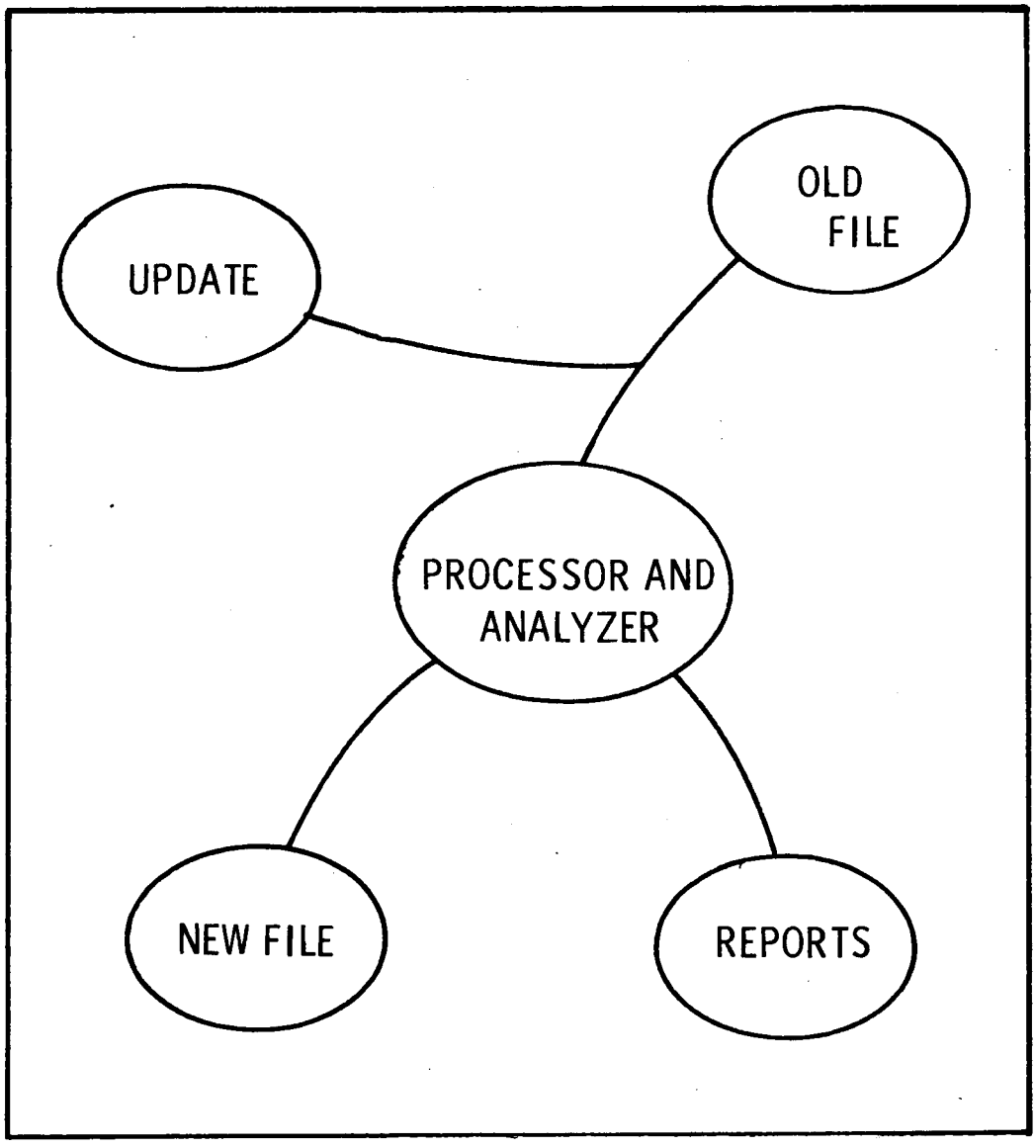


Figure 26. Data System Design.

these locations. Since the primary purpose of the data system is directed at traffic oriented problems, the needs of the traffic study will be discussed first, followed by possible other uses.

Hazardous location identification. The determination of hazardous locations requires an accurate accident location from the data system. An inaccurate accident location would result in determining locations to be hazardous when they were not or worse, excluding hazardous locations from the list.

Accident reduction probabilities. Although accident reduction probabilities were available for similar type improvements, the data system should provide post-improvement reductions in order to establish additional probability tables. Data required are time, weather conditions, accident types, traffic volumes, date, type and location of roadway improvements, etc.

Cost analysis. Cost analysis requires data on accidents costs, construction costs of improvements, and the estimated service life of the improvements.

The data system was envisioned as ultimately leading to a central system for all base functions and although data requirements were not firmly established, some potential uses of the data system which were considered in its design are discussed next.

Data system uses.

Law enforcement - To analyze the accuracy and adequacy of accident investigations, to compile information for required reports to higher

headquarters, and to act as a central file for all accident reports thus providing a highly responsive source for accident inquiries.

Vehicle inspection - Aid in assuring that vehicle inspection requirements are updated as vehicle malfunctions are indicated as possible contributory causes to accidents.

Vehicle registration - Integrate the existing vehicle registration system into the data system and ultimately lead to handling vehicle registrations by mail as most states presently do.

Safety office - To provide information on driver arrests and issuance of traffic citations so that drivers may be recommended for remedial drivers training, to provide required reports to higher headquarters, and to keep the motorists utilizing Eglin's roadways educated on current traffic accident data.

Base locator and postal services - To provide a speedy and accurate source of locating personnel, and to assist the postal services personnel in making mail deliveries to the located personnel.

Ultimately, each of the users discussed above should be furnished a remote station hookup to assure responsiveness for both retrieving information from and supplying basic data to the comprehensive data system.

Identify processing and storage requirements. The design of a data system as invisioned above would have been a major undertaking, and costly; therefore, the decision was made to include only that portion which was directly related to the traffic analysis. The initial plan was to develop computer programs for automating the origin-destination study, and the accident analysis to include identifying the hazardous locations and applying the cost methodology.

Data collection. Air Force Regulation 125-14 requires individuals "to maintain current Air Force vehicle registration" including "prompt action to submit changes in vehicle registration data." With this in mind, it was decided that the vehicle registration section on Eglin was an ideal location for the initial collection of data and could be used as a depository for information needed to update the system. (Update information could be mailed.)

Since vehicle registration was executed on Air Force Form 1312, Figure 27, this form was used to provide the basic data for the system. ADTC Form 0-276, Figure 28, was designed to supplement the information found on Air Force Form 1312.

The data collection process was begun in May 1970. Over 9000 forms were completed when the vehicle registration section was advised by Headquarters USAF to immediately initiate a new vehicle registration system. This new system did not require the collection of vehicle information, other than the name of the registrant and certification that he carried at least the minimum amount of insurance as prescribed by the laws of the state of Florida. Since only a partial data base had been obtained at the time and by regulation no additional AF Forms 1312's could be collected, the development of the data system was terminated.

Comments on Proposed Data System

Data collection forms. The data collection form discussed above was a "first attempt" and as such may not have contained all the data required by the system. A field test as was intended would be essential to evaluate the usefulness of the form.

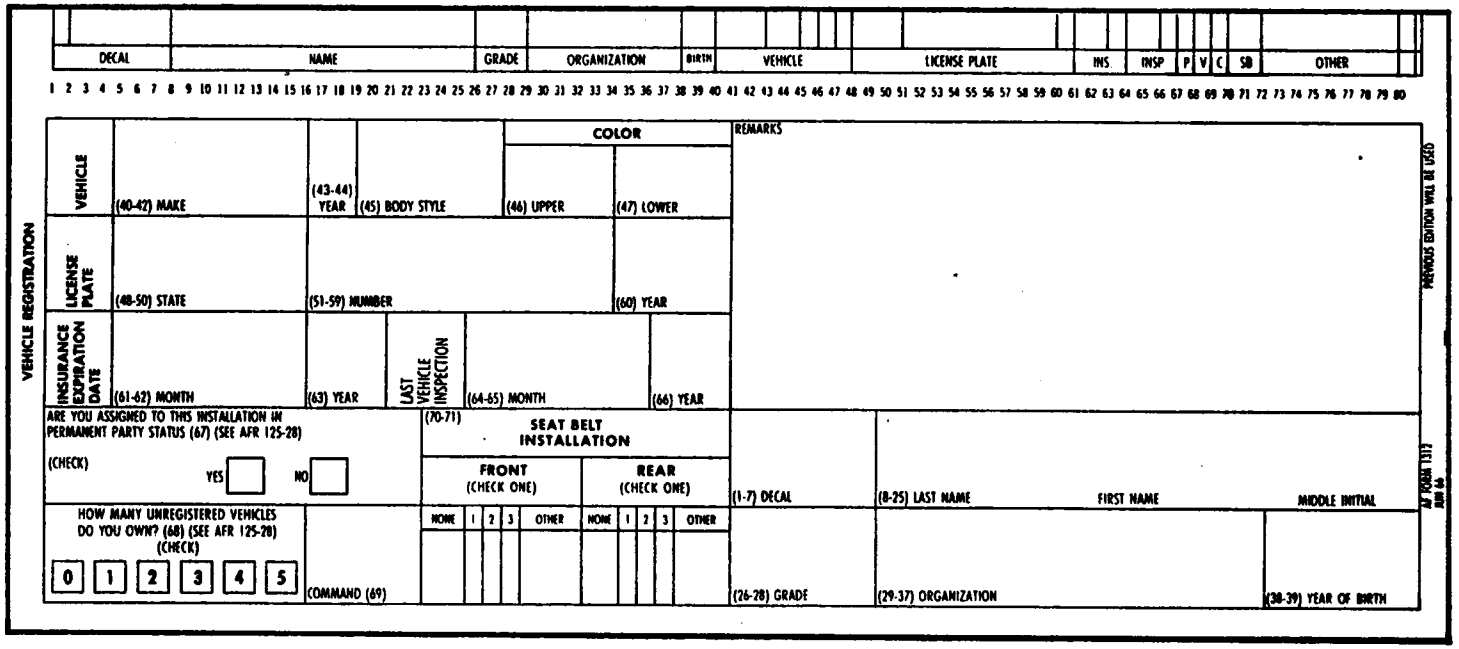
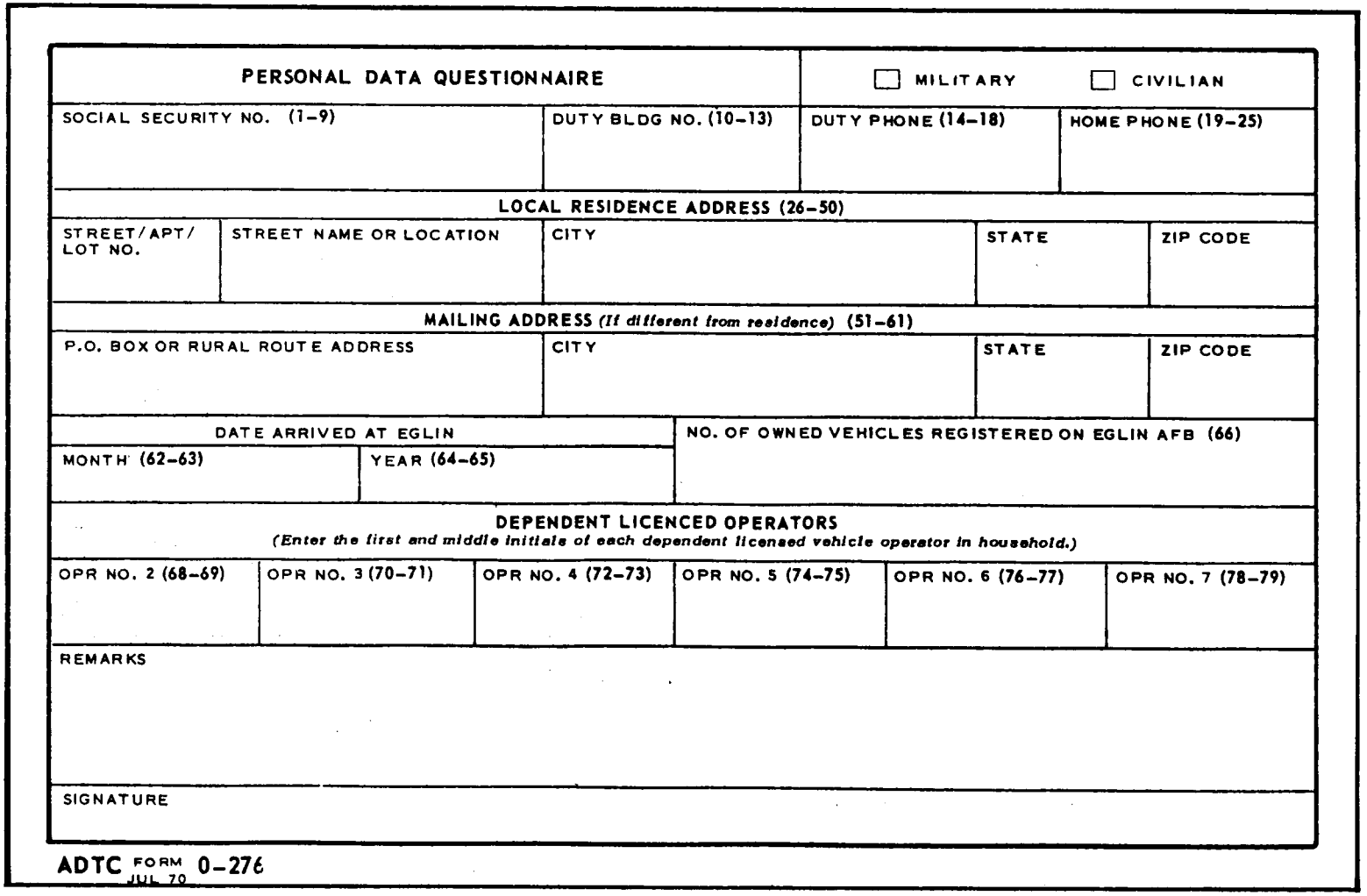


Figure 27. AF Form 1312, Vehicle Registration.



PERSONAL DATA QUESTIONNAIRE ☐ MILITARY ☐ CIVILIAN

SOCIAL SECURITY NO. (1–9)	DUTY BLDG NO. (10–13)	DUTY PHONE (14–18)	HOME PHONE (19–25)

LOCAL RESIDENCE ADDRESS (26–50)

STREET/APT/ LOT NO.	STREET NAME OR LOCATION	CITY	STATE	ZIP CODE

MAILING ADDRESS *(If different from residence)* **(51–61)**

P.O. BOX OR RURAL ROUTE ADDRESS	CITY	STATE	ZIP CODE

DATE ARRIVED AT EGLIN		NO. OF OWNED VEHICLES REGISTERED ON EGLIN AFB (66)
MONTH (62–63)	YEAR (64–65)	

DEPENDENT LICENCED OPERATORS
(Enter the first and middle initials of each dependent licensed vehicle operator in household.)

OPR NO. 2 (68–69)	OPR NO. 3 (70–71)	OPR NO. 4 (72–73)	OPR NO. 5 (74–75)	OPR NO. 6 (76–77)	OPR NO. 7 (78–79)

REMARKS

SIGNATURE

ADTC FORM JUL 70 0-276

Figure 28. ADTC Form 0-276, Personal Data Questionnaire.

Manipulation of data. Except as discussed in the applicable sections, all data manipulation and calculations for this study were performed "by-hand". This was an extremely tedious and time consuming process; however, the proposed data system, if implemented, would greatly simplify this task.

Cost. The cost of the data system would amount to the preparation and collection of approximately 25,000 forms, punching one or more ADP cards for each vehicle registrant on Eglin, plus costs associated with collecting, storing, maintaining, and updating the system. An economic evaluation of this system should be conducted at the onset of any future traffic study.

CHAPTER V

DISCUSSION OF RESULTS AND CONCLUSIONS

I. INTRODUCTION

The purpose of this chapter is to briefly summarize the results and conclusions drawn from this thesis. A brief summary of related results from a study using the methodology shown in this thesis will also be presented.

II. RESULTS

Results by Sections

Traffic volume counts. The traffic volume counts obtained readily reflected the change in density of people when they moved from one area of the base to another due to the construction of new buildings. The volume counts also quantified the levels of use of the roadways and provided the measure of exposure required to generate the two accident statistics, accidents per million vehicles, and accidents per million vehicle miles used to accomplish the accident analysis.

Intersection capacity studies. The capacity studies conducted on the main signalized intersections of the base provided the quantitative data needed to show the serious traffic overloads occurring at some of these intersections. Two intersections of the five analyzed were overloaded to the point of requiring major construction to eliminate the constricted traffic flow. In addition, a signalized intersection study using data provided by the origin-destination questionnaire determined the future signal timing required for an intersection still under construction.

Traffic accident analysis. The traffic accident analysis study provided a scientific method of identifying and determining the cost effectiveness of improving hazardous locations on the base roadways. The cost of the hazard improvements on the Eglin Boulevard system were shown to pay for themselves through accident cost savings.

Origin-destination survey and study. The origin-destination questionnaire method provided an efficient means for determining the desires and opinions of the Eglin work force. The desire line maps and future work trip maps showed these desires pictorially. O-D questionnaire data also determined that base personnel were not in favor of a base transit system to shuttle them to work from a central parking area, but were in favor of more parking space throughout the base and more traffic lanes on Eglin Boulevard. Other data showed that the mean number of blocks walked after parking for all zones of the base was less than one block.

Data system. The proposed data system, though never completed, showed much promise. The system would have provided a means for manipulating the large amount of data used on this study by computer instead of "by hand" and a considerable time savings would have resulted.

Related Results

The traffic accident analysis results of this study involving the Eglin Boulevard system were presented by Eglin AFB officials to a review board at Headquarters, Air Force Systems Command (AFSC), Andrews Air Force Base, Maryland. The purpose of the presentation was to inform the board of the need for funds to accomplish military construction projects

at Eglin. The review board's responsibility was to critically examine all requests from AFSC facilities and approve only those that were thoroughly justified and absolutely essential. The board then took all the AFSC requests and combined and arranged them into a list showing the greatest need or highest priority first. This list then went to the Chief of Staff Air Force for futher trimming prior to going to Congress for final approval. During this total process, the Eglin Boulevard project enjoyed a high priority; funds were approved and the road was designed and constructed.

The road, opened in April, 1974, appears to exceed expectations. During the 28 month period covered by the accident analysis in this study, the Eglin Boulevard system was experiencing over 7.5 accidents per month, two people lost their lives, and 35 injury accidents occurred. In three months operation of the new roadway, only three property damage accidents have occurred. . .This is a total accident reduction of 87 percent.

III. CONCLUSIONS

A. This study provides a systems engineering analysis program that can be used to plan and program traffic improvements on an economic basis. Its usefulness has been successfully demonstrated at Eglin Air Force Base, Florida.

B. The program can be used by any traffic planning group to accomplish sound planning based on scientific principles and cost effectiveness.

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LIST OF REFERENCES

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APPENDIXES

MOTOR VEHICLE ACCIDENT INVESTIGATION REPORT

MOTOR VEHICLE ACCIDENT INVESTIGATION REPORT • | NO. *(FOR OFFICE USE ONLY)*

If more than two vehicles are involved, use an additional form and alter the vehicle numbers appropriately. If more space is required for any item, continue in Item 38 and identify by item number.

GENERAL LOCATION

CITY OR BASE: CITY, TOWN, OR AIR FORCE BASE ON WHICH ACCIDENT OCCURRED | COUNTY | STATE

RURAL AREA: HIGHWAY NUMBER OR NAME OF ROAD | COUNTY | STATE

NO. OF MILES | DIRECTION | FROM LIMITS OF *(Nearest city or town)*

2. EXACT LOCATION

AT INTERSECTION	NOT AT INTERSECTION
NAME OF STREET, ROAD, OR HIGHWAY NO.	NAME OF STREET, ROAD, OR HIGHWAY NO.
	NO. OF FEET / DIRECTION
	FROM *(Nearest street, highway, road, alley, building, bridge, culvert, etc.)*

3. TIME OF ACCIDENT	4. TYPE OF ACCIDENT				5. ACCIDENT INVOLVED			
DAY OF WEEK	☐	HEAD ON	☐	LOST CONTROL	☐	OTHER MOTOR VEHICLE	☐	ANIMAL *(Ridden, herded or unattended)*
	☐	HEAD TO SIDE	☐	HIT AND RUN	☐	STREET CAR	☐	PARKED AIRCRAFT
	☐	REAR END	☐	INTERSECTION	☐	MOTOR BUS	☐	RAILROAD TRAIN
HOUR / DATE	☐	BACKING	☐	FIXED OBJECT	☐	BICYCLE	☐	ROAD MAINTENANCE OR FARM EQUIPMENT
	☐	SIDE-SWIPE	☐	PEDESTRIAN	☐	PEDESTRIAN	☐	NON-COLLISION
	OTHER *(Describe)*				OTHER *(Describe)*			

6. VEHICLE NO. 1	7. VEHICLE NO. 2
NAME OF OPERATOR *(If military, give grade and service no.)*	NAME OF OPERATOR *(If military, give grade and service no.)*
ADDRESS OR STATION	ADDRESS OR STATION
AGE / SEX / PROFESSION, TRADE, OR AFSC	AGE / SEX / PROFESSION, TRADE, OR AFSC
DRIVING EXPERIENCE *(Years)*: MILITARY / CIVILIAN	DRIVING EXPERIENCE *(Yrs)*: MILITARY / CIVILIAN
DRIVER LICENSE: ☐ GOVERNMENT ☐ CHAUFFEUR ☐ STATE ☐ DRIVER	DRIVER LICENSE: ☐ GOVERNMENT ☐ CHAUFFEUR ☐ STATE ☐ DRIVER
PASSENGERS: NO. / FRONT / REAR	PASSENGERS: NO. / FRONT / REAR
BADGE OR LICENSE NO. / STATE / EXPIRES	BADGE OR LICENSE NO. / STATE / EXPIRES

8. VEHICLE LICENSE DATA				9. VEHICLE LICENSE DATA			
TYPE: ☐ GOVERNMENT ☐ STATE	LICENSE OR SERIAL NO.	STATE	YEAR	TYPE: ☐ GOVERNMENT ☐ STATE	LICENSE OR SERIAL NO.	STATE	YEAR
VEHICLE OWNED BY/ASSIGNED TO *(Include address)*				VEHICLE OWNED BY/ASSIGNED TO *(Include address)*			
VEHICLE INSURED BY	AMOUNT	POLICY NO.		VEHICLE INSURED BY	AMOUNT	POLICY NO.	

10. TYPE OF VEHICLE				11. TYPE OF VEHICLE			
TYPE: ☐ GOVERNMENT ☐ PRIVATE	MODEL	MAKE	YEAR	TYPE: ☐ GOVERNMENT ☐ PRIVATE	MODEL	MAKE	YEAR

12. DAMAGE			13. DAMAGE		
PARTS OF VEHICLE	ESTIMATED REPAIR COST	NO. DAYS OUT OF SERVICE	PARTS OF VEHICLE	ESTIMATED REPAIR COST	NO. DAYS OUT OF SERVICE

14. STATUS *(Military)*				15. STATUS *(Military)*			
☐ ON DUTY ☐ OFF DUTY	HOURS OF DUTY	☐ ON BASE ☐ OFF BASE		☐ ON DUTY ☐ OFF DUTY	HOURS OF DUTY	☐ ON BASE ☐ OFF BASE	

Figure 29. Motor Vehicle Accident Investigation Report.

16. DAMAGE TO PROPERTY OTHER THAN VEHICLES *(Name, object, show ownership, state nature of damage)*

17. MEDICAL AID RENDERED *(Name, address, and telephone no.)*

18. KILLED OR INJURED

NAME AND ADDRESS	VEHICLE NO.	AGE	SEX	(Check one) DRIVER	PASS.	PED.	FIRST AID	INJURED	KILLED

DISPOSITION OF INJURED OR KILLED *(Name of hospital or other location)*

19. WITNESSES

NAME	ADDRESS	TELEPHONE NO.

20. DATA CONCERNING PEDESTRIAN INVOLVED

A. CONDITION	C. ACTION	
NORMAL	CROSSING AT INTERSECTION - NO SIGNAL	PUSHING OR WORKING ON VEHICLE
PHYSICAL DEFECT	CROSSING AT INTERSECTION - WITH SIGNAL	COMING FROM BEHIND PARKED VEHICLE
DRINKING INDICATED	CROSSING AT INTERSECTION - AGAINST SIGNAL	PLAYING IN ROADWAY
INTOXICATED	CROSSING AT INTERSECTION - DIAGONALLY	WORKING IN ROADWAY
VIEW OBSTRUCTED	CROSSING - NOT AT INTERSECTION	LYING IN ROADWAY
B. VISION OBSCURED BY	WALKING IN ROADWAY - WITH TRAFFIC	GETTING ON OR OFF BUS OR STREET CAR
VEHICLE NO. 1	WALKING IN ROADWAY - AGAINST TRAFFIC	STANDING IN SAFETY ZONE
VEHICLE NO. 2	HITCHING ON VEHICLE	GETTING IN OR OUT OF A VEHICLE

21. PHYSICAL CONDITION

VEHICLE NO. 1	VEHICLE NO. 2	CONDITION OF DRIVERS
		NORMAL
		PHYSICAL DEFECTS
		DRINKING INDICATED
		INTOXICATED
		FATIGUED
		ASLEEP

23. SPEED DATA

		DISTANCE DRIVER FIRST NOTICED DANGER OF ACCIDENT
		ESTIMATED SPEED AT THAT TIME
		ESTIMATED SPEED AT MOMENT OF ACCIDENT
		DISTANCE TRAVELED AFTER IMPACT
		LEGAL SPEED LIMIT
		MAXIMUM SAFE SPEED UNDER CONDITIONS PREVAILING

24. CONDITION OF VEHICLES

		NORMAL
		DEFECTIVE

25. VISIBILITY *(Good, fair, poor)*

22. ACTION OF DRIVERS

VEHICLE NO. 1	VEHICLE NO. 2	TYPE OF ACTION
		GOING STRAIGHT AHEAD
		TURNING LEFT
		TURNING RIGHT
		MAKING "U" TURN
		FORWARD FROM PARKING
		BACKWARD FROM PARKING
		BACKING
		STOPPED IN TRAFFIC LANE
		PARKED
		DOUBLE-PARKED
		DROVE OFF HIGHWAY
		CROWDED OFF HIGHWAY
		OVER-TAKING
		PASSING ON HILL
		PASSING ON CURVE
		SLOWING OR STOPPING
		SKIDDING
		ON WRONG SIDE OF ROAD

Figure 29. (continued)

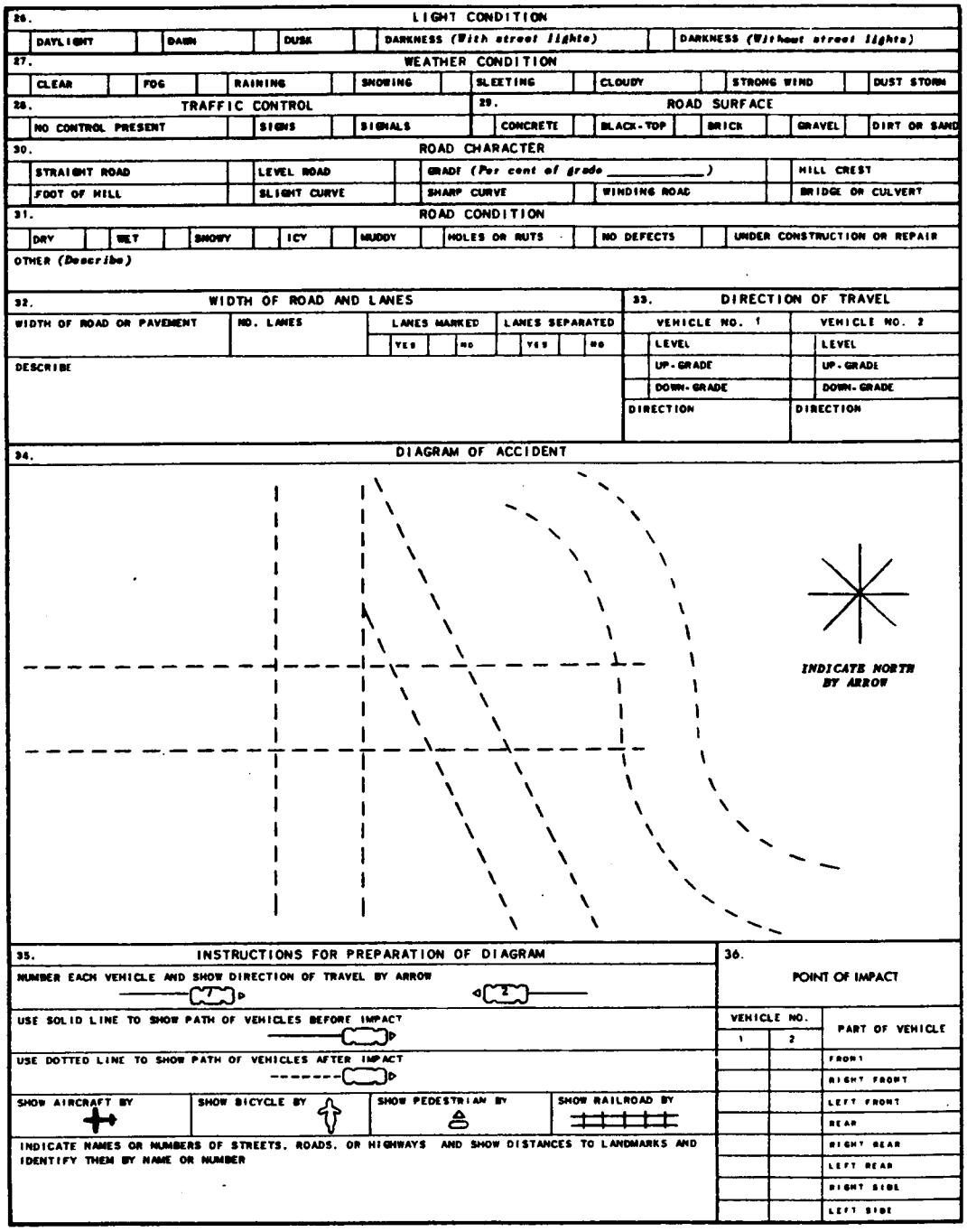


Figure 29. (continued)

37 DRIVER'S DESCRIPTION OF WHAT HAPPENED

VEHICLE NO. 1

VEHICLE NO. 2

38. REMARKS BY INVESTIGATOR *(Include opinion as to cause of accident and appropriate statement regarding evidence of compliance or non-compliance with seat belt or safety helmet and protective eye-piece requirements - AFR 127-5.)*

39. TRAFFIC VIOLATION TICKETS GIVEN OR ARRESTS MADE	40. ALCOHOL TEST GIVEN	TYPE OF TEST	RESULT	TEST GIVEN BY *(Name and grade)*
☐ TICKET(S) ☐ ARREST(S)	☐ YES ☐ NO			

41. COVERAGE OF ACCIDENT		42. PHOTOGRAPHS TAKEN	
☐ INVESTIGATED	☐ NOT INVESTIGATED	☐ YES	☐ NO

43. NAMES OF INVESTIGATING AIR POLICEMEN AND/OR CIVILIAN OFFICERS

44. OTHER AGENCIES INVESTIGATING AT THE SCENE	44A. COPIES OF THIS REPORT FURNISHED TO *(Give name of agency making request)*

45. AUTHENTICATION OF INVESTIGATOR MAKING THIS REPORT

DATE	TYPED NAME AND GRADE	ORGANIZATION	SIGNATURE

46. REMARKS BY REVIEWING OFFICIAL *(Were drivers within scope of employment and/or laws; cause of accident, was accident preventable; and action taken)*

47. AUTHENTICATION OF REVIEWING OFFICIAL

DATE	TYPED NAME AND GRADE	ORGANIZATION	SIGNATURE

Figure 29. (continued)

APPENDIX B

ACCIDENT DATA INSTRUCTION CODE SHEET

Card Column	Field Description	Special Instructions
	Case Number	
1-3	Number	Enter three (3) digits of accident number for the month.
4-5	Month	Enter two (2) digit code for month 01 through 12 for January through December, respectively.
6-7	Year	Enter last two (2) digits of year.
8-11	Location	Enter alpha/numeric characters of accident location as defined by code map.
12-15	Time	Enter four (4) digits for time of accident (Use 24-hour clock).
16	Type Accident	Enter one (1) digit code for type of accident.
	1 Head On 2 Head to Side 3 Rear End 4 Backing 5 Side Swipe	6 Lost Control 7 Fixed Object 8 Pedestrian 9 Other
17	Accident Involved	Enter one (1) digit code for other object involved in accident.
	1 Other Motor Vehicle 2 Motor Bus 3 Bicycle 4 Pedestrian 5 Animal	6 Railroad Train 7 Road Maintenance Equipment 8 Parked Aircraft 9 Non-Collision 0 Other
	Operator Vehicle No. 1	
18-19	Grade	Enter two (2) digit code for grade.
	Civil Service Personnel Enlisted Personnel Officer Personnel Retired Military Contractor Personnel Other	01 through 18 (GS-1 through GS-18 respectively) 21 through 29 (E-1 through E-9, respectively) 31 through 39 (O-1 through O-9) 40 50 60
20-28	SSN	Enter nine (9) digits of social security number.

Figure 30. Accident Data Instruction Code Sheet.

Card Column	Field Description	Special Instructions
	Operator Vehicle No. 2	
29-30	Grade	Enter two (2) digit code for grade.
31-39	SSN	Enter nine (9) digits of social security number.
40	Type of Vehicle No. 1	Enter one (1) digit code for type of vehicle No. 1.
	1 - Government 2 - Private	
41	Type of Vehicle No. 2	Enter one (1) digit code for type of vehicle No. 2.
42	Accident Classification	Enter one (1) digit code for the accident classification.
	1 - Property Damage Only 2 - Injury 3 - Fatality	
43	Number Personnel Injured	Enter digit for number of people injured.
44	Number of Fatalities	Enter digit for number of people killed.
	Data Concerning Pedestrian Involved	
45	Condition	Enter one (1) digit code for pedestrian condition.
	1 - Normal 2 - Physical Defect 3 - Drinking Indicated 4 - Intoxicated 5 - View Obstructed	
46-47	Action	Enter two (2) digit code for action of pedestrian at time of accident.
	01 Crossing at Intersection - No signal 02 Crossing at Intersection - With signal 03 Crossing at Intersection - Against signal 04 Crossing at Intersection - Diagonally 05 Crossing - Not at Intersection 06 Walking in Roadway - With traffic 07 Walking in Roadway - Against traffic 08 Hitching on Vehicle 09 Pushing or Working on Vehicle 10 Coming from Behind Parked Vehicle 11 Playing in Roadway 12 Working in Roadway 13 Lying in Roadway 14 Getting on or off Bus 15 Standing in Safety Zone 16 Getting in or out of Vehicle	

Figure 30. (continued)

Card Column	Field Description	Special Instructions
	Physical Condition of Drivers	
48	Vehicle No. 1	Enter one (1) digit code for condition of driver
	1 - Normal 2 - Physical Disabilities 3 - Drinking Indicated 4 - Intoxicated 5 - Fatigue 6 - Asleep	
49	Vehicle No. 2	Enter one (1) digit from above code.
	Action of Drivers	
50-51	Vehicle No. 1	Enter two (2) digit code for action of vehicle.
	01 Going Straight Ahead 02 Turning Left 03 Turning Right 04 Making "U" Turn 05 Forward from Parking 06 Backward from Parking 07 Backing 08 Stopped in Traffic Lane 09 Parked 10 Double Parked 11 Drove off Highway 12 Crowded off Highway 13 Overtaking 14 Passing on Hill 15 Passing on Curve 16 Slowing or Stopping 17 Skidding 18 On Wrong Side of Road	
52-53	Vehicle No. 2	Enter two (2) digit code from above code.
54	Light Condition	Enter one (1) digit code for light conditions.
	1 - Daylight 2 - Dawn 3 - Dusk 4 - Darkness (with street lights) 5 - Darkness (without street lights)	
55-58	Weather Condition	Enter one (1) digit code for weather condition in each card column as applicable.
	1 - Clear 2 - Fog 3 - Raining 4 - Snowing 5 - Sleeting 6 - Cloudy 7 - Strong Wind 8 - Dust Storm	
59	Traffic Control	Enter one (1) digit code for traffic control method.
	1 - No control present 2 - Signs 3 - Signals	
60	Road Surface	Enter one (1) digit code for type of road surface.

Figure 30. (continued)

Card Column	Field Description	Special Instructions
Continuation of Road Surface		
	1 - Concrete 2 - Black-top 3 - Brick 4 - Gravel 5 - Dirt	
61-63	Road Character	Enter one (1) digit code for road characteristics in each card column as applicable.
	1 - Straight 2 - Foot of Hill 3 - Level 4 - Slight Curve 5 - Sharp Curve 6 - Grade 7 - Winding 8 - Hill Crest 9 - Bridge Culvert	
64-67	Road Condition	Enter one (1) digit code for conditions of surface in each card column as applicable.
	1 - Dry 2 - Wet 3 - Snowy 4 - Icy 5 - Muddy 6 - Holes or Ruts 7 - No Defects 8 - Under Construction or Repair 9 - Other	
	Direction of Travel	
68-69	Vehicle No. 1	Enter two (2) digit code for direction of travel.
	First Digit Code: 1 - Level; 2 - Upgrade; 3 - Downgrade Second Digit Code: 1 - N; 2 - NE; 3 - E; 4 - SE; 5 - S; 6 - SW; 7 - W; 8 - NW	
70-71	Vehicle No. 2	Enter two (2) digit code for direction of travel using preceding code.

Figure 30. (continued)

Card Column	Field Description	Special Instructions
72-73	Primary Cause	Enter two (2) digit code for primary cause of accident (Section 38 of AF Form 1315)

01 Failure to have vehicle under control
02 Following too closely
03 Failure to use due caution
04 Failure to use due caution while backing, etc.

74-75	Contributing Cause	Enter two (2) digit code for contributing cause of accident (Section 38 of AF Form 1315)

01 View obstructed
02 Pavement slick
03 No shoulder on road
04 Environmental hazard such as sun glare, etc.

76	Disposition	Enter one (1) digit code for disposition of case.

1 - Ticket citation given
2 - Arrest made
3 - Ticket citation and arrest
4 - No action taken

77	Disciplinary Action	Enter one (1) digit code for disciplinary action administered.

1 - Point given
2 - Remedial driving course given
3 - Article 15
4 - Courts Martial

Figure 30. (continued)

APPENDIX C

RATE QUALITY-CONTROL METHOD

Assuming that the number of accidents per year at a location is distributed according to the Poisson distribution with parameter, A (average number of accidents per study period) and assuming $A=R_a \cdot M$ where M is traffic volume per study period and the constant, R_a, is average accident rate, the probability of N or fewer accidents in the study period is:

$$P = \sum_{x=0}^{N} \frac{e^{-A} A^{x}}{x!} \cong \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{N-A+\frac{1}{2}}{\sqrt{A}}} e^{\frac{-y^2}{2}} dy$$

where the right side of the above equation is the normal approximation to the Poisson.

Thus, the one-sided upper 90 percent confidence limit on x is approximately equal to $A + 1.282 \sqrt{A} - 1/2$

Then dividing by M we get the corresponding limit on accident rate.

$$R_c = \frac{A}{M} + 1.282 \sqrt{\frac{A}{M} \cdot \frac{1}{M}} - \frac{1}{2M}$$

$$= R_a + 1.282 \sqrt{\frac{R_a}{M}} - \frac{1}{2M}$$

The critical accident rate, R_c, from the above equation has only a 10 percent probability of being exceeded by chance for a particular location with a traffic volume of M in the period of study. The units of M must be consistent with units of R_a; for example, million vehicles and accidents per million vehicles, respectively, in the study period. (17)

The rationale behind the quality control method is that eliminating high accident rate locations which could easily have occurred by chance, improves the chance of obtaining truly abnormal locations.

The value of R_a for this study was computed from data taken from the entire state of Florida (18). However, data for three-lane roadways with reversible center lane and intersections were not available on a statewide basis. For this value of R_a, the average accident rate for Eglin Boulevard was used.

APPENDIX D

ADJUSTMENTS OF COSTS FROM 1958 TO 1969 PRICES

I. Consumers' Price Index (Source: World Almanac, 1969) (21)

Illinois costs are for 1958

Base Year of Consumers' Price Index, 1957-59 average = 1.00

Average Price Indexes for 7 Months - 1969, January-July

All Items - 1.262
Transportation - 1.235
Other Goods and Services - 1.268
Medical Care - 1.533

Use

Medical Care - 1.533
All other costs - 1.255 (Average of Transportation, Other Goods & Services, and All Items)

II. Price Index for Fatal Involvements

(From California Report citing Illinois Report) (19)

$1,150,973	medical expenses @ 1.533 =	$ 1,764,442
7,987,403	other expenses @ 1.255 =	10,024,191
$9,138,376	Totals	$11,788,633

$\frac{\$11,788,633}{9,138,376}$ = 1.29 price index.

III. Price Index for Injury Involvements

$ 21,195,556	medical expenses @ 1.533 =	$ 32,492,787
120,644,657	other expenses @ 1.255 =	151,409,044
$141,840,213		$ 183,901,831

$\frac{183,901,831}{141,840,213}$ = 1.29 price index.

IV. Price Index for Property Damage Only Involvements

(No medical expense involved)

1.255 price index.

Note: The price index for all accident severities is reasonably close to the average of 1.278. A 28% increase in all prices is therefore used.

APPENDIX E

ACCIDENT DATA IN CHART FORM

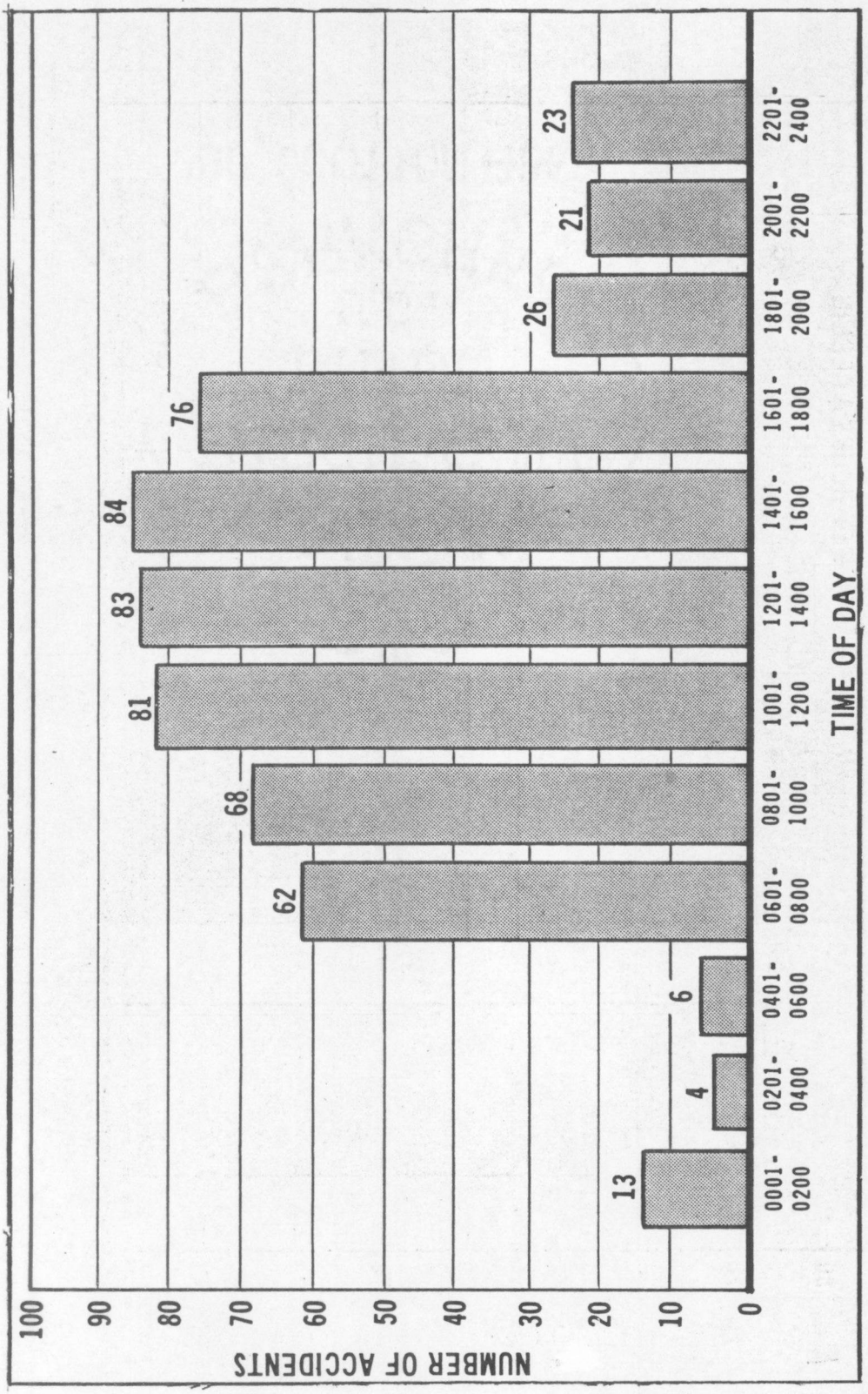


Figure 31. Distribution of Accidents by Time of Day.

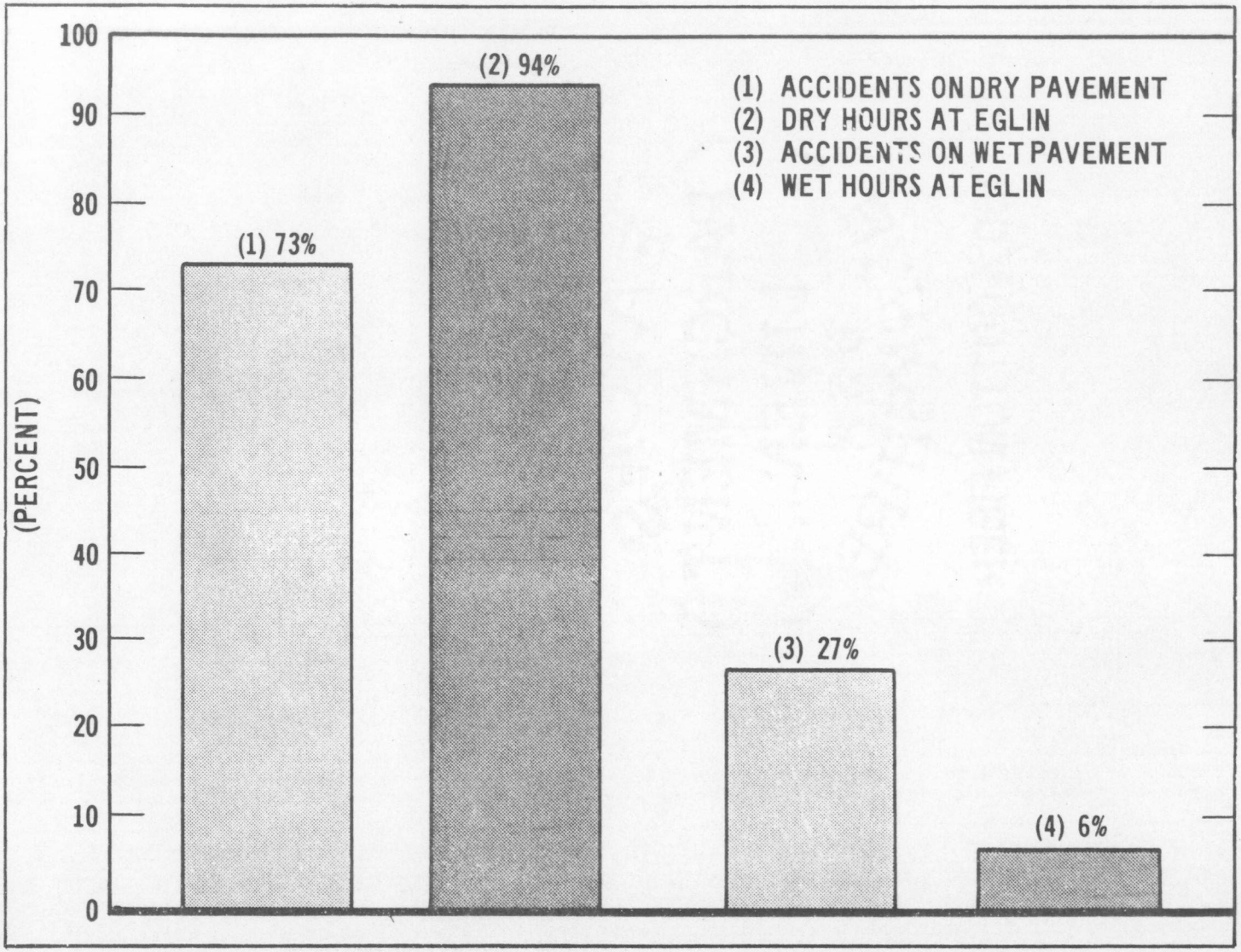


Figure 32. Effect of Wet Pavement on Accidents.

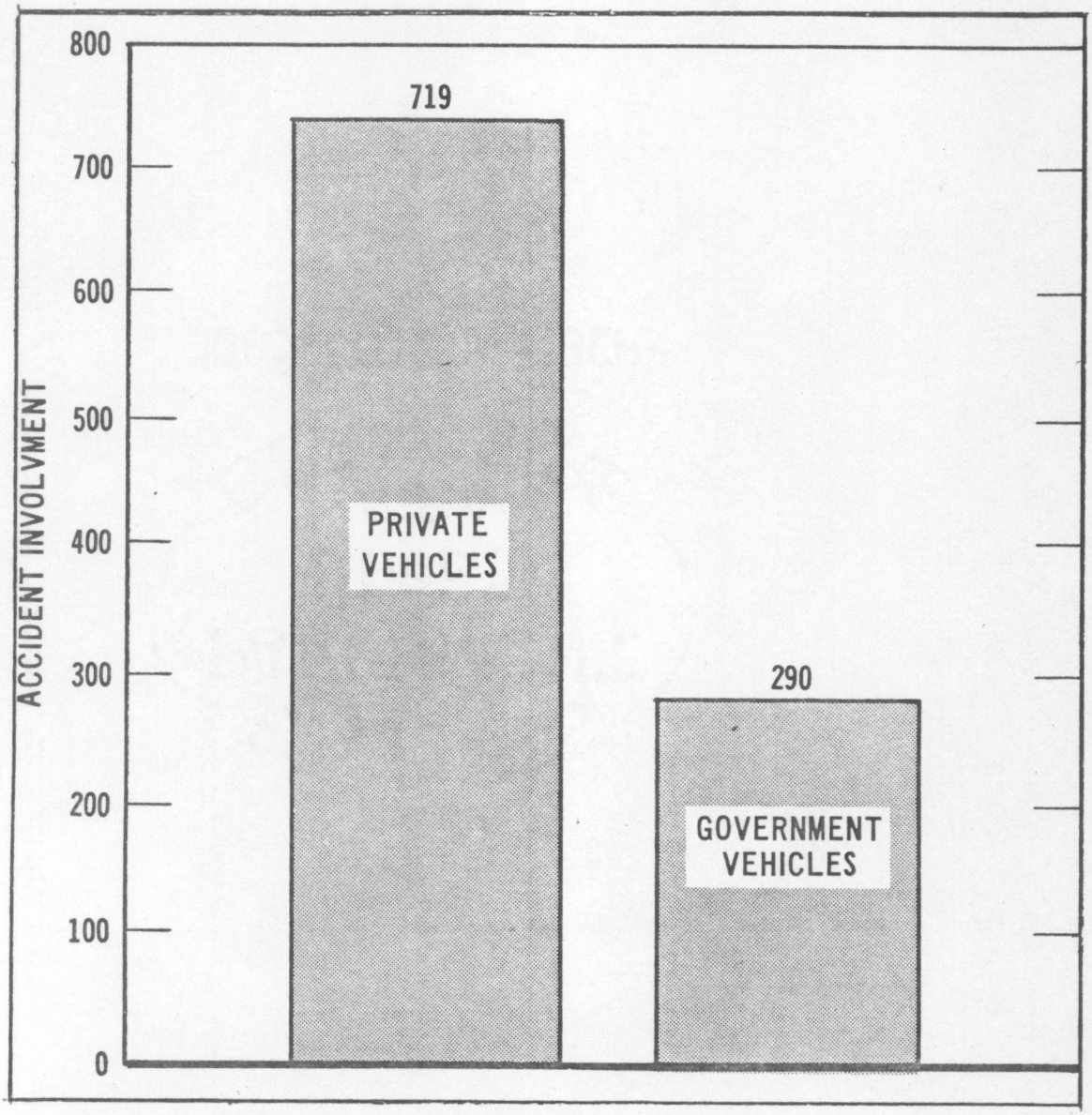


Figure 33. Accident Involvement.

APPENDIX F

KOLMOGOROV-SMIRNOV TEST OF GOODNESS OF FIT

This test was used to compare the distribution of accidents by month to an assumed uniform distribution. (22)

Null Hypothesis. (H_o): There is no difference in the expected average number of accidents for each of the twelve months, and any observed difference is merely by chance and is expected in a random sample from a population where the frequencey of occurrence is

$$f_1 = f_2 = ... = f_{12}.$$

Alternate Hypothesis (H_1): The frequencies f_1, f_2, . . . , f_{12} are not all equal.

Significance Level. Let α =.01. N = 237, the sum on the monthly accident averages.

Table 17 shows the average number of accidents occurring each month and presents this data in a format for applying the Kolmogorov-Smirnov Test.

Table 17. Average Number of Accidents by Month.

	MONTH IN WHICH ACCIDENTS OCCURRED											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
f	16	23	19	19	25	20	18	20	22	21	16	18
$F_o(x)$	1/12	2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	12/12
$S_{237}(x)$	16/237	39/237	58/237	77/237	102/237	122/237	140/237	160/237	182/237	203/237	219/237	237/237
$F_o(x)-S_{237}(x)$	.016	.002	.001	.001	.014	.015	.007	.008	.018	.023	.007	-0-

Note that f is the average number of accidents by month. $F_o(x)$ is the theoretical cumulative distribution under H_o where H_o is that each of the 12 months would receive 1/12 of the average number of accidents. $S_{237}(x)$ is the observed cumulative distribution of average number of accidents. The bottom row of Table 34 gives the absolute deviation of each observed value from the corresponding expected value, e.g., the first absolute deviation of .016 is obtained by subtracting 16/237 from 1/12. Inspection of the table reveals that the maximum absolute deviation D = .023. The table of critical values of D contained in the reference shows that for N = 237 and a .01 level of significance, D = .106. Since the observed D value is less than the expected value of D, the null hypothesis is accepted. Therefore, the hypothesis that the average number of accidents per month are distributed uniformally cannot be rejected.

VITA

William A. Ellis was born in Chattanooga, Tennessee on August 17, 1932. He attended elementary school there and was graduated from Chattanooga High School in 1951. In October, 1952 he enlisted in the United States Navy and was selected to attend the U.S. Navy Electronics School at Treasure Island, California. Upon graduation he was assigned to the Pacific Fleet and honorably served on several ships until his release from duty in 1956. He entered The University of Chattanooga in September 1957, and received a Bachelor of Science degree in Engineering Physics in June 1961.

From September 1961 to June 1966 he was employed as a Staff Project Engineer with Vitro Corporation of America, Fort Walton Beach, Florida. From June 1966 to the present he has been a civilian employee of the United States Air Force at Eglin Air Force Base, Florida, holding several key engineering positions. He is presently a senior Test Programming Engineering in the 3246th Test Wing at Eglin.

He is married to the former Patricia Anne Mansfield of Chattanooga, Tennessee. They have four children and reside in Fort Walton Beach, Florida.