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16. Abstract

A process was developed in this study to aid the District personnel of the Texas Department of Highways and Public Transportation (SDHPT) in their tasks of: identifying high accident locations on urban Interstate highways and urban non-Interstate freeways; analyzing accident causative factors associated with these high accident sites; and determining and evaluating appropriate remedial measures at these sites. A conceptual approach was first developed, which was then revised and improved based upon experience gained from field tests of 10 sites selected from three participating SDHPT Districts. It was found that, in order for the process to be useful, it is necessary to automate the process to the extent possible. An existing mainframe computer program, known as WINDOW, was modified to identify high accident locations and to create an analysis file for use with a Microcomputer Accident Analysis Program (MAAP). The MAAP program identifies accident characteristics at the high accident locations that are overrepresented when compared to the average for similar highway type in the same county. The program also has the capability to produce various tables and reports for detailed evaluaton of the high accident locations. The MAAP program was field tested with 30 sites from the three participating Districts.

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ACCIDENT ANALYSIS FOR URBAN FREEWAYS

VOLUME I. TECHNICAL REPORT

By

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Research Report 399-1F

on

Research Study Number 2-18-84-399
Analysis of Accident Rates Along Urban Freeways
To Determine Where and When Added Enforcement
or Other Remedial Measures Are Required

Sponsored By

Texas State Department of
Highways and Public Transportation

In Cooperation With

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May 1988

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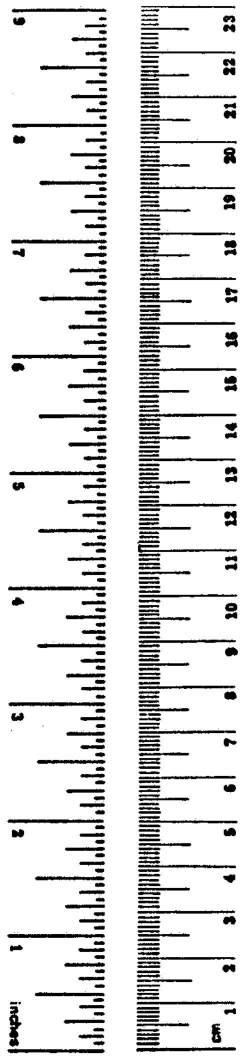
College Station, Texas 77843

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

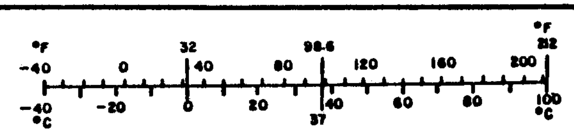
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the State Department of Highways and Public Transportation. This report does not constitute a standard, specification, or regulation.

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ABSTRACT

A process was developed in this study to aid the District personnel of the Texas Department of Highways and Public Transportation (SDHPT) in their tasks of: identifying high accident locations on urban Interstate highways and urban non-Interstate freeways; analyzing accident causative factors associated with these high accident sites; and determining and evaluating appropriate remedial measures at these sites. A conceptual approach was first developed, which was then revised and improved based upon experience gained from field test of 10 sites selected from three participating SDHPT Districts. It was found that, in order for the process to be useful, it is necessary to automate the process to the extent possible. An existing mainframe computer progran, known as WINDOW, was modified to identify high accident locations and to create an analysis file for use with a Microcomputer Accident Analysis Program (MAAP). The MAAP program identifies accident characteristics at the high accident locations that are overrepresented when compared to the average for similar highway type in the same county. The program also has the capability to produce various tables and reports for detailed evaluation of the high accident locations. The MAAP program was field tested with 30 sites from the three participating Districts.

CHAPTER I. INTRODUCTION

1.1 Problem Statement

Identification of high accident locations and associated accident causative factors as well as determination and evaluation of appropriate remedial measures at these sites are continuing functions of highway engineers. These functions are critical in the effort to provide and maintain a safe and efficient highway system. However, this process is time consuming and tedious, requiring extensive compilation and analysis of accident data and engineering studies. Given the current climate of ever-increasing demand for safety and mobility and declining funding and manpower resources, it would be desirable to establish this process in a systematic manner and to automate as much of the process as possible to aid the engineers in performing this task more systematically and efficiently.

1.2 Study Objectives

The goal of this study is, therefore, to develop a systematic and efficient process to aid the engineers in identifying and analyzing high accident locations on urban Interstate highways and urban non-Interstate freeways. The specific objectives of the study are to develop procedures for the following activities:

1. To identify and rank high accident locations,

2. To analyze accident data at selected high accident locations,

3. To identify accident causative factors and to devise appropriate remedial measures, and

4. To evaluate remedial measures actually implemented.

1.3 Scope of Study

A conceptual framework of the process was first developed and pilot tested with four selected sites in San Antonio (District 15), Texas. Further testing was conducted with six more selected sites, three each in Fort Worth (District 2) and Houston (District 12), Texas. Remedial measures were implemented at two sites and attempts were made to evaluate the effectiveness of these measures, though unsuccessfully.

Appropriate modifications were made to the process based on experience gained from the test sites. Specifically, a microcomputer-based program was developed to automate the process of analyzing accident characteristics of selected high accident locations. At the request of the Federal Highway Administration (FHWA), the program was field tested at the three participating Districts. Thirty sites, 10 from each District, were selected and analyzed with the program. The results were provided to the Districts for their evaluation. Further refinements were then added to the program and the program was installed at one District.

A description of the conceptual approach is presented in Chapter II. Details of the procedure for identifying and ranking high accident locations are described in Chapter III and the automated accident analysis procedure is presented in Chapter IV. General discussions on field evaluation of selected high accident locations, identification of remedial measures, and attempts to evaluate the effectiveness of remedial measures implemented are presented in Chapter V. A summary of conclusions and recommendations is highlighted in Chapter VI. A user's manual for the microcomputer accident analysis program is provided in Volume II of the final report.

CHAPTER II. CONCEPTUAL APPROACH

2.1 General

The conceptual approach used in this study can be viewed in the form of a series of questions. First, where are the high accident locations? Why do more accidents occur at these locations than others? What can be done to minimize or alleviate the accident problem at these locations? Finally, are the countermeasures implemented working as intended? Accordingly, the process is delineated into four major tasks:

1. To identify high accident locations,

2. To analyze the accident characteristics of these locations,

3. To evaluate these locations for potential countermeasures,

4. To assess the effectiveness of implemented countermeasures.

More detailed discussions on each of these tasks are presented in the following sections.

2.2 Identification of High Accident Locations

The initial step is to define what constitutes a high accident location. There are a number of factors to be considered:

1. Definition of a site,

2. Accident measure used,

3. Definition of a "high accident" location.

Brief discussions of these factors and how they affect the definition of a high accident location as used in this study are presented as follows.

Site Definition. For the purpose of this study, a site is defined as a two-mile segment of main lanes on urban Interstate highways or urban non-Interstate freeways, excluding ramps and frontage roads. The length of two miles is chosen arbitrarily on the premise that the accident experience of shorter sections tends to vary widely on a year-to-year basis while longer sections do not provide the needed specificity due to the close spacing of interchanges in urban areas.

Frontage roads are excluded for obvious reasons. They provide access to businesses and residences along the highways and to the surface streets. The traffic characteristics and accident experience of frontage roads are totally different from those of the main lanes. Ramps are also excluded since it is not possible to differentiate if accidents on ramps are affected by the traffic on the main lanes, the ramps themselves, or the frontage roads.

Accident Measure. The next step is to define the accident measure to be used in the identification of high accident locations. For the purpose of this study, the accident measure used is the number of fatal and injury accidents per 100 million vehicle miles of travel, excluding construction zone accidents. The latest three years of accident data are used in the determination of the accident rate.

The accident measure takes accident severity into account by including only fatal and injury accidents. This would favor locations with more serious accidents which are of greater concern than fender-bender, property-damage-only type of accidents. Also, this would minimize the impact of differing accident reporting thresholds between various law enforcement agencies within the area. Some large urban police departments have adopted the policy of reporting only injury and fatal accidents as opposed to the statewide reporting threshold of injury or over 250 dollars in property damages. It should be noted, however, that all available accidents, including property-damage-only accidents, are used in the analysis of the accident characteristics at individual sites.

There is a continuing debate on the use of accident rate versus accident frequency as an accident measure. Accident rate takes the exposure in terms of traffic volume into account and is generally considered a better measure than accident frequency. For example, a highway carrying 100,000 vehicles per day is very different from one carrying only 10,000 vehicle per day. Accident frequency does not take this into account and favors highways with heavy traffic volume. On the other hand, it may be argued that greater safety benefits can be achieved by working on those locations with the highest accident frequency.

Construction zone accidents are excluded from consideration since traffic operating conditions, and hence the accident characteristics and appropriate safety improvements, are very different in construction zones when compared to normal highway conditions. It would also indirectly help to exclude roadway sections that have undergone extensive construction activities within the study period since the analysis would not be too meaningful given the changes made to the roadway.

A period of three years is used for the accident data. Accidents tend to vary greatly on a year-to-year basis and are not too stable if the time period used is too short. Also, it is desirable to have as large a sample size, i.e., number of accidents, as possible for analysis purposes which means a longer period of time. On the other hand, too many changes may have occurred that would affect the accident experience if the time period used is too long. A period of three years is found to provide a reasonable balance and is thus used in the study.

Definition of High Accident Location. The last step is to determine what constitutes a high accident location. There are a number of ways to define a high accident location. For instance, a critical level of accident frequency or rate may be specified, such as using a quality control chart approach, so that any location with accident frequency or rate higher than the critical value is considered a high accident location.

The approach used in this study makes use of an existing computer program and is somewhat different from that described above. Instead of determining if each highway section is a high accident location, the two-mile highway sections are simply ranked in descending order of accident rate and the top ranked sites are listed for further evaluation.

It should be noted that there is a lot of flexibility as to how high accident locations are defined. The procedure used in this study can easily be modified to suit the particular needs of the user. For example, the user could specify the use of total accidents instead of fatal and injury accidents in the accident measure or include accidents on ramps in addition to accidents on main lanes.

Another consideration is that it may be desirable to screen the high accident locations before further analysis. Locations where major improvements, such as reconstruction, are recently completed, currently underway, or planned for the near future are usually not good candidates for safety improvements on the assumption that safety is already or will be enhanced by the major improvements. However, the plans for all near future projects should be checked to see that the planned improvement will actually address the safety problem. This would eliminate any unnecessary work and streamline the process.

2.3 Accident Analysis of High Accident Locations

After these high accident locations are identified, the next step is to analyze the accident characteristics of each of these sites to determine why they have such high accident rates. The methodology used is based on the simple concept of overrepresentation. The basic underlying assumptions of the accident analysis methodology are:

1. There are certain accident characteristics (factors) and/or combinations of factors that are overrepresented at a high accident location when compared to the average of similar highway type within the area;

2. These overrepresented accident factors and/or combinations of factors are indicative of accident causative factors at the high accident location.

For illustrative purposes, consider the simple example shown in Table 1 in which the proportion of accidents occurring under wet pavement conditions is compared between a given site and the average for all accidents on the same type of highway (e.g., Interstate highway) within the same general area (e.g., same county). In Case A, 15 percent of the accidents at the site occurred under wet pavement conditions compared to the average of 20 percent. It is evident that accidents under wet pavement conditions are not overrepresented (i.e., at or below average) at the site in Case A.

However, if 30 percent of the accidents at the site occurred under wet pavement conditions as in Case B, it may be concluded that such accidents are overrepresented at the site when compared to the average of 20 percent. Statistical tests are then conducted to make sure that the

TABLE 1. ILLUSTRATIVE EXAMPLE ON THE CONCEPT OF OVERREPRESENTATION

Pavement Condition	Site		Average	
	No.	%	No.	%
Wet	30	15	1,000	20
Dry	170	85	4,000	80
Total	200	100	5,000	100

Case A. No Overrepresentation for Accidents Under Wet Pavement Condition

Pavement Condition	Site		Average	
	No.	%	No.	%
Wet	60	30	1,000	20
Dry	140	70	4,000	80
Total	200	100	5,000	100

Case B. Overrepresentation for Accidents Under Wet Pavement Condition overrepresentation is significant from the statistical standpoint and not the result of random fluctuations.

Overrepresented conditions may be indicative of problems at the site which resulted in it being a high accident location. For example, the overrepresentation of accidents under wet pavement conditions may be the result of low pavement skid resistance or poor drainage. It is reasonable to argue that the amount of precipitation at that site should be similar to that of the general area. Also, the occurrence of accidents under wet pavement conditions should be similar between the site and other similar highways in the area if the site is typical of that highway type. A significant overrepresentation would therefore suggest that accidents are more likely to occur at the site during wet weather conditions than other similar highways, which may then be linked to pavement skid resistance and drainage.

The above example is intended as an illustration of the concept of overrepresentation and is a gross simplification of the analysis methodology. The example shows a single factor (i.e., wet pavement condition) as being overrepresented which rarely happens in practice. Instead, it is more likely to find a combination of factors as being overrepresented, such as single vehicle accidents during evenings and nights under wet pavement conditions. The statistical procedure developed in this study looks at not only single factors, but all combinations of the factors. More detailed descriptions of the procedure are presented in Chapter IV and the statistical algorithm is detailed in Appendix B of this report.

2.4 Field Evaluation of High Accident Locations

The results from the accident analysis provide indications of accident factors and/or combinations of factors that are significantly overrepresented at the location under evaluation. Some logical inferences are also made as to the suggested items for field observation and potential improvements. However, the accident analysis cannot and should not replace detailed field studies and sound engineering judgement in the effort to determine potential causative factors and possible remedial measures.

A multidisciplinary team approach was envisioned initially for the field evaluation. The team would consist of an accident analyst, a traffic engineer, and an analyst with human factors and/or law enforcement expertise, to provide a broad spectrum of expertise to the evaluation process. It is the intent of the study to examine not only engineering type of safety improvements, but all potential remedial measures, including law enforcement efforts. Also, only low-cost, short-term safety countermeasures are considered for this study, excluding any major improvements, such as realignment of roadway or reconstruction.

Results from the accident analysis and other available information, such as as-built plans, traffic counts, etc. are first analyzed in the office to identify potential accident causative factors and remedial measures. The team then visits the site to evaluate if the identified potential accident causative factors and remedial measures are appropriate. There are many site-specific factors that are evident only when viewed from the field by personnel with engineering knowledge. The accident data are simply not detailed enough to provide the needed information. On the other hand, the results from the accident analysis can provide the field personnel with clues and leads on what to look for while at the site. This greatly simplifies the work of the field personnel, leading to higher efficiency and better results.

This team approach worked well for the research team, but it is evident that such an approach may not work at the District level due to the manpower situation. It appears that a team comprised of the traffic safety specialist and a traffic engineer or technician may probably be the best that can be hoped for. This will not provide the wide spectrum of expertise originally envisioned, but should be adequate for the intended task. However, it is always advisable to have the participation of law enforcement and/or human factors personnel, if at all possible, since accidents are the results of multiple factors which may or may not be resolved with engineering improvements alone.

2.5 Countermeasure Evaluation

After the accident problem has been identified and remedial measures are implemented at a given site, it is also important to evaluate the effectiveness of the implemented countermeasure. The evaluation provides feedback to the engineer as to whether the remedial measures are performing as intended or additional improvements are needed. Furthermore, the information will serve as an example to future work of a similar nature and improves the state-of-the-knowledge and expertise of the personnel involved.

The methodology for evaluating countermeasure effectiveness is fairly well established. Guidelines and procedures to be followed in the evaluation are available from a number of publications, such as the "Accident Research Manual". Thus, only an outline of the methodology is presented in Chapter V of this report. For more details, the users are referred to other available publications for reference.

Countermeasure evaluation may seem like a simple and straightforward process on the surface, but in effect it is extremely difficult to conduct an evaluation properly. The typical before-and-after with comparison or control type of study in which accident experience or another surrogate measure before implementing the countermeasure is compared to that after implementation is full of pitfalls that could render the results practically useless. Examples of such pitfalls are regression-to-the-mean effect, lack of control for other influencing factors, inadequate sample size, etc. A properly conducted evaluation requires considerable time and efforts to carefully plan and design the evaluation, followed by close monitoring and control.

In fact, given the experience from this study, it is recommended that evaluations on countermeasure effectiveness be conducted as special studies and not as a routine part of operation. This does not imply that operational personnel cannot properly conduct evaluations, but rather they do not have the time necessary to monitor the evaluations on top of their already heavy workload. Also, this does not mean that the countermeasures are not to be monitored, but the evaluation would be more cursory in nature to check if the countermeasures are performing as intended or if there are any undesirable or negative side effects that need further improvement.

CHAPTER III. IDENTIFICATION OF HIGH ACCIDENT LOCATIONS

3.1 WINDOW Program

As mentioned previously under conceptual approach in Chapter II, the methodology used to identify and rank high accident locations is based on an existing computer program, known as the "WINDOW" program, previously developed by TTI for the Texas SDHPT. The program utilizes a "window", which is simply a highway segment of user-specified length, e.g., 2 miles. This window is then moved along the highway network in 0.1 mile increments. For each increment, the accident rate is calculated for the window and compared to that of windows at other increments. Windows at those increments with the highest accident rates are identified and ranked in descending order of accident rate.

The WINDOW program was designed with numerous built-in options to accommodate the specific user needs. Depending on the application, the program parameters may be varied with user-specified inputs, including:

1. Years of accident data (one to five),

2. Accident selection (subsetting) criteria, e.g., county, highway type, accident type, accident location, accident severity, etc.,

3. Length of window (0.1 to 10 miles),

4. Ranking by accident frequency or rate, and

5. Output format, e.g., number of roadway segments to be ranked, reports to be generated, etc.

For this specific application, the latest three years of accident data are used. The accidents are subsetted by county (only one county is studied at one time), highway type (urban Interstate highways and urban non-Interstate freeways), accident location (main lanes only), accident type (excluding construction zone accidents), and accident severity (injury and fatal accidents only, excluding property-damage-only accidents). A two-mile long window is used and the roadway segments are ranked by accident rate per 100 million vehicle miles of travel. These parameters were considered by the project staff as the most appropriate based on results of the pilot study, more details of which will be presented later in this chapter. However, as pointed out previously, these parameters may be varied by the user if deemed necessary.

Traffic volume and other roadway-related data are obtained from the computerized roadway inventory file (RI2-TLOG). A computerized milepoint-milepost equivalency file provides a "track" in "going-down-the-highway" order. The window is then moved along this track and takes "snapshots" every 0.1 mile to find the locations with the highest accident rates.

The WINDOW program outputs a user-specified number of two-mile highway segments ranked by accident rate, an example of which is shown in Table 2. The table heading, which is user specified, can include such information as

TABLE 2. EXAMPLE OUTPUT FROM WINDOW PROGRAM

SECTION 01

1984-1986 HARRIS COUNTY INTERSTATE MAINLANE ACCIDENTS
EXCLUDING PDO AND CONSTRUCTION ZONE ACCIDENTS

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL- ITIES	INJ ACCS	INJ- URIES	PDO ACCS
			COUNTY	CONTROL- SECTION	MPT	COUNTY	CONTROL- SECTION	MPT							
1	12	IH 0610	HARRIS	0271-17	33.1	HARRIS	0271-17	35.1	403	270.55	2	2	401	596	0
2	12	IH 0610	HARRIS	0271-15	5.9	HARRIS	0271-16	21.0	209	250.48	3	3	206	299	0
3	12	IH 0045	HARRIS	0500-03	15.4	HARRIS	0500-03	17.4	310	237.44	2	2	308	496	0
4	12	IH 0010	HARRIS	0271-07	28.0	HARRIS	0508-01	1.9	147	200.97	4	4	143	201	0
5	12	IH 0610	HARRIS	0271-14	5.6	HARRIS	0271-14	7.6	143	192.24	0	0	143	211	0
6	12	IH 0610	HARRIS	0271-15	3.3	HARRIS	0271-15	5.3	136	189.91	4	5	132	208	0
7	12	IH 0045	HARRIS	0500-03	20.6	HARRIS	0500-03	22.6	250	182.89	3	3	247	367	0
8	12	IH 0610	HARRIS	0271-16	9.6	HARRIS	0271-17	31.5	163	151.90	2	2	161	237	0
9	12	IH 0610	HARRIS	0271-16	6.5	HARRIS	0271-16	8.5	173	146.29	0	0	173	280	0
10	12	IH 0010	HARRIS	0508-01	34.4	HARRIS	0508-01	36.4	131	143.16	6	8	125	188	0
11	12	IH 0010	HARRIS	0271-07	25.9	HARRIS	0271-07	27.9	124	142.62	5	5	119	165	0
12	12	IH 0610	HARRIS	0271-14	10.6	HARRIS	0271-14	12.6	88	140.83	1	1	87	116	0
13	12	IH 0045	HARRIS	0500-03	11.5	HARRIS	0500-03	13.5	139	140.58	1	1	138	212	0
14	12	IH 0610	HARRIS	0271-17	36.9	HARRIS	0271-14	0.9	223	132.76	1	1	222	324	0
15	12	IH 0010	HARRIS	0508-01	2.3	HARRIS	0508-01	32.3	102	131.75	3	5	99	134	0
16	12	IH 0610	HARRIS	0271-16	21.1	HARRIS	0271-16	23.1	107	125.76	2	2	105	149	0
17	12	IH 0610	HARRIS	0271-14	1.0	HARRIS	0271-14	3.0	150	108.75	1	2	149	201	0
18	12	IH 0610	HARRIS	0271-14	8.4	HARRIS	0271-14	10.4	65	106.96	1	1	64	96	0
19	12	IH 0610	HARRIS	0271-16	24.1	HARRIS	0271-16	26.1	105	105.34	0	0	105	169	0

the years of accident data used, highway type, number of segments ranked, length of segment and subsetting criteria, etc. Other reports can also be generated, such as listing of highway sections sorted by highway number and accident counts by 0.1 milepoints.

The user then selects specific segments of interest from the list of high accident locations generated from the WINDOW program for evaluation. Each of the selected high accident locations is then analyzed individually using the microcomputer accident analysis program. It should be noted that minor changes in the beginning and ending milepoints of the locations can be made to coincide with identifiable landmarks, such as interchanges and bridge structures, for field evaluation purposes. These changes, if necessary, are accommodated by the microcomputer accident analysis program.

The accident data, as used on the mainframe computer, are not suitable for use with the microcomputer. The WINDOW program was thus modified to allow for the creation of an analysis data file from the State master accident data file suitable for use with the microcomputer accident analysis program. The analysis data file includes all accidents within the study area (i.e., county) that meet the subsetting criteria used with the WINDOW program, except for accident severity (i.e., property-damage-only accidents are also included in the analysis file).

Since storage space is limited on the microcomputer, only 21 data elements are selected from the mainframe accident data file for inclusion in the analysis data file. Two of the data elements are location identification variables, i.e., control section number and milepoint. The remaining 19 data elements are further recoded and/or combined to create the following 10 data elements for use with the microcomputer accident analysis program:

Time of Accident
Accident Type
Weather/Surface Condition
Degree of Curve
Vehicle Type
Accident Severity
Speeding
DWI or DW Drugs
Driver Age
Driver License Status

The subsetting and recoding of the data elements are handled by the modified WINDOW program. The analysis data file is then transferred to the microcomputer for use in analyzing the accident characteristics of selected high accident locations. More detailed description of this modified WINDOW program (called MAAP version of the WINDOW program) is provided in the user and programmer manuals available at D-18STO.

3.2 Pilot Test

The use of the WINDOW program to identify and rank high accident locations was pilot tested with the cooperation of District 15 (San Antonio) of the SDHPT. The San Antonio Police Department maintains a manual listing and ranking of Interstate and freeway segments within the city limits and the information is provided to the District on a routine basis. The highway segments are of varying length and broken down by direction of travel. Accident rates are calculated in terms of total accidents per 100 million vehicle miles of travel. The availability of this manual listing and ranking of Interstate and freeway segments provided a means for checking the ranking from the WINDOW program and to establish the input parameters for the program.

Specifically, the following items were evaluated in the pilot test:

1. Manual ranking vs. WINDOW program ranking,
2. Accident frequency vs. accident rate as the accident measure,
3. The length of roadway segment,
4. Time period of the accident data,
5. Subsetting criteria.

The rankings from the manual process and the WINDOW program are not directly comparable. The segments used in the manual process are of varying lengths, from 0.3 mile to several miles long, and different directions of travel are treated as separate segments. On the other hand, the WINDOW program uses a uniform segment length and includes both directions of traffic. Despite these differences, the highway segments identified as high accident locations and the rankings from both processes using total accident rate (i.e., total number of accidents per 100 million vehicle miles of travel) are very similar. The segments are in the same general vicinity although the beginning and ending milepoints may be slightly different. The rankings may vary somewhat, but the variations are of little practical significance.

Rankings by both accident frequency (number of accidents per mile per year) and accident rate (number of accidents per 100 million vehicle miles of travel) were evaluated. Accident frequency, as may be expected, favors highway segments with heavy traffic volume. The top ranked segments are at locations usually associated with very high traffic volume and severe congestion during weekday rush hours. Minor safety improvements at these locations would generally not be effective unless efforts to improve capacity and traffic flow are also implemented.

Accident rate takes into account the exposure in terms of traffic volume and is generally a better indicator of potential safety problems. The problem with ranking by accident rate is the opposite of that for accident frequency in that it favors highway segments with very low traffic volume. It is possible to have a very high accident rate and ranking for a highway segment with a small number of accidents simply because of very low traffic volume. This problem can be partially alleviated by specifying a minimum number of accidents, e.g., 30 accidents in three years, in order for a site to be ranked. Overall, it is still believed that accident rate is a better measure than accident frequency for the purpose of this study.

The length of the segment and the time period for the accident data were also varied for evaluation. It is found that short segments (e.g., one-half mile) or short time periods (e.g., one year) tend to produce wide variations in accident rates from year to year and are not too stable or consistent. Segment lengths that are too long (e.g., 5 miles) do not provide the needed specificity, given the relatively close spacing of interchanges in urban areas. Longer time periods provide a larger number of accidents for analysis which is desirable from the sample size standpoint, but it is also more likely for changes to have occurred at the site that would significantly affect the accident pattern or characteristics of the site. It seems that a segment length of two miles and a time period of three years provide the best compromise and are thus used for the procedure.

The effect of various subsetting criteria was also examined. Roadway segments with major constructions during the study period were found to have higher than normal number of accidents during the construction period, as may be expected. Also, the accident characteristics of the site during and after the constructions would likely be changed and the analysis would not be too meaningful. Construction zone accidents are thus eliminated from the analysis in an attempt to minimize the inclusion of sites with major constructions or improvements during the three-year study period. Also, these sites can be screened and excluded from further evaluation in the manual screening and site selection process.

It was also noted during the pilot test that some of the high ranking sites have a very high percentage of property-damage-only accidents, again reflecting problems with severe congestion and over-capacity during weekday rush hours. It seems appropriate that more emphasis should be placed on locations with more severe accidents. It was thus decided to exclude property-damage-only accidents from the identification and ranking of high accident locations. Only fatal and injury accidents are now included in the determination of accident rates.

3.3 Field Test

After the parameters for the WINDOW program were defined in the pilot test, this process of identifying and ranking high accident locations on urban Interstate highways and non-Interstate freeways using the WINDOW program was repeated with Districts 2 (Fort Worth) and 12 (Houston) as part of a field test. The process worked well in providing the information as specified. A number of observations were made by the project staff from review of the rankings and from discussions with District personnel, which are discussed as follows.

There is some concern that the accident information may be somewhat outdated. First, there is a time lag of 30 to 60 days in obtaining the accident data from the Department of Public Safety. Secondly, it is likely that the analysis data file will be updated only once a year so that the accident data may have a time lag of as long as one year. By updating the analysis file more frequently, e.g., once every quarter, this time lag can be reduced. However, this would greatly increase the data processing effort and would not be cost-beneficial in the opinion of the project staff unless there are other compelling reasons to keep the accident data more current than annual updating. It is important to keep this time lag in mind in analyzing the accident characteristics, particularly for locations that have experienced major changes recently.

The Interstate highways and some non-Interstate freeways in large urban areas in Texas are undergoing a massive rehabilitation and reconstruction program. Most locations identified are included in the program so that major improvements are either recently completed, currently underway, or planned for the near future. This greatly narrowed down the list of candidate sites for the field test. It appears that the utility of the procedure developed in this study will be somewhat limited until this rehabilitation and reconstruction program is completed or unless the procedure is extended to other highway types.

The high ranking of locations with only a small number of accidents and very low traffic volume is noted for some of the sites identified in the field test. This is not really a problem since the sites are screened manually and such sites can simply be excluded during the selection process. It may be interesting to note that, of the couple of such sites evaluated during the field test, it was found that there are generally some unusual circumstances associated with these sites and they may be better candidates for minor safety improvements than sites with large number of accidents resulting from heavy traffic volume.

CHAPTER IV. ACCIDENT ANALYSIS OF HIGH ACCIDENT LOCATIONS

4.1 Accident Analysis Methodology

After the high accident locations are identified and specific sites of interest are selected for further study, the accident characteristics at each of these high accident locations are analyzed to determine the causative factors and potential remedial measures. As discussed previously under "Conceptual Approach" in Chapter II, the methodology used in analyzing accident characteristics of selected high accident locations is based on the concept of overrepresentation and the assumptions that there are individual and/or combinations of accident characteristics overrepresented at the high accident location and these overrepresented conditions are indicative of causative factors contributing to the accident occurrence.

The basis of comparison used for determining overrepresentation of accident characteristics at a given high accident location is the average for the same highway type within the same study area. For example, if the high accident location is on Interstate Highway 10 located in Bexar County, the basis of comparison is the average for all Interstate highways within Bexar county. The county is chosen as the unit for analysis since it is the smallest governmental unit readily identifiable from the accident data file. While data on cities and towns are also available, they are more difficult to use since it is common in major urban areas to have many local jurisdictions.

Some questions have been raised regarding the appropriateness of using the countywide average as the basis of comparison. The concern is that, even for the same highway type within the same county, there are too many variations in traffic and accident characteristics for the average to be truly representative. For example, a highway segment in the downtown area would have different characteristics from those of a loop or at the fringes of the urban area even if they are of the same highway type.

This is certainly a valid concern to make sure that the basis of comparison is appropriate and correct. A better approach may be to further constrain the data so that the high accident site being analyzed and the highway sections based on which the average is calculated are as comparable as possible. For example, if the high accident location is a six-lane Interstate highway on a loop with 150,000 ADT, we may want to constrain the comparison sites to only Interstate highways on a loop with six lanes and an ADT range of 125,000 to 175,000 and then use that average as the basis for comparison. This would improve on the comparability between the high accident site and the average used as the basis for comparison. However, it would also greatly complicate the procedure, rendering it more difficult and less efficient to use. The countywide average for the same highway type seems to be adequate for the purpose of this analysis and it is questionable if the improved comparability would substantially affect the analysis results to justify the added complexity.

4.2 Pilot Test

The accident analysis methodology was pilot tested with four sites in District 15. The four test sites were selected by District personnel from the list of high accident locations identified by the WINDOW program. The criteria used in selecting these test sites were that no major improvement was undertaken during the previous three years or currently under way or planned for the near future. Also, attempts were made to select the sites from different parts of the county with varying site and traffic conditions.

Accident characteristics of these four pilot test sites were then analyzed by the project staff and the results reported back to District personnel for their consideration. Results of the analysis for these four pilot test sites are shown in Appendix A of this report. Note that the results are in summary form with little attached detail since they were intended for use as notes in a presentation to the District.

While the methodology worked well with the test sites in identifying overrepresented conditions and potential causative factors, it became apparent that the process is too tedious and time consuming to be a practical tool for use by District personnel in day-to-day operations. For each test site, the accident characteristics have to be compared to the countywide average individually and in combinations to identify overrepresented conditions. This requires compilation and analysis of literally hundreds of tables, when combinations of accident characteristics are involved.

The list of accident characteristics to be analyzed was thus reduced to only 10 variables that are considered the most important to this application and the levels within each of these variables are condensed to the extent possible, as shown in Table 3. However, even with the reduced number of variables and levels within each variable, the number of possible combinations, 17,280 to be exact, remains astronomical. It is true that only a small portion of the combinations will be applicable for any given site and many of the combinations will be eliminated from consideration due to insignificance. Nevertheless, it is still too tedious and time consuming to be of any practical use.

The obvious solution is to automate and computerize this accident analysis process so that the users are not required to go through this tedious and time consuming process. An algorithm suitable for automation and a microcomputer program were thus developed for this specific application. Brief descriptions of the algorithm and the computer program are presented in the next section.

4.3 Microcomputer Accident Analysis Program

The Microcomputer Accident Analysis Program (MAAP) is designed to automatically analyze the accident characteristics of a given site and to provide the users with a list of accident factors and their interactions that are significantly overrepresented at the location under consideration in comparison to the countywide average. The program also provides the users with the capability to generate various supplemental reports on accident characteristics at the location.

TABLE 3. VARIABLES USED IN ACCIDENT ANALYSIS

Variable	Levels
	PRIMARY VARIABLES
Accident Time	Weekday, Rush Hour Weekday, Non-Rush Hour or Weekend, Daytime Evening/Night
Accident Type	Single Vehicle Multi-Vehicle, Rear-End Multi-Vehicle, Sideswipe Multi-Vehicle, Head-On/Angle
Weather/Surface Condition	Adverse No Adverse
Degree of Curve	Straight < 4 Degrees >= 4 Degrees
Vehicle Type	Passenger Car Pickup Truck/Van Truck/Bus
	SECONDARY VARIABLES
Accident Severity	Fatal/Injury Property Damage Only
DWI or DW Drugs	Yes No
Speeding	Yes No
Driver Age	Under 21 21 to 55 Over 55
Driver License Status	Out of State In State

The MAAP program is written in turbo-pascal for use with IBM PC-XT, AT, or compatible microcomputers with MS-DOS version 2.1 or above. A minimum configuration of 512K memory and a 10 Mb hard disk drive is required to use the program. A full memory of 640K is recommended to allow for the use of other memory resident programs. The processing time could be sped up with a math co-processor, but this would require compiling the source code using Turbo 87 Pascal. The current compiled version does not support a math co-processor so that it can be used with any IBM-compatible microcomputer. A program compiled with Turbo 87 Pascal will not run on a microcomputer without a math co-processor. Detailed information on the MAAP program is provided in the user manual in Volume II of the final report. A programmer manual is also available from D-18STO for anyone interested in the technical details.

A decision was made to develop the program for use on a microcomputer instead of the mainframe computer. The use of microcomputers in SDHPT has been limited up to this time, but is expected to grow rapidly in the upcoming years. By running smaller programs on microcomputers, this would free up the mainframe computers for large applications, such as computer-aided design. Also, this would allow the District personnel to have more control and ready access to the program and data with reduced turnaround time.

The accident analysis algorithm was developed specifically for this application and is based on a statistical (discrete multivariate) approach. Only a brief and general description of the algorithm is presented in this section. For users that are interested in the details of the algorithm and the accompanying statistics, a detailed step-by-step description of the algorithm is presented in Appendix B of this report.

The algorithm uses a two-staged procedure: (1) variable selection, and (2) modeling. The first stage, variable selection, identifies those variables that are significantly overrepresented at the high accident site. These significant variables will then be analyzed in the second stage, modeling, while the nonsignificant variables are eliminated from further consideration. This intermediate step is required because the number of variables that can be simultaneously analyzed in the modeling stage is restricted by the number of accidents at a given site. It is therefore desirable to reduce the number of variables to only those that are statistically significant to minimize the problem with insufficient sample size in the modeling process.

Note that the 10 variables, shown previously in Table 3, are categorized as either "primary" or "secondary". The primary variables (1 through 5) are considered to be more important since they are directly applicable to the development of engineering related countermeasures. The secondary variables (6 through 10) contain mostly driver related factors and are useful for law enforcement related countermeasures. The algorithm favors the primary variables in that they are selected prior to consideration of the secondary variables.

After the significant variables are identified in the variable selection process, the algorithm proceeds to the second stage modeling process. All possible combinations of the significant variables are tested statistically for overrepresentation at the high accident location. The overrepresented conditions that are statistically significant are then identified and listed in the program output.

The entire analysis process is rather complicated, requiring extensive table compilations and computations, but is totally transparent to the user. In other words, the process is completely automated so that user intervention at any of the intermediate steps is not required. The only required input by the user is to specify the rank of the site (in accordance with rankings from the WINDOW program) to be analyzed. If the site is not ranked by the WINDOW program or if minor changes to the beginning and ending milepoints of a ranked site are desired, the user will have to input the location of the site, including the control section number and the beginning and ending milepoints.

The program will first identify all accidents within the high accident location. The analysis process will then be initiated, starting with the variable selection process and automatically proceeding to the modeling process upon completion of the variable selection process. The user will be provided with a summary of overrepresented accident conditions in a tabular format and suggested items for field observation and potential improvements for that site at the end of the program.

Table 4 illustrates a typical output from the MAAP program. The over-represented conditions are reported in tabular format for ease of use. The table heading identifies the county, highway type, and the location, accident frequency and rank of the site being evaluated. Significant variables and levels of these variables are shown as rows and columns of the table.

Entries are shown only for those cells, i.e., combinations of levels of variables, that are significantly overrepresented. Each entry shows both the expected and the observed number of accidents. The expected number of accidents is based on the countywide average for the same highway type as the site being evaluated. In other words, this is the number of accidents expected for that specific combination of factors if the site under evaluation is an average site for that highway type within the county. The observed number of accidents is the actual number of accidents for that specific combination of factors found at the site under evaluation.

The program output also provides a list of suggested items for field observation and improvements based on the overrepresented conditions. A list of the overrepresented conditions and the corresponding suggested items for field observation and improvements is shown in Table 5. This is a very crude attempt to provide the users with some suggestions on what to look for in the field inspection and some potential remedial measures. Each suggestion corresponds to only one variable and one level of that variable at a time. In other words, the suggestions do not take interactions or combinations of factors into account. This is one area where major improvements can be made to the MAAP program in the future.

TABLE 4. TYPICAL OUTPUT FROM MAAP PROGRAM

Tarrant County, Interstate Freeway. On site accidents were 717 of a County Total of 9538

Rank 01 - Control Section 0014-16 Milepoint 6.5 to 8.5

ACCIDENT TYPE	ACCIDENT TIME		VEHICLE TYPE	
			TRUCK OR BUS	VAN OR PICKUP
M/V SIDESWIPE	WEEKDAY RUSH HOUR	EXPECTED	9.4	
		ACTUAL	19	
	WEEKDAY NON-RUSH HOUR	EXPECTED	8.7	
		ACTUAL	19	
		EXPECTED		27.6
		ACTUAL		40
M/V ANGLE OPPOSITE	WEEKDAY NON-RUSH HOUR	EXPECTED	1.0	
		ACTUAL	6	
		EXPECTED		2.1
		ACTUAL		6
	EVENING OR NIGHT	EXPECTED	0.9	
		ACTUAL	5	

TABLE 4. TYPICAL OUTPUT FROM MAAP PROGRAM (CONTINUED)

Accident Type = Multi-vehicle, Sideswipe

The proportion of sideswipe accidents are overrepresented. Check merging and weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

Accident Type = Multi-vehicle, Head-on/Angle

The proportion of head-on or angle accidents are overrepresented. Check to make sure that this roadway section is correctly identified as freeway. The number of head-on or angle accidents is probably too high for freeway conditions. If the problem is with median crossovers, assess the possibility of closing off these crossovers.

Accident Time = Weekday, Rush Hour

The proportion of accidents during weekday rush hours is higher than average. This suggests a problem with over-capacity during rush hours which is generally not affected by safety-related improvements. Check for potential means of increasing capacity and improving traffic flow.

Accident Time = Weekday, Non-Rush Hours or Weekend, Daytime

The proportion of accidents during weekday non-rush hours and/or weekend daytime hours is higher than average. Check if the traffic volume is already approaching capacity at these time periods while traffic speeds are relative high. If such is the case, safety-related improvements will generally not be effective. Check for potential means of increasing capacity and improving traffic flow.

Accident Time = Evening/Night

The proportion of accidents during the evening and nights is higher than average. Check lighting conditions and night visibility for potential improvements, such as increasing lighting level, improving delineation, raised pavement markers, etc.

TABLE 5. OVERREPRESENTED CONDITIONS AND CORRESPONDING SUGGESTIONS FOR FIELD OBSERVATION AND IMPROVEMENTS

Overrepresented Condition	Suggested Items for Field Observations and Improvements
1. Accident Type = Single Vehicle, Fixed Object or Other	1. The proportion of single vehicle accidents is overrepresented. Check roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.
2. Accident Type = Multi-Vehicle, Rear-End	2. The proportion of rear-end accidents is over-represented. Check the roadway section for conditions leading to sudden stops and rear-end accidents, such as traffic backup on main lanes, poor sight distance, frequent entrance and exit of slow-moving vehicles, etc.
3. Accident Type = Multi-Vehicle, Sideswipe	3. The proportion of sideswipe accidents is represented. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.
4. Accident Type = Multi-Vehicle, Head-On/Angle	4. The proportion of head-on or angle accidents is overrepresented. Check to make sure that this roadway section is correctly identified as freeway. The number of head-on or angle accidents is probably too high for freeway conditions. If the problem is with median cross-overs, assess the possibility of closing off these crossovers.
5. Accident Time = Weekday, Rush Hour	5. The proportion of accidents during weekday rush hours is higher than average. This suggests a problem with over-capacity during rush hours which is generally not affected by safety-related improvements. Check for potential means of increasing capacity and improved traffic flow.
6. Accident Time = Weekday, Non-Rush Hours or Weekend, Daytime	6. The proportion of accidents during weekday non-rush hours and/or weekend daytime hours is higher than average. Check if the traffic volume is already approaching capacity at these time periods while traffic speeds are relatively high. If such is the case, safety-related improvements will generally not be effective. Check for potential means of increasing capacity and improved traffic flow.

Table 5. OVERREPRESENTED CONDITIONS AND CORRESPONDING SUGGESTIONS FOR FIELD OBSERVATIONS AND IMPROVEMENTS (CONTINUED)

Overrepresented Condition	Suggested Items for Field Observations and Improvements
7. Accident Time = Evening/Night	7. The proportion of accidents during evenings and nights is higher than average. Check lighting conditions and night visibility for potential improvements, such as increased lighting level, improved delineation, raised pavement markers, etc.
8. Weather/Surface Condition = Adverse	8. Accidents under adverse weather or surface condition are overrepresented. Check pavement condition for low skid resistance and/or poor drainage.
9. Degree of Curve = Less than 4 Degrees	9. Accidents on curve sites are overrepresented. Look for any unusual situation with the curves that may contribute to accidents occurring at these curves. Check if the roadway geometrics and cross-sectional design elements, such as superelevation, at the curves can be improved. Also, check if any warning or advance warning signs are warranted for the curve sites.
10. Degree of Curve = 4 Degrees or More	10. Accidents on curve sites with high degree of curvature are overrepresented. Identify the sharp curve sites within the roadway section and look for any unusual situation with the curves that may contribute to accidents occurring at these curves. Check if the roadway geometrics and cross-sectional design elements, such as superelevation, at the curves can be improved. Also, check if any warning or advance warning signs are warranted for the curve sites.
11. Vehicle Type = Pickup Truck/Van	11. Accidents involving pickup trucks or vans are overrepresented. Check if the over-representation is simply a reflection of the exposure (i.e., higher than average percentage of pickup trucks or vans in the traffic mix) or there are specific factors causing their over-involvement.
12. Vehicle Type = Truck/Bus	12. Accidents involving trucks or buses are over-represented. Check if the overrepresentation is simply a reflection of the exposure (i.e., higher than average percentage of trucks or buses in the traffic mix) or there are specific factors causing their over-involvement.

Table 5. OVERREPRESENTED CONDITIONS AND CORRESPONDING SUGGESTIONS FOOR FIELD OBSERVATION AND IMPROVEMENTS (CONTINUED)

Overrepresented Condition	Suggested Items for Field Observations and Improvements
13. Accident Severity = Fatal or Injury	13. The proportion of fatal or injury accidents is higher than average for this roadway section. Check for possible causes of such over-representation of fatal or injury accidents. Examples of such possible causes are work zones, excessive speeding, limited sight distance, hazardous roadside conditions, etc. Identify appropriate countermeasures once the possible causes are determined.
14. Driver Age = Under 21	14. Younger drivers under 21 years of age are over-involved in accidents. Check for conditions, e.g., poor signing and delineation, that may contribute to this over-involvement of younger inexperienced drivers.
15. Driver Age = Over 55	15. Older drivers over 55 years of age are over-involved in accidents. Check for conditions, e.g., poor signing and delineation, inadequate merging or weaving areas, poor lighting condition, etc., that may contribute to this over-involvement of older drivers.
16. Speeding = Yes	16. The proportion of accidents involving excessive speeding is higher than average. Check if traffic speed is excessive during time periods shown to be overrepresented. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.
17. DWI or DW Drugs = Yes	17. The proportion of accidents involving driving under the influence of alcohol or drugs is higher than average. Check the roadway section for potential sources of alcohol or drugs. Increased level of law enforcement, such as a STEP program, may be considered. Also, check the signing and delineation for possible assistance to the impaired drivers.
18. Driver License Status = Out-of-State	18. The proportion of accidents involving out-of-State drivers is higher than average. Check the signing and delineation for possible confusion and miscues to unfamiliar drivers.

4.4 Field Test

A draft version of the MAAP program was field tested with six sites, three each from Districts 2 (Fort Worth) and 12 (Houston). The analysis was conducted by the project staff and the results presented verbally to District personnel in a manner similar to that used for the pilot test sites in the San Antonio District.

Results of the analysis as presented to the Districts are shown in Appendix A of this report. Again, the results were in summary format intended for use as notes in verbal presentations to District personnel. It should be noted that the draft version of the program did not have the tabular reporting format or suggested items for field observation and improvements. The results were summarized manually and had different formats from that of the final version of the program shown earlier.

The field test went very smoothly and demonstrated the utility of the program as an automated tool for analyzing accident characteristics of given sites. Instead of spending weeks in going through hundreds of accidents and tables to identify overrepresented conditions as was the case with the four pilot test sites in San Antonio, the analysis was completed in less than one day for the other two Districts.

4.5 Field Evaluation Study

It was originally planned that, upon successful completion of the field test, the MAAP program would be revised to incorporate potential improvements noted during the field test, including an improved reporting format for the analysis results. This improved program would then be ready for installation at any interested District(s). However, due to concerns expressed by FHWA regarding the utility of the MAAP program, the work plan was changed to include an additional field evaluation of the MAAP program.

The concern was that the District personnel are already provided with all the necessary information so that the MAAP program would be of little utility. The information currently available to the Districts is generated from the WINDOW program and includes ranking of roadway segments by total number of accidents, number of single vehicle fixed object accidents, number of wet weather accidents, and number of intersection related accidents. A cross-tabulation of selected accident variables, e.g., type of fixed object struck, by each tenth milepoint for ranked sites is also available. It was argued that this information is sufficient for analyzing accident characteristics at the high accident locations.

The project staff disagreed with this assessment, arguing that the WINDOW program output provides only information on where the high accident locations are, but no information on what are the causative factors that contributed to the high incidence of accident occurrence at these locations.

It was finally decided that the utility of the MAAP program can be best determined by the Districts. The three Districts (2, 12, and 15) that participated in the original pilot and field tests were again asked to participate in this field evaluation study to assess the utility of the MAAP program. Thirty sites, 10 from each of the three participating Districts, were selected and analyzed using the MAAP program. The results of the analysis were then provided to the Districts for their evaluation. The results of analysis for these 30 sites as provided to the Districts are shown in Appendix C of this report.

All three participating Districts found the MAAP program to be a useful tool in analyzing the accident characteristics at high accident locations. A decision was then made to continue development of the MAAP program. A number of major improvements were made to the program, including user-friendly, menu-driven screens to help unfamiliar users with use of the program, and the capability to generate supplemental reports on the accident characteristics of the evaluated sites. The improved version of the MAAP program was demonstrated to the three participating Districts through an advisory committee and installed in District 12 (Houston).

The supplemental reporting capability greatly enhances the versatility of the MAAP program. The analysis portion of the MAAP program identifies significant overrepresented conditions with suggestions for field evaluation and potential countermeasures. The supplemental reporting portion of the program allows the user to further examine and study the accident characteristics of the site under evaluation. The user can specify and generate any number of reports in the form of one-way tables, charts, graphs and two-way tables for any of the 19 accident variables and the 10 analysis variables in the analysis data file, e.g., accident time, weather condition, accident type by tenth milepoint, etc. These supplemental reports provide the user with additional information about the location under evaluation in preparation of the site inspection or in the effort to determine causative factors and appropriate countermeasures. Examples of available supplemental reports are shown in Table 6.

While the MAAP program was intended for analysis of high accident locations, District 12 has found other applications for the program in their day-to-day operation. Since the MAAP program is designed so that it can be used for any location on urban interstates and freeways by simply specifying the control section number and the beginning and ending milepoints, the District has been using the program as a means to determine accident frequencies and analyze accident characteristics for selected locations in response to inquiries from other District personnel and citizens.

TABLE 6. SUPPLEMENTAL REPORTING EXAMPLES

M A A P
SDHPT DISTRICT 2
List of Fatal Accidents

SITE	16
ACCIDENT TIME	WEEKDAY RUSH HOUR
ACCIDENT TYPE	SINGLE VEHICLE
ACC SEVERITY	FATAL/INJURY
WEATHER/SURFACE	NO ADVERSE
DEGREE OF CURVE	STRAIGHT
VEHICLE TYPE	VAN OR PICKUP
SPEEDING	SPEEDING
DWI	DWI OR DW DRUGS
DRIVER AGE	21 TO 55
DRIVER STATUS	IN STATE
DAY	WEDNESDAY
TIME	5-5:59 PM
FIRST HARMFUL	FIXED OBJECT
SEVERITY	FATAL
WEATHER	CLEAR (CLOUDY)
SURFACE	DRY
MANNER/COLLISION	SINGLE VEHICLE GOING STRAIGHT
OBJECT STRUCK	MEDIAN BARRIER DIVIDER
OTHER FACTOR	NO CODE APPLICABLE
LOC OF IMPACT	MEDIAN
POINT OF IMPACT	AREA BETWEEN MAIN LANES
VEHICLE 1 STYLE	PICKUP TRUCK
VEHICLE 2 STYLE	NO SECOND VEHICLE
CONTRIB FACTOR 1	AT LEAST ONE SPEEDING-UNSAFE
CONTRIB FACTOR 2	AT LEAST ONE DWI OR DW DRUGS
DRIVER 1 AGE	AGE 41
DRIVER 2 AGE	NO SECOND VEHICLE
DRIVER 1 STATUS	TEXAS
DRIVER 2 STATUS	NO SECOND VEHICLE
Control Section	0271-16
MILEPOINT	22.5

TABLE 6. SUPPLEMENTAL REPORTING EXAMPLES (CONTINUED).

SDHPT DISTRICT 2
DRIVER AGE TABLE YOUNG DRIVERS BY DWI

DRIVER AGE by DWI

Total Row % Column % Total %	UNKNOWN	DWI OR DW DRUGS	NO DWI/DW DRUGS	TOTAL
UNKNOWN	0 0.0 undefined 0.0	0 0.0 0.0 0.0	7 100.0 2.5 2.4	7
OVER 55	0 0.0 undefined 0.0	1 2.9 10.0 0.3	34 97.1 12.2 11.8	35
UNDER 21	0 0.0 undefined 0.0	1 2.4 10.0 0.3	40 97.6 14.3 13.8	41
21 TO 55	0 0.0 undefined 0.0	8 3.9 80.0 2.8	198 96.1 71.0 68.5	206
TOTAL	0	10	279	289

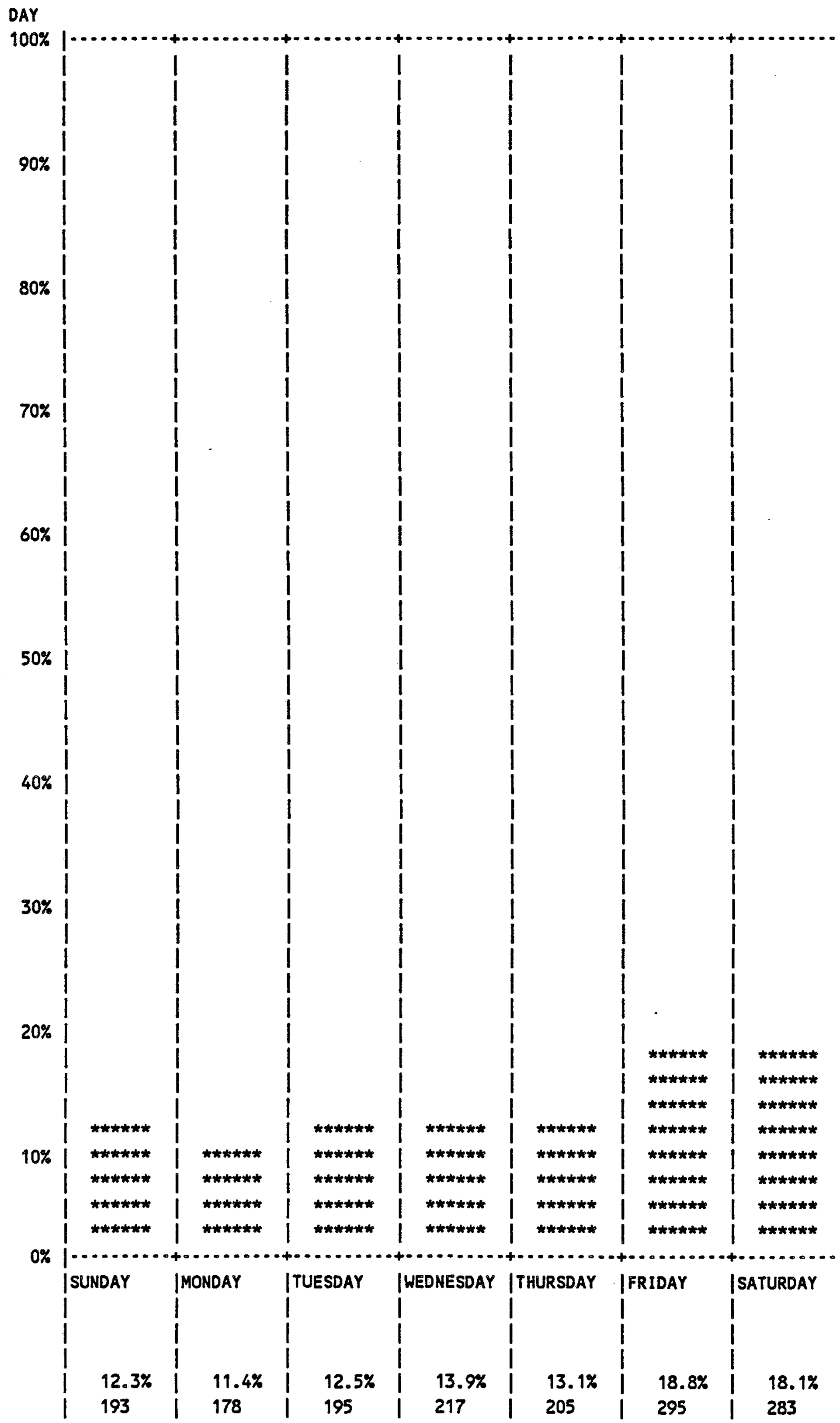
TABLE 6. SUPPLEMENTAL REPORTING EXAMPLES (CONTINUED).

```
                                              SDHPT DISTRICT 2
                                          Fatal Accidents Due to DWI

DAY
            FREQ  PERCENT
                     0%    10     20     30     40     50     60     70     80     90    100
                     |------+------+------+------+------+------+------+------+------+------|
SUNDAY          25   |
             20.7%   |****************
                     |****************
                     |
MONDAY          16   |
             13.2%   |**********
                     |**********
                     |
TUESDAY         12   |
              9.9%   |******
                     |******
                     |
WEDNESDAY       16   |
             13.2%   |**********
                     |**********
                     |
THURSDAY         8   |
              6.6%   |****
                     |****
                     |
FRIDAY          15   |
             12.4%   |*********
                     |*********
                     |
SATURDAY        29   |
             24.0%   |******************
                     |******************
                     |
TOTAL          121   |------+------+------+------+------+------+------+------+------+------|
                    0%     10     20     30     40     50     60     70     80     90    100
                                           Frequency Percent
```

TABLE 6. SUPPLEMENTAL REPORTING EXAMPLES (CONTINUED).

SDHPT DISTRICT 2
Barchart of Accidents Involving Drivers Under 21



CHAPTER V. COUNTERMEASURE IDENTIFICATION AND EVALUATION

5.1 Field Evaluation of High Accident Locations

Results from the MAAP program provide indications of accident factors and/or combinations of factors that are significantly overrepresented at the high accident location under evaluation. Some logical inferences are also made as to the potential accident causative factors and suggested items for field observation and potential improvements. The next, and perhaps the most crucial, step is to conduct a field evaluation or engineering study at the site to determine the specific accident causative factors and appropriate remedial measures, if necessary.

However, this step is also the most difficult to formulate or standardize since each site is unique in itself. Two sites with seemingly similar accident characteristics may have different causative factors or require different remedial measures. The differences could be the result of site-specific design elements, traffic conditions, land use patterns, etc., that are evident only when viewed from the field by knowledgeable and experienced personnel. It is perhaps best to only formulate an outline for this step and leave the details to the engineering knowledge and judgement of the field personnel. The emphasis of the procedure is therefore to provide the field personnel with as much information as possible to assist them in their evaluation effort.

A multidisciplinary team approach was envisioned initially for the field evaluation. The team would consist of personnel with knowledge and expertise in the areas of accident analysis and/or highway safety, highway and traffic engineering, and human factors and/or law enforcement, to provide a broad spectrum of expertise. This approach was used by the project staff in the field test of the process and found to have worked very well. However, given the current personnel situation in the Districts, the setup of a multidisciplinary team does not appear to be a practical approach.

It is perhaps more reasonable to expect that the field evaluation will be conducted by the District safety specialist and a traffic engineer or an engineering technician under the supervision of an engineer. The emphasis of the evaluation would likely be oriented toward engineering related factors and remedial measures, and less on human factors and law enforcement areas. This is to be expected since the field personnel are more familiar with engineering related measures, which are under the direct control of the Department.

On remedial measures requiring law enforcement efforts, it will be necessary to secure the cooperation of law enforcement agencies. In many of the metropolitan areas in Texas, cooperation of law enforcement agencies could be secured through the Corridor Management Team (CMT) which is comprised of representatives from SDHPT and local transportation and law enforcement agencies with the objective of fostering closer cooperation and coordination among the various agencies in the area.

The outline of the field evaluation procedure is as follows. Results of accident analysis from the MAAP program and other available information, such as as-built plans and traffic counts, are first analyzed in the office to identify potential accident causative factors and remedial measures. This narrows down the scope of the field evaluation and provides the field personnel with specific items to look out for while in the field. The team or person will then visit the site to determine if the accident causative factors and remedial measures identified are appropriate.

The field evaluation begins with driving through the site a number of times to get a better feel of the site and traffic characteristics. Each of the identified potential accident causative factors will be evaluated in light of the actual site and traffic conditions. Problem locations within the site, e.g., a particularly sharp curve, a confusing sign, a longitudinal barrier with evidence of numerous hits, etc., will be noted for more detailed study. If video recording equipment is available, it is a good idea to tape the site from the moving vehicle for future reference in the office. Some preliminary findings and conclusions will be formed in this initial step, including narrowing down the list of potential accident causative factors and corresponding remedial measures to those that are most appropriate as well as identifying specific problem locations within the site.

More detailed field study will then be conducted as necessary to verify the preliminary findings and conclusions and to examine the problem locations. This could involve simply observation of conflicts and erratic maneuvers at some specific locations in some instances. In other cases, it may involve the collection of additional data, such as skid measurements, speed data, etc. It is not possible to be any more definitive about what should be done in this step since each site is different. The only guideline is to do whatever is necessary to provide sufficient information to verify and finalize the preliminary findings and conclusions.

It is a good idea to go back to the office and review the available data one more time to make sure that the findings and conclusions are appropriate and the best possible. A video tape of the site will be most helpful for this review process. It is not unusual for changes to be made at this time. Some clues may have been overlooked in the field observation or a better remedial measure can be devised. Recommendations on the best course of action will be made and, if approved, incorporated into the overall program of the District for implementation.

As mentioned previously, it would be a futile attempt to formulate a more detailed or standardized procedure for the field evaluation since no two sites are exactly alike. The person(s) responsible for this field evaluation will have to depend on his/her engineering knowledge and judgement to determine the best course of action on a site-by-site basis. The goal of the procedure is therefore to provide the field personnel with as much information as is available in a format that is easy to understand and use, and some general and systematic guidelines on steps to be taken in the evaluation.

5.2 Countermeasure Evaluation

The process does not end with the identification of accident problems and implementation of countermeasures at a site. It is also important to evaluate the effectiveness of the implemented countermeasures. The evaluation provides feedback to the involved personnel as to whether the implemented remedial measures are performing as intended in alleviating the accident problems or if additional treatments are needed. The information will also improve the state-of-the-knowledge and expertise of the involved personnel and help them in future work of a similar nature.

The methodology for evaluating countermeasure effectiveness is fairly well established. There are a number of publications available outlining the procedure to be followed in conducting such an evaluation. A before-and-after with comparison or control type of design is typically used for the evaluation in which accident experience or another measure of effectiveness before implementing the countermeasure is compared to that after implementation. The major steps involved are as follows:

1. Select the measure of effectiveness,
2. Select the comparison or control group,
3. Collect data on the measure of effectiveness for both treatment and comparison or control group before installing the countermeasure,
4. Collect data on the measure of effectiveness for both treatment and comparison or control group after installing the countermeasure,
5. Analyze the data to determine countermeasure effectiveness.

The most direct and preferred measure of effectiveness is of course accident experience, expressed as frequency (e.g., number of accidents per mile per year), rate (e.g., number of accidents per 100 million vehicle miles of travel), or severity (e.g., percent fatal and incapacitating injuries). The problem with the use of accident as the measure of effectiveness is the sample size. The number of accidents at a given site is usually very small so that it will either take a lot of sites or a long time at a few sites before a sufficient sample size is attained for meaningful analysis. Also, it is necessary to define what constitutes an "affectable" accident. For example, the installation of guardrail will only affect single vehicle ran-off-road type of accidents and not multi-vehicle type of accidents.

It may be possible in some cases to use a surrogate measure, e.g., speed, headway, conflicts and erratic maneuvers, etc. instead of accident experience as the measure of effectiveness. The advantages of using a surrogate measure are that sample size is no longer a problem and the surrogate measure can be selected to be truly reflective of the effect of the countermeasure. The drawback is that there are no established relationships between most of the surrogate measures and accident experience. In other words, changes in a surrogate measure may or may not indicate similar changes in the accident experience.

It is important to make sure that the effects observed are really those of the countermeasure and not from other factors. Ideally, the countermeasure should be the only change made at the site during the study period and all other influencing factors are kept unchanged. Even if this is possible, it is still necessary to have some sort of comparison or control group in the evaluation to make sure that there are not other changes not controlled for during the study period which could affect the evaluation results. Some commonly used comparison or control group are sites with characteristics similar to those of the treatment site(s), or another accident type not affected by the countermeasure. The exact comparison or control group to be used depends on the specific evaluation to be conducted and data availability.

The collection of before and after data and the analysis itself are very straightforward once the evaluation is properly designed and set up. Detailed instructions and discussions are presented in such references as the "Accident Research Manual" and will not be repeated herein.

Countermeasure effectiveness evaluation may seem like a simple and routine process on the surface, but in practice it is extremely difficult to conduct an evaluation properly even under the best of conditions. It is rarely possible to control for all other influencing factors at a given site, many of which may be beyond the control of the Department. A good comparison or control group is very difficult to find in any event. There are other pitfalls such as regression-to-the-mean effect, inadequate sample size, etc. that must be avoided. In short, the proper conduct of an evaluation requires first detailed and careful planning and design of the evaluation, followed by close monitoring and control.

Given the current heavy workload of District personnel, it seems unrealistic to expect them to spend the time and resources required to conduct the countermeasure evaluations in a manner necessary to assure valid results. It is perhaps more appropriate for such evaluations to be conducted as special studies and not as a routine part of operations. This does not imply that operational personnel cannot properly conduct the evaluations, but rather a question of time and manpower availability. Also, this does not mean that the implemented countermeasures are not to be monitored, but that the evaluations would be more cursory in nature. The emphasis is not to determine precisely the effectiveness of the countermeasure, but simply to check if the countermeasure is apparently performing as designed and there are no unintended negative side effects. If the accident problem persists or worsens, a more detailed study should then be considered to check if the identified causative factors and implemented remedial measures are appropriate or if further countermeasures are warranted.

5.3 Field Test

The field evaluation methodology was field tested at the 10 test sites, including four sites in District 15 and three sites each in Districts 2 and 12. Results of the field evaluation on the individual sites are described in Appendix A of this report. Only general observations and discussions will be presented in this section.

Results from the accident analysis are found to be very helpful in directing the field evaluation and focusing the effort on specific items of interest. It usually takes about half an hour of preparation time per site in the office to review the accident analysis results and other available information in planning for the field observation. The preliminary field observation takes between one to one and a half hours depending on the number of items requiring evaluation. Of course, additional studies, such as skid measurements and speed study, will take more time and may require additional visits to the site.

As mentioned previously, it is found that no two sites are exactly alike. Two sites with seemingly identical overrepresented conditions may have totally different problems which are evident only in the field. The ability to detect the potential problem situations and accident causative factors and to devise the appropriate remedial measures is totally dependent on the experience and expertise of the field personnel. Any field evaluation procedure, no matter how specific and detailed, is no replacement for human knowledge and judgment. The programs and procedures are simply tools to make the job of the field personnel easier and less time consuming.

The fact that a site is identified as a high accident location does not necessarily mean that safety improvements are needed. At several of the sites evaluated in this study, the accidents are found to be results of operational deficiencies, such as over-capacity and congestion. No remedial measures are recommended for these sites since minor safety improvements will unlikely have any significant effect in reducing accidents at these sites. On the other hand, the safety at some of the sites could be improved through some minor improvements and are thus recommended for implementation.

Increased level of law enforcement effort in controlling speed and driving under the influence of alcohol or drugs is recommended as the remedial measure for some sites, but not actually implemented at any of the sites. The Department has no direct control over the implementation of this remedial measure and has to rely on State or local law enforcement agencies to do the work. The law enforcement agencies, especially those in large urban areas, may have different priorities in deploying their limited resources and speed control or sobriety checkpoints may not necessarily be high on their list. The best means of implementing this remedial measure is probably through programs such as STEP in which the law enforcement officers are specifically assigned to this task.

Attempts to evaluate the effectiveness of implemented countermeasures at two of the test sites have met with little success. At one site, the countermeasure was installed before the project staff had a chance to collect any before data, which precluded any meaningful evaluation for that site. At the second site, only one of three planned countermeasures was installed and evaluated before unexpected work at the site canceled the remaining two measures. It is obvious from this limited experience that extensive evaluation of installed countermeasures is not a practical requirement for the operating personnel. A cursory evaluation to make sure that there is no undesirable or negative effect due to the implemented countermeasure is perhaps the best that can be hoped for.

CHAPTER VI. FINDINGS AND RECOMMENDATIONS

6.1 Summary of Findings

A process was developed in this study to aid the District personnel in their task of: identifying high accident locations on urban Interstate highways and urban non-Interstate freeways; analyzing accident causative factors associated with these high accident sites; and determining and evaluating appropriate remedial measures at these sites. A conceptual approach was first developed, which was then revised and improved based on experience gained from field tests of 10 sites selected from three cooperating Districts.

A number of observations were made during the course of the study which significantly influenced the development of the process as presented in this report. First, in order for the process to be a useful tool to the Districts, it must be automated to the extent possible due to the current heavy workload of the District personnel. A manual process which requires considerable time on the part of the users will not often be used. The modification of the WINDOW program and the development of the MAAP program are the results of this automation effort.

The determination and evaluation of remedial measures are not amenable to automation since each site is unique in itself and must be assessed on a site-by-site basis. Thus, only general guidelines were developed to assist the District personnel in carrying out this portion of the process. In fact, it is recommended that any evaluation of the implemented countermeasures be only cursory in nature since the District personnel would not be able to devote the required time and effort to conduct a detailed evaluation. The study effort was therefore concentrated on the portions of the process that can be automated, i.e., the identification and analysis of high accident locations. In this way, the District personnel would be provided with as much information as available to assist them in determining the appropriate remedial measures for the identified accident problems without placing a lot of demand on their time and increasing the already heavy workload.

Secondly, the process should be designed for ready access and internal use by the Districts. This led to the decision of developing the MAAP program for use on a microcomputer. Even though the use of microcomputers is still not widespread in the Districts at this time, it is believed that their use will increase rapidly in the next few years and become a routine part of daily operations.

Thirdly, the process was designed to look at not only engineering-related factors at the high accident locations, but all potential countermeasures, including law enforcement efforts. However, the effort to implement any law enforcement related remedial measures at the field test sites has met with little success so far. The Department has no authority over law enforcement activities and can only pass along the information with suggestions to the law enforcement agencies for their consideration through such channels as the CMT or direct contact. It seems that the emphasis will still be with engineering-related measures and the process is thus designed accordingly.

A schematic diagram illustrating the key steps of the process is shown in Figure 1 and are summarized as follows:

1. High accident locations are identified and ranked using the modified WINDOW program. A site is defined as a two-mile segment of main lanes, excluding ramps and frontage roads. Accident rate, in terms of number of fatal and injury accidents per 100 million vehicle miles of travel (but excluding construction zone accidents), is selected as the measure to identify and rank the high accident locations. The latest three years of accident data are used in the determination of the accident rate. Specific sites of interest to the District are then selected for further analysis with the MAAP program.

2. An analysis data file is also generated from the State master accident data file by the modified WINDOW program. The program first subsets all accidents within the county that meet the criteria used with the WINDOW program, including property-damage-only accidents. The program then extracts the selected data elements from the accident data that are used in the analysis with the MAAP program and recodes the selected data elements to the 10 analysis variables. The subsetting and recoding of the data elements are necessary since storage space is limited on a microcomputer. The analysis data file is then transferred to the microcomputer for use in analyzing the accident characteristics of selected high accident locations.

3. Each selected site is then analyzed with the MAAP program to identify accident characteristics (factors) and/or combinations of factors that are overrepresented at that site relative to the countywide average. The MAAP program outputs a list of these overrepresented conditions in a tabular format, together with suggested items for field observation and potential improvements. Supplemental reports can also be generated to further examine and evaluate the accident characteristics of the site under evaluation.

   It should be noted that the MAAP program has the option for adjusting the location of the site to be analyzed. This allows for changes in the beginning and ending milepoints of the site if necessary to coincide with identifiable landmarks, e.g., interchange, bridge, etc. In fact, the program can be used to analyze any site in the county for that highway type regardless of whether it is a high accident location by entering the control section number and beginning and ending milepoints of the location. This provides the Districts with the flexibility to look at any site of interest as the need arises.

4. Results of the accident analysis and supplemental reporting from the MAAP program and other available information, such as as-built plans and traffic counts, are first analyzed in the office to identify potential accident causative factors and remedial measures. This narrows down the scope of the field evaluation and provides the field personnel with specific items to look for while at the site.

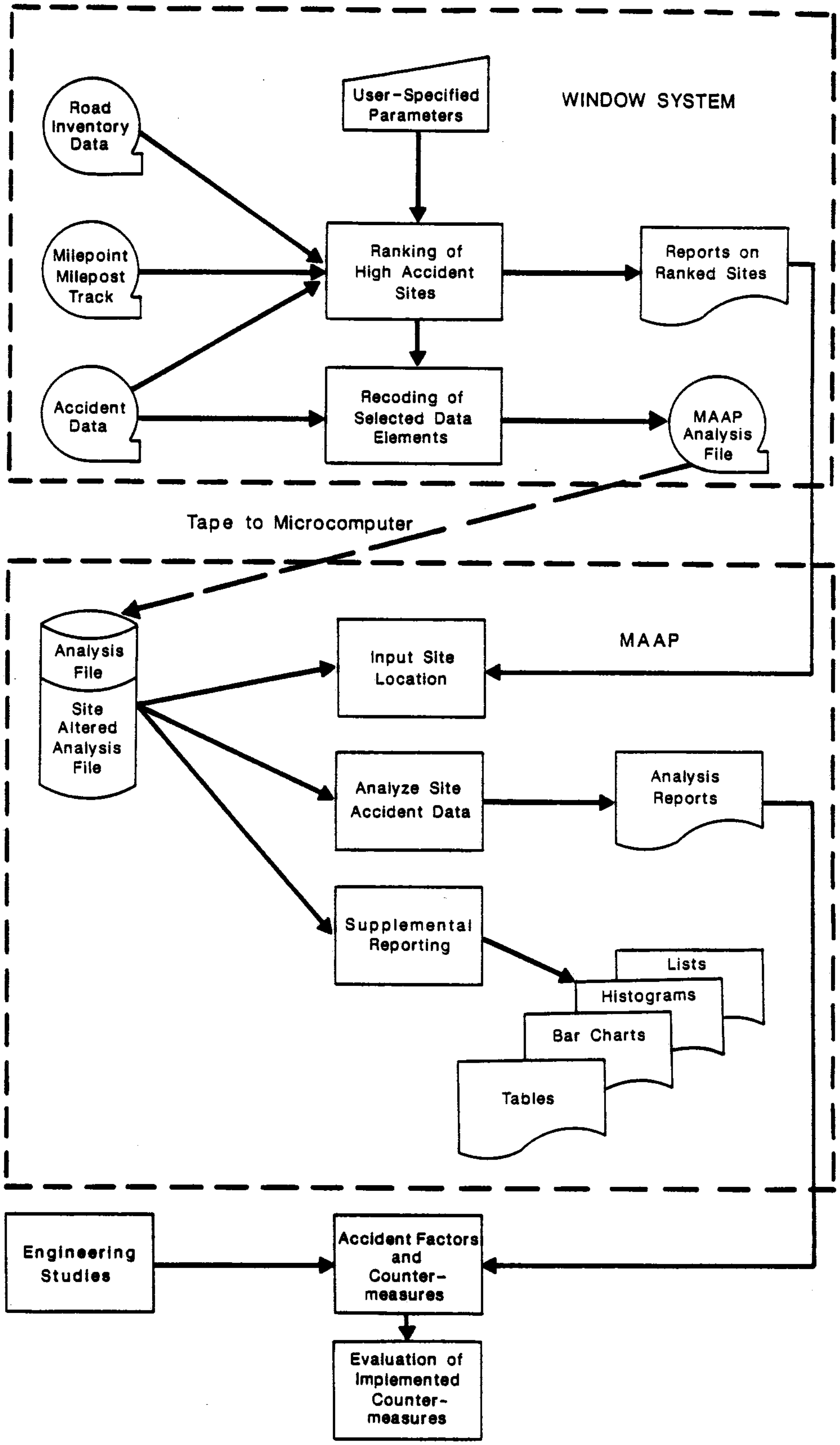


Figure 1. Schematic Diagram Illustrating Key Steps for the Process

The site is then visited by field personnel to determine if the accident causative factors and remedial measures identified are appropriate. The field evaluation begins with driving through the site a number of times to become familiar with the site and traffic characteristics. Each identified potential accident causative factors will then be evaluated in light of the site and traffic conditions. Problem locations within the sites will be noted for more detailed study. Videotaping of the site is recommended for future reference in the office. Some preliminary findings and conclusions will be formed and verified with more detailed study if necessary. Additional data will be collected as appropriate.

The preliminary findings and conclusions will be reviewed again in the office, using the available information and the videotape, to make sure that the findings and conclusions are appropriate and the best possible. Recommendation on the best course of action will then be made and implemented if approved.

5. The performance of the installed countermeasures will be monitored to check if the countermeasure is performing as intended and there is no unintended negative side effects. As mentioned previously, it is expected that the evaluations will be cursory in nature unless time and manpower resources are made available to conduct a more detailed study. However, if the accident problem appears to persist or even worsen, a more detailed study should be considered to identify the potential causes and additional remedial measures.

6.2 Recommendations

The process developed in this study shows promise as a useful tool for the Districts in identifying and evaluating high accident locations (or any location of interest) on urban Interstate highways and non-Interstate freeways. Some limited field tests of the process were conducted as part of the study and the results are very encouraging. However, unforeseen problems and/or needed improvements may be identified as the process is implemented in one or more Districts. Further refinements or improvement to the process may be needed as more experience is gained from actual implementation.

One suggestion by personnel from the participating Districts is to extend this process to other highway types. The Interstate highways and freeways in most urban areas are currently undergoing a major reconstruction program to meet the ever increasing traffic demand. The application of this process, which is aimed at minor safety improvements, would be rather limited in the near future. Furthermore, current funding for safety improvements is directed at on-system non-freeway facilities. The utility of this process to the Districts would be greatly enhanced if it is applicable to all highway types. It would be a relatively minor effort to extend this process to on-system non-freeway facilities. The basic methodology would remain the same. The only new addition would be a means to analyze intersection type of accidents which are practically nonexistent for freeway facilities.

APPENDIX A

SUMMARY OF ACCIDENT ANALYSIS RESULTS ON PILOT AND FIELD TEST SITES

APPENDIX A

SUMMARY OF ACCIDENT ANALYSIS RESULTS ON PILOT AND FIELD TEST SITES

After a conceptual framework for the process of identifying and evaluating high accident locations on urban Interstate highways and urban non-Interstate freeways was developed, the process was pilot tested with four selected sites in District 15 (San Antonio), followed by further field testing with three sites each from Districts 2 (Fort Worth) and 12 (Houston).

The pilot test with District 15 covered the entire process, including: identification of high accident locations with the WINDOW program; analysis of overrepresented accident characteristics of the four selected sites; field observation and evaluation of the selected sites for accident causative factors and potential remedial measures; and evaluation of implemented countermeasures. As a result of the pilot test, the process of identifying high accident locations was established with a modified version of the WINDOW program and the MAAP program to automatically analyze the accident characteristics of a given site for overrepresented conditions was developed. Thus, for the field tests with Districts 2 and 12, the evaluation actually started with the outputs from the MAAP program and proceeded through the field evaluation and the identification and evaluation of implemented countermeasures.

This appendix presents a summary of the evaluation results on the 10 pilot and field test sites. The following information is provided on each site: (1) results of accident analysis; (2) summary of field observations; and (3) recommended actions.

PILOT TEST SITES

District 15 (San Antonio)

Bexar County

SITE 1

IH 410, from Jones Maltsberger Road to Nacogdoches Road
Control Section 521-4, Milepoints 21.3 to 23.5

Significantly Overrepresented Conditions:

- Multi-vehicle accidents during weekday afternoon rush hours (35.6%) are overrepresented, particularly during the month of June and on Tuesdays and Fridays from 5:00 to 6:00 p.m.

- Male drivers under 21 and female drivers over 55 are overrepresented.

- The milepoints with high accident frequency are 21.4 - 21.5 (Jones Maltsberger Road), 21.8 (Airport Boulevard), 22.3 - 22.4 (Wetmore Road), 22.6 (Broadway), 23.1, and 23.4 (Nacogdoches). These milepoints correspond with either entrance or exit ramps.

Summary of Field Observations and Possible Countermeasures:

- The overrepresentation of accidents during rush hours is apparently the result of traffic congestion and over-capacity. This section of highway carries about 150,000 ADT and has bumper-to-bumper traffic during rush hours. The interchanges are very closely spaced with heavy entering and exiting traffic. There are no readily available low-cost countermeasures short of increasing the capacity of the highway. Relocation of ramps and braided ramps to increase the length of weaving and merging areas may reduce traffic conflicts and accidents.

- One observation is that some drivers are not making use of the exclusive exit ramp at the westbound McCollough exit. This may be attributed to the difference in pavement surface color between the main lanes and the exclusive exit lane, which was converted from the shoulder. Resurfacing to make the pavement color of the exit lane the same as the main lanes and the use of double-wide edge markings may encourage drivers to make better use of the exclusive exit lane.

Recommended and/or Implemented Countermeasures:

None.

SITE 2
IH 37, from Florida Street to IH 35 Interchange
Control Section 73-8, Milepoints 9.9 to 12.3

Significantly Overrepresented Conditions:

- Over half (54.8%) of the accidents occurred under adverse weather/surface condition.
- Overrepresented on single-vehicle accidents involving longitudinal barriers (30.5%) and on curves.
- Accidents are overrepresented during the month of April.
- Unsafe speed is cited in 21.9% of the accidents.
- High accident milepoints are 9.9-10.0 (multi-vehicle accidents), 11.6 (multi-vehicle accidents), and 12.0-12.3 (single vehicle accidents).
- For accidents under adverse weather/surface condition, the following accident types are overrepresented:

  Multi-vehicle sideswipe and single vehicle - barrier during hours of darkness
  Multi-vehicle rear-end accidents at curves
  Accidents involving pickup trucks and vans.

Summary of Field Observations and Possible Countermeasures:

- The high percentage of accidents under adverse weather/surface condition suggests that some improvement in the skid characteristics of the pavement surface may be desirable. It was noted during the field visit that this highway section had been resurfaced.
- This highway section is mostly on elevated structures with curved alignment. The overrepresentation of single vehicle accidents on curves involving longitudinal barriers is therefore a reflection of increased exposure for this type of accident due to the specific site condition.
- The overrepresentation of accidents in the month of April is due to the Fiesta celebration during that month. The Fiesta celebration is a major attraction, drawing heavy traffic and crowds to the downtown area. This overrepresentation is again a reflection of increased exposure.
- It may be desirable to check if nighttime visibility can be improved at this site, e.g., increased lighting level, raised pavement markers, post-mounted delineators, etc.

- One observation is that traffic from IH 35 South to IH 37 South has a left-hand entrance and vehicles have to cross four lanes of traffic in order to exit at the Nolan interchange. This creates some undesirable merging and weaving conditions. However, there are no apparent countermeasures to this problem short of closing the Nolan exit.

Recommended and/or Implemented Countermeasures:

The only recommended countermeasure would have been to resurface the section for better skid resistance. However, this problem was also recognized by the Department and the section was resurfaced in an action unrelated to this study.

SITE 3

US 281, from Hildebrand to IH 35 Interchange
Control Section 73-8, Milepoints 23.8 to 26.1

Significantly Overrepresented Conditions:

- Accidents under adverse weather/surface condition are overrepresented (39.0%).
- Single vehicle - longitudinal barrier accidents (33.5%) and multi-vehicle sideswipe accidents are overrepresented during hours of darkness.
- Nearly half of the accidents occurred on the two curves at milepoints 23.9 - 24.0 (Hildebrand interchange, multi-vehicle sideswipe and single vehicle rollover accidents) and 25.6 - 26.1 (IH 35 interchange, multi-vehicle sideswipe and rear-end and single vehicle - longitudinal barrier accidents).
- For accidents under adverse weather/surface condition, the following factors are overrepresented:

  Single vehicle - longitudinal barrier accidents under darkness
  Drivers over 55.

Summary of Field Observations and Possible Countermeasures:

- In an effort to minimize impacts to the environment, this section of US 281 was constructed to a design speed lower than the adjoining sections with numerous sharp curves. The speed limit for this highway section is correspondingly lowered to 50 mph.

  Of particular concern is the curve southbound at the Hildebrand interchange. This is a compound curve with a curvature of 8 degrees for the central portion, which is a very sharp curve by freeway standards. The problem is further aggravated by the following factors:

  1. The speed of traffic entering this curve is too high for the condition, despite the reduced speed limit. This excessive speeding is caused by several factors. First, the roadway alignment has been relatively gentle up to this curve. Second, there is a 3 to 4 percent downgrade leading into the curve. Third, the sharpness of the curve is not evident to the approaching drivers since they cannot see the central portion of the compound curve from the approach.
  2. Since the central portion of the curve is not evident from the approach, it is observed that some of the approaching drivers have positioned their vehicles for the outer portion of the compound

curve. When they recognize the sharper central portion, the vehicles are not in the proper position and their speed is too high to negotiate the central portion of the curve properly.

3. The shoulder width gradually narrows down in the curve, thus reducing the available recovery area.

- The pavement surface is relatively worn and polished. Check the skid resistance of the pavement surface.

- Check for possible improvements in nighttime visibility, e.g., increased lighting level, raised pavement markers, post-mounted delineators, etc.

Recommended and/or Implemented Countermeasures:

It is the opinion of the project staff that the most effective approach is to reduce the traffic speed prior to entering the curve. A number of potential countermeasures were considered, such as speed actuated flashing yellow beacons for advance warning; rumble bars with transverse striping effect, lane narrowing at the approach to provide a tunneling effect, and increased enforcement of speed limit. After considerable discussions with the District personnel, the following series of countermeasures were recommended:

1. An overhead curve warning sign showing the speed limit of 50 mph with flashing beacons at the beginning of the curve, supplemented by an advance warning sign 1,000 feet prior to the curve.

2. A series of transverse stripes with logarithmic decreasing spacing to give the drivers an illusion that they are speeding up.

3. Supplement the transverse stripes with three-foot wide thin (3/8") overlays to provide kinesthetic (i.e., noise and vibration) input to the drivers.

The first countermeasure was implemented and evaluated, but the two subsequent measures were canceled due to unscheduled grooving and resurfacing of the section.

SITE 4

US 90, from IH 410 Interchange to Military Road
Control Section 24-8, Milepoints 0.5 to 2.2

Significantly Overrepresented Conditions:

- DWI (19.5%) and DUI drugs (2.4%) are highly overrepresented, especially for injury accidents (26.7% DWI and 6.7% DUI drugs).

- Accidents are mostly under darkness (63.5%), and single vehicle accidents (42.3%) and drivers under 21 (27.6%) are overrepresented.

- High accident milepoints are 0.7 - 0.8 (IH 410 Interchange), 1.2 - 1.5, and 2.1 (Military Road).

- For accidents involving DWI or DUI drugs:

  Month - February and December overrepresented
  Day of week - Thursdays overrepresented, Saturdays are also high
  Time of day - 7:00 - 8:00 p.m. overrepresented, 11:00 p.m. to midnight and 1:00 - 2:00 a.m. are also high
  Male drivers under 21 are overrepresented.

Summary of Field Observations and Possible Countermeasures:

- This section of roadway is straight and level with clear roadside. The traffic volume is very low with widely spaced interchanges. No unusual characteristics were observed in the field visit.

- Due to the proximity to a major military base, it is suspected that many of the drivers involved in the accidents (male drivers under 21 years of age) are related to the military base. The time patterns are rather unusual, suggesting that there may be some functions scheduled during these periods.

- This seems to be a good candidate for Selective Traffic Enforcement Program (STEP) and sobriety check points. Also, check for nearby bars and clubs where drinking takes place to see if any corrective action is possible.

Recommended and/or Implemented Countermeasures:

Increased law enforcement level through such program as STEP is recommended, but not implemented since the San Antonio Police Department does not participate in the STEP program.

FIELD TEST SITES

District 2 (Fort Worth)

Tarrant County

SITE 1 (Rank 8, Interstate)

IH 35W, from 0.3 mile east of Pharr St. to 0.4 mile east of SH 183
Control Section 14-16, Milepoints 8.4 to 10.4

Significantly Overrepresented Conditions:

- Accidents at curve sites (less than 2 degrees) under adverse weather/ surface condition and involving out-of-State drivers are overrepresented. This suggests potential problems with skid resistance and/or drainage at curve sites. Also, there is indication that there may be some confusion to unfamiliar drivers.

- The milepoints with the highest accident frequency are 8.5 and 10.0 (SH 183 interchange).

Summary of Field Observations and Possible Countermeasures:

- No significant factors are noted on curvature or pavement surface condition. The curves are relatively gentle. The pavement surface is worn and polished, but does not appear to be slick. A skid test of the pavement surface would be helpful as a check. The signing is adequate for the roadway geometrics. However, there are two potential problem spots which coincide with the two high accident milepoints.

- The northbound exit at SH 183 West is accompanied by a lane drop. The lane is signed and marked as exit-only lane and a tapered recovery area is provided beyond the gore area. However, since no delineation is evident for the recovery area (or too worn to be noticed) and the roadway curves to the right at that point, unfamiliar or inattentive drivers may not have perceived this as a lane drop and would proceed into the recovery area as if it were a through lane. This could result in a hazardous situation since the drivers would have to merge into the through lanes in a relatively short distance. Delineation with jiggle bars could alleviate this potentially hazardous situation and is thus recommended.

- At one southbound curve location where a lane is added, the concrete pavement form line diverges from the lane line. Under adverse weather/ surface condition, the lane delineation is difficult to see while the form line is clearly evident. This could mislead drivers into following the form line and encroaching the adjacent lane, thus creating a potentially hazardous situation. This condition could be minimized with the use of raised pavement markers or delineators and is recommended.

Recommended and/or Implemented Countermeasures:

Improved delineation treatments at the two problem locations discussed above were recommended for consideration.

SITE 2 (Rank 4, Non-Interstate Freeway)

SH 199, from Loop 344 to Scotland Avenue
Control Section 171-04, Milepoints 0.8 to 3.3

Significantly Overrepresented Conditions:

- Multi-vehicle angle or opposite direction accidents are overrepresented, involving drivers of ages under 21 or over 55. The high incidence of this accident type suggests the presence of at-grade intersections, which is not consistent with the classification of freeway.
- Single-vehicle accidents involving roadside fixed objects are overrepresented for drivers under 21 years of age.
- The milepoints with the highest accident frequency are 1.5, 2.4, and 3.2.

Summary of Field Observations and Possible Countermeasures:

- As indicated by the accident analysis, there are several at-grade intersections within the section, roughly corresponding to the milepoints with the highest accident frequency. This explains the predominance of multi-vehicle angle and opposite direction accidents.
- At some locations within the section, guardrails are placed very close to the roadway edge. The presence of these guardrails is obscured by the overgrown vegetation at the time of field evaluation. These guardrails could possibly be relocated to increase the clear recovery area which in turn may reduce the number of single vehicle fixed object type of accidents.

Recommended and/or Implemented Countermeasures:

No specific recommendation was made since this site is not a freeway site and does not meet the study criteria. The recommendation would be the potential relocation of some guardrails to increase the clear recovery area.

SITE 3 (Rank 10, Non-Interstate Freeway)

SH 121, from Carson Road to Beach Street
Control Section 363-03, Milepoints 4.3 to 6.3

Significantly Overrepresented Conditions:

- The only significantly overrepresented condition is drivers cited for DWI or DUI drugs.
- The accidents are fairly evenly distributed over the entire section.

Summary of Field Observations and Possible Countermeasures:

- No deficiency in roadway or operational characteristics noted. Also, there are no apparent sources for alcohol or drugs along the section. The only suggestion would be increased level of law enforcement through the STEP program.

Recommended and/or Implemented Countermeasures:

Increased level of law enforcement through the STEP program is suggested.

FIELD TEST SITES

District 12 (Houston)

Harris County

SITE 1 (Rank 18, Interstate)

IH 610, from Richmond Road to Memorial Drive
Control Section 271-17, Milepoints 34.2 to 37.2

Significantly Overrepresented Conditions:

- Multi-vehicle sideswipe and rear-end accidents are overrepresented, but with low severity, i.e., high percentage of property-damage-only accidents. The accidents occurred during daylight hours and under no adverse condition.

- Accidents involving speeding are overrepresented as well as drivers under 21 years of age.

Summary of Field Observations and Possible Countermeasures:

- No deficiency is noted in the roadway or geometric characteristics. The traffic volume is extremely high (ADT of over 200,000 vehicles). The overrepresentation of low severity sideswipe and rear-end types of accidents are generally indicative of an over-capacity problem and are not affected by minor safety improvements.

- The operating speed of the traffic is very high, considering the heavy traffic volume.

Recommended and/or Implemented Countermeasures:

None. The only potential countermeasure is to increase the level of law enforcement to reduce excessive traffic speed.

SITE 2 (Rank 16, Non-Interstate Freeway)

SH 225, from Goodyear Plant Entrance Road to Richey Street
Control Section 502-1, Milepoints 1.2 to 3.2

Significantly Overrepresented Conditions:

- Multi-vehicle sideswipe accidents are overrepresented during weekday rush hours and during evening and night on curves with less than 2 degrees.
- Single vehicle fixed-object accidents are overrepresented during evenings and nights, resulting in higher than average proportion of injuries and fatalities on curves of greater than 2 degrees.
- Excessive speeding is overrepresented as are drivers under 21 years of age.
- The milepoints with the highest accident frequency are 1.5 to 1.7, and 2.6.

Summary of Field Observations and Possible Countermeasures:

- Entrance and exit ramps for access to the Goodyear plant are relatively short which could account for some of the sideswipe accidents observed. This problem may be partially alleviated by providing exclusive entrance and exit lanes to the ramps.
- A large portion of the section is on elevated structures and numerous hits on the median barrier and guardrails are noted. This increased exposure may account for the overrepresentation of such accidents.
- At one eastbound location where the roadway curves sharply to the left, the approaching drivers' attention may be distracted or confused by two tall power transmission towers directly in their line of vision as they enter the curve, particularly during hours of darkness. An advance curve warning sign and chevron panels mounted on the bridge rail or posts at the outside of the curve may be helpful to better delineate the curve.

Recommended and/or Implemented Countermeasures:

The installation of advance curve warning sign and chevron panels at the curve site and the lengthening of entrance and exit lanes were recommended. The District implemented the countermeasure at the curve location and will monitor the accident experience before considering the other recommended countermeasure.

SITE 3 (Rank 21, Non-Interstate Freeway)

US 290, from Antonie Street to 18th Street
Control Section 50-9, Milepoints 36.0 to 38.0

Significantly Overrepresented Conditions:

- Accidents are overrepresented during weekday rush hours and evenings and nights. Excessive speeding is also overrepresented.

- The milepoints with the highest accident frequency are 37.5, 37.7, and 37.9.

Summary of Field Observations and Possible Countermeasures:

- No deficiency was noted on any roadway or geometric characteristics. There are a couple of interesting observations. First, on one section of the roadway where a concrete glare screen was installed on top of the concrete median barrier, there were numerous tire marks on the barrier. However, single vehicle accidents involving longitudinal barriers were not overrepresented and there are no apparent causes for such impacts. At the Antonie Street entrance ramp, traffic is required to merge more than one lane due to a lane drop shortly beyond the end of the entrance ramp.

Recommended and/or Implemented Countermeasures:

None.

APPENDIX B

STATISTICAL ALGORITHM USED IN THE MICROCOMPUTER ACCIDENT ANALYSIS PROGRAM

APPENDIX B

STATISTICAL ALGORITHM USED IN THE MICROCOMPUTER ACCIDENT ANALYSIS PROGRAM

The Microcomputer Accident Analysis Program (MAAP) is designed to provide the users with a tool to identify, from computerized accident data, characteristics (factors) of accidents and their interactions that are significantly overrepresented at the high accident location under evaluation in comparison to some "average". Full documentation of the MAAP program is provided in the user manual in Volume II of the final report and in the programmer manual available from D-18STO. Description of the statistical algorithm used with the MAAP program is presented in this appendix.

The accident analysis methodology is based on the simple concept of overrepresentation. It is first assumed that certain accident characteristics (factors) and/or combinations of factors are overrepresented at a high accident location when compared to the average of similar highway type within the same study area. For the purpose of this study, the highway type is either urban Interstate highway or urban non-Interstate freeway. The study area is defined as the county within which the high accident location is situated. Note that a different baseline of comparison can be used if deemed necessary. It is further assumed that these overrepresented accident factors and/or combinations of factors are indicative of accident causative factors at the high accident location.

The algorithm is based on the principles of discrete multivariate analysis and is capable of simultaneously analyzing a number of potential variables. In this way, both the effects of individual variables and the interactions of these variables with one another can be systematically evaluated. Also, effects due to confounding variables, which may jeopardize the results, can be minimized or avoided.

A two-staged algorithm is used: (1) variable selection, and (2) modeling. The first stage, variable selection, identifies those variables that are significantly overrepresented at the high accident site. These significant variables will then be analyzed in the second stage, modeling, while the nonsignificant variables are eliminated from further consideration. This intermediate step is required because the number of variables that can be simultaneously analyzed in the modeling stage is restricted by the number of accidents at a given site, which is not likely to be very large for a two-mile segment over the period of three years. It is therefore desirable to first narrow down the list of 10 potential variables to only those with significant influence on accident overrepresentation at the high accident site.

Variable Selection

The variable selection algorithm is a sequential procedure based on two measures of statistical association used in contingency table analyses: Q_T and Q_{CMH} (1). In each step of the process, the most significant independent variable is selected after examining the effects of all (unselected) variables on accident overrepresentation at a site. The dependent variable is site versus average. The null hypothesis associated with the tests of Q_T and Q_{CMH} can be stated as follows (1):

H_0: For each level of the independent variables, the accidents are distributed at random between the site and the countywide average for all levels of the covariables.

The 10 analysis variables, as shown in Table B-1, are categorized as either "primary" or "secondary" variables. The primary variables (1 through 5) are considered to be more important since they are directly applicable to the development of engineering related countermeasures. The secondary variables (6 through 10) contain mostly driver related factors and are useful for law enforcement related countermeasures. The algorithm favors the primary variables in that they are selected prior to the secondary variables.

A step-by-step description of the variable selection process is presented as follows:

1. Each of the primary variables is cross-classified with the dependent variable (i.e., site vs. average) to form a two-way contingency table with accident frequency (i.e., counts) as entries in the cells. Pearson chi-square statistics are calculated for each of these tables. The variable with the highest value of chi-square per degree of freedom (i.e., smallest p-value or highest level of significance) is selected in this initial step.

2. For each of the primary variables not yet selected, a three-way contingency table is formed among this variable, the dependent variable, and the variable previously selected in step (1). The statistic, Q_T, is then calculated which reflects both the main effect of this variable and its interaction with the previously selected variable. The variable with the highest Q_T value per degree of freedom is then selected as the second variable. Also, variables with nonsignificant Q_T values are eliminated from further analysis.

   In this context, the Q_T statistic expresses the extent of "total association" of the variable with the dependent variable, having accounted for the previously selected variable. The equation for calculating Q_T is as follows (1):

$$Q_T = \sum_{h=1}^{q} \underset{\sim}{G}_h' \left[\underset{\sim}{Var} \left(\underset{\sim}{G}_h \mid H_0 \right) \right]^{-1} \underset{\sim}{G}_h \qquad (1)$$

where h = 1, 2, ... , q, levels of the previously selected variable(s),

$\underset{\sim}{G}_h$ = a matrix of the differences between observed and expected frequencies under H_0,

$\underset{\sim}{G}_h'$ = a transposed matrix of $\underset{\sim}{G}_h$.

TABLE B-1. LIST OF PRIMARY AND SECONDARY VARIABLES

Variable	Level: Selection	Level: Modeling
PRIMARY VARIABLES		
Accident Time	Weekday, Rush Hour Weekday, Non-Rush Hour or Weekend, Daytime Evening/Night	Same
Accident Type	Single Vehicle MV: Rear-End MV: Sideswipe MV: Head-On/Angle	Single Vehicle MV: Rear-End MV: Sideswipe MV: Head-On/Angle
Weather/Surface Condition	Adverse Not Adverse	Same
Degree of Curve	Straight Curve	Straight < 4 Degrees >= 4 degrees
Vehicle Type	Passenger Car Pickup Truck/Van Truck/Bus	Same
SECONDARY VARIABLES		
Accident Severity	Fatal/Injury PDO	Same
DWI or DW Drugs	Yes No	Same
Speeding	Yes No	Same
Driver Age	Under 21 21 to 55 Over 55	Same
Driver License Status	Out of State In State	Same

The degrees of freedom for Q_T is q(s-1)(r-1), where s and r are the levels of the independent variable under evaluation and the dependent variable, respectively.

3. The process in step (2) is repeated for the remaining primary variables, with the addition of one more selected variable at each step. The process will continue until all primary variables have been either selected or eliminated, or until the data become sparse.

   It is commonly found that, after the first few steps of the variable selection process, the cell frequencies may have thinned out so much that the sample size for a large number of cells in the contingency table becomes too sparse for proper analysis.

   In this situation, Q_{CMH} is used instead of Q_T as the selection statistic since Q_{CMH} is not as sensitive to small cell sample size as is Q_T, and its test of significance is based on (s-1)(r-1) degrees of freedom instead of q(s-1)(r-1). The Q_{CMH} statistic is capable of capturing weak but consistent effect of a variable although it does not reflect the "total contribution" which includes interactions with other variables as does Q_T (2). The equation for Q_{CMH} is as follows (1):

$$Q_{CMH} = \underset{\sim}{G}' \left[\underset{\sim}{Var} \, (\underset{\sim}{G} \mid H_0)\right]^{-1} \underset{\sim}{G} \qquad (2)$$

   where $\underset{\sim}{G} = \sum_{h=1}^{q} \underset{\sim}{G}_h$

   The variable selected is the one with the highest Q_{CMH} value per degree of freedom.

   The process will stop when the data become too sparse even for the Q_{CMH} statistic. At this point, the last entered significant primary variable is dropped and the process as described in step (2) is repeated with each of the sparse variables. If the Q_T or Q_{CMH} statistic is significant, the sparse variable will be included in the modeling process. If the Q_T or Q_{CMH} statistic is not significant or if the data remain sparse, the variable will be dropped from further analysis.

4. After all primary variables have been evaluated, the variable selection process is continued for the secondary variables. Again, the process described in steps (2) and (3) are repeated until all the secondary variables are either selected or eliminated, including the sparse variables. Only variables found to be significant or sparse but significant will be evaluated in the modeling process.

Note that the levels within the variables may vary between the variable selection process, the modeling process, and the program output, as shown in Table B-1. The levels for some of the variables are condensed in the variable selection process in an attempt to minimize the number of potential combinations, which in turn may reduce the number of sparse variables. As for the program output, the levels for most of the variables are condensed to make the output easier to read and understand.

Modeling

The purpose of the modeling process is to identify and to isolate combinations of levels within the significant variables that contribute to accident overrepresentation at the high accident location, relative to the average. The model estimation technique also quantifies the magnitude of their overrepresentation. A step-by-step description of the modeling algorithm is presented as follows:

1. A contingency table on accident frequency for the county is created including all the significant primary and secondary variables previously identified, but excluding sparse variables that are significant. The cell probabilities for all the cells in the contingency table are then computed. There are a number of ways that these cell probabilities can be obtained (1). The method chosen for this microcomputer program is as follows.

   For illustration purposes, assume that three significant variables are selected in the variable selection process. For the $(i,j,k)^{th}$ cell, the cell probability, P_{ijk}, is determined by dividing the accident count in the cell (Y_{ijk}) by the overall total ($\sum_{ijk} Y_{ijk}$), i.e.,

$$P_{ijk} = Y_{ijk} / \sum_{ijk} Y_{ijk} \qquad (3)$$

   The subscripts i, j, and k denote the levels of the three selected significant variables.

2. A contingency table of expected accident frequency, E_{ijk}, of the site under evaluation is then computed based on the average cell probabilities for the county. This contingency table is cross-classified by the same variables as those for the county under step (1). The equation for determining the expected cell counts is as follows:

$$E_{ijk} = N \times P_{ijk} \qquad (4)$$

   where N is the total number of accidents for the high accident site under evaluation.

3. The actual or observed accident frequency for each cell of the site contingency table, X_{ijk}, is compared to the expected accident frequency for that cell, E_{ijk}, determined under step (2). The Freeman-Tukey deviate (3), Z_{ijk}, is used as the overrepresentation indicator, which is then calculated for all the cells of the contingency table:

$$Z_{ijk} = \sqrt{X_{ijk}} + \sqrt{X_{ijk} + 1} - \sqrt{4E_{ijk} + 1} \qquad (5)$$

The overrepresentation indicator, Z_{ijk}, reflects the extent to which the actual or observed number of accidents in any one cell of the site contingency table differs from the expected number of accidents in the cell, if the site is no different from the countywide average. A large positive value of Z_{ijk} indicates that the observed number of accidents at the site is higher than expected for that cell, which is therefore overrepresented. A negative value of Z_{ijk} indicates that the number of accidents observed at the site for that cell is less than expected. When the observed and expected number of accidents are similar, Z_{ijk} will be a small positive number less than 1.

One useful property of this indicator is that its magnitude is a function of both: (a) the extent to which the observed accident frequency differs from the expected frequency, and (b) the cell sample size. In other words, a larger value of either (a) or (b) will result in a larger positive Z_{ijk}. Thus, a cell with higher accident counts will display a higher overrepresentation ranking indicator than a cell with lower accident counts even if both may have identical percent differences between observed and expected accident frequencies.

Cells with residuals, Z_{ijk}, greater than +1.5 are considered to be significantly overrepresented, i.e., the observed accident count is significantly higher than the expected frequency based on the countywide average. The value of +1.5 is chosen arbitrarily and can be changed as appropriate.

4. This modeling process, as described in steps (1) through (3), is then repeated for each of those variables that are sparse but significant. Recall that these sparse variables are tested without the last entered significant variable. Thus, the last entered significant variable is also excluded in the modeling process for the sparse variables.

Sample Illustration

The analysis carried out for one of the 10 field test sites is shown in this section to illustrate the algorithm used in the MAAP program. This sample site is a 2.4-mile segment in San Antonio, Texas. It is a six-lane urban freeway with full access control. There were 254 accidents reported in this segment for the three-year period from 1980 to 1982. The comparison used for this site is the countywide average for all accidents on urban non-Interstate freeways in Bexar County.

The results of the variable selection process are presented below in a step-by-step fashion, similar to the steps previously described in the variable selection process.

1. Table B-2 shows the values of the Pearson Chi-square, χ_p^2, obtained for the five primary variables evaluated: accident type, accident time, weather/surface condition, degree of curve, and vehicle type. The variable "degree of curve" has the largest Chi-square per degree of freedom and is selected in this initial step.

2. Table B-3 shows the values of Q_T for the four primary variables not selected in Step (1). The variable, weather/surface condition, has the

Table B2

Result of Variable Selection: Step 1

Independent Variable	X_p^2	D.F.	p-value
degree of curvature	228.0	1	0
weather/surface condition	31.2	1	0
accident time	8.8	2	0.012
accident type	14.0	2	0.001
vehicle type	1.6	2	0.437

Table B3

Result of Variable Selection: Step 2

Variable	QT	D.F.	p-value
curvature x surface condition	25.5	2	0
curvature x accident time	17.9	4	0.001
curvature x accident type	12.7	4	0.013
curvature x vehicle type	1.3	4	0.856*

* Eliminated

largest Q_T per degree of freedom and is selected as the second variable. The variable "vehicle type" has a nonsignificant Q_T value and is eliminated from further analysis.

3. Table B-4 shows the values of Q_T for the two remaining primary variables not yet selected or eliminated. Q_{CMH} values are also computed for these variables. Although the Q_T values for these variables are not highly significant, the Q_{CMH} value for the variable "accident time" is. This indicates that the variable "accident time" has consistent main effect on accident overrepresentation at the site. This variable is thus selected.

   The only remaining unselected variable is "accident type". A cross-classification of accident frequency by degree of curve, weather/surface condition, accident time, and accident type results in 32 percent of the cells having fewer than 4 accidents. The variable "accident type" is therefore considered as a sparse variable. The last entered significant variable "accident time" is dropped and the analysis repeated with the variables degree of curve, weather/surface condition, and accident type. The Q_{CMH} value for the variable "accident type" , as shown previously in Table B-4, is not significant and the variable is therefore eliminated from further analysis.

4. Having exhausted the primary-variable list, the selection process continued with the secondary variables. Only severity, driver age, speeding, and driver license status show cells with reasonable sample size to justify variable-selection analyses. The values of Q_T and Q_{CMH} for these variables are shown in Table B-5. Of these, only the variable "speeding" shows a significant Q_T value and all four variables have nonsignificant Q_{CMH} values. The variable "speeding" was therefore selected while the other secondary variables are eliminated from further analysis.

The independent variables that are found to be significant from the variable selection process are: degree of curve, weather/surface condition, accident time and speeding.

The analysis then continues with the modeling process, the results of which are presented as follows, again in a step-by-step fashion.

1. A contingency table of accident frequency for the county, cross-classified by the selected variables: degree of curve, weather/surface condition, accident time, and speeding, is shown in Table B-6. The cell probabilities, determined by dividing the accident count in each cell by the overall total, are also shown in the table.

2. Table B-7 shows both the expected and observed number of accidents at the site, cross-classified by the same selected variables.

3. The magnitude of accident characteristics that are overrepresented at the site relative to the countywide average is computed for each of the cells in the contingency table using equation (5). The results are shown in Table B-8. Only those cells with the overrepresentation indicator (Z_{ijk}) greater than +1.5 and the observed accident frequency

Table B4

Result of Variable Selection: Step 3

Variable	Q_T	D.F.	p-value	Q_{CMH}	D.F.	p-value
curvature x surface x accident time	16.9	8	0.032	11.8	2	.003
curvature x surface x accident type	15.2	8	0.055	8.7	2	.013

Table B5

Result of Variable Selection: Step 4

Variable	Q_T	D.F.	p-value	Q_{CMH}	D.F.	p-value
Selected variables x Speeding	22.4	12	.034	1.16	1	.281
Selected variables x Driver Age	14.0	12	.302*	0.78	1	.378
Selected variables x Severity	11.2	12	.511*	0.43	1	.510
Selected variables x License Status	9.7	12	.641*	2.33	1	.127

* Eliminated

Table B6

Number of Accidents for County

Curvature (V4)	Condition (V3)	Time (V2)	Speeding (V1)	
			Yes	No
Straight	Dry	Weekday, Rush Hour	42	82
		Weekday, Non-Rush	25	59
		Weekend, Day	7	21
		Evening or Night	90	179
	Wet	Weekday, Rush Hour	15	17
		Weekday, Non-Rush	9	10
		Weekend, Day	6	7
		Evening or Night	40	28
Less Than 2°	Dry	Weekday, Rush Hour	3	6
		Weekday, Non-Rush	3	6
		Weekend, Day	2	3
		Evening or Night	10	21
	Wet	Weekday, Rush Hour	0	2
		Weekday, Non-Rush	0	2
		Weekend, Day	2	0
		Evening or Night	2	6
Greater Than 2°	Dry	Weekday, Rush Hour	0	4
		Weekday, Non-Rush	0	3
		Weekend, Day	0	1
		Evening or Night	9	9
	Wet	Weekday, Rush Hour	0	2
		Weekday, Non-Rush	2	1
		Weekend, Day	0	2
		Evening or Night	3	4

Table B7

Expected** and Observed Number of Accidents for Site

Curvature (V4)	Condition (V3)	Time (V2)	Speeding (V1) Yes		Speeding (V1) No	
Straight	Dry	Weekday, Rush Hour	(12.7)	7	(26.1)	9
		Weekday, Non-Rush	(8.8)	2	(18.2)	8
		Weekend, Day	(3.7)	0	(7.7)	7
		Evening or Night	(29.4)	8	(60.6)	11
	Wet	Weekday, Rush Hour	(5.3)	3	(5.4)	6
		Weekday, Non-Rush	(3.6)	4	(3.7)	6
		Weekend, Day	(1.5)	6	(1.5)	3
		Evening or Night	(12.2)	5	(12.5)	6
Less Than 2°	Dry	Weekday, Rush Hour	(1.3)	2	(2.8)	3
		Weekday, Non-Rush	(.9)	2	(1.9)	1
		Weekend, Day	(.4)	0	(.8)	2
		Evening or Night	(3.1)	1	(6.5)	7
	Wet	Weekday, Rush Hour	(.6)	1	(.6)	2
		Weekday, Non-Rush	(.4)	0	(.4)	0
		Weekend, Day	(.2)	0	(.2)	1
		Evening or Night	(1.3)	4	(1.3)	2
Greater Than 2°	Dry	Weekday, Rush Hour	(.8)	7	(1.6)	9
		Weekday, Non-Rush	(.6)	2	(.11)	11
		Weekend, Day	(.2)	1	(.5)	6
		Evening or Night	(1.8)	17	(3.8)	28
	Wet	Weekday, Rush Hour	(.3)	8	(.3)	1
		Weekday, Non-Rush	(.2)	11	(.2)	1
		Weekend, Day	(.1)	7	(.1)	0
		Evening or Night	(.8)	12	(.8)	9

** Numbers in parentheses are expected numbers of accidents

Table B8

Accident Overrepresentation Indicators for Site

Curvature	Condition	Time	Speeding Yes	Speeding No
Straight	Dry	Weekday, Rush Hour	*	*
		Weekday, Non-Rush	*	*
		Weekend, Day	*	*
		Evening or Night	*	*
	Wet	Weekday, Rush Hour	*	*
		Weekday, Non-Rush	*	*
		Weekend, Day	*	*
		Evening or Night	*	*
Less Than 2°	Dry	Weekday, Rush Hour	*	*
		Weekday, Non-Rush	*	*
		Weekend, Day	*	*
		Evening or Night	*	*
	Wet	Weekday, Rush Hour	*	*
		Weekday, Non-Rush	*	*
		Weekend, Day	*	*
		Evening or Night	*	*
Greater Than 2°	Dry	Weekday, Rush Hour	3.43	3.44
		Weekday, Non-Rush	*	5.58
		Weekend, Day	*	*
		Evening or Night	5.50	6.66
	Wet	Weekday, Rush Hour	4.35	*
		Weekday, Non-Rush	5.44	*
		Weekend, Day	4.26	*
		Evening or Night	5.02	4.11

* Overrepresentation Indicator (z) less than +1.50 or observed number of accidents less than 7.

of at least 7 are shown in the table. These are the cells with significantly higher number of accidents at the site than expected.

4. Since there is no variable that is sparse but significant, the modeling process is completed for this sample illustration.

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APPENDIX C

SUMMARY OF ACCIDENT ANALYSIS RESULTS ON ADDITIONAL FIELD STUDY SITES

APPENDIX C

SUMMARY OF ACCIDENT ANALYSIS RESULTS ON ADDITIONAL FIELD STUDY SITES

Due to concern expressed regarding the utility of the MAAP program, it was decided to conduct an additional field study with the three participating Districts. Thirty sites, 10 from each of the three Districts, were selected by personnel from the respective Districts. The sites were selected from lists of high accident locations identified and ranked by the WINDOW program for both urban Interstate highways and urban non-Interstate freeways. These sites were analyzed using the MAAP program. The results of the analysis were then provided to the Districts for their evaluation of the utility of the MAAP program. The analysis results of these 30 additional field study sites, as submitted to the Districts, are presented in this Appendix.

The materials are presented one District at a time, including a list of the 10 sites selected for evaluation, followed by summary information on each of the selected sites. Note that the summary information on the sites was prepared by the project staff and not the actual output of the MAAP program. At the time the decision was made to conduct this additional field study, the reporting portion of the MAAP program output was still under development. The program output then was intended strictly for internal use by the project staff and the program output was somewhat difficult to decipher without detailed instructions.

In order for the District personnel to properly evaluate the MAAP program, the summary information was prepared for each of the sites in a format similar to what was planned for the MAAP program as a finished product. In fact, slight variations in the reporting format were purposely used for the three Districts, from narrative descriptions to tabular summation, in an effort to determine which format is favored by the District personnel in terms of ease of use and understanding. The reporting format eventually used for the MAAP program reflects the feedback received from the District personnel, subject to time and funding constraints.

The summary information on each site is usually one to two pages long and includes the following items:

1. Location identification, i.e., county, highway type, ranking, control section number, and beginning and ending milepoints.

2. Accident summary, i.e., frequency of fatal, injury, and total accidents, and accident rate (number of fatal and injury accidents per 100 million vehicle miles of travel).

3. Summary of findings. The overrepresented conditions are listed in descending order of significance according to the overrepresentation indicator, i.e., cell residual. Tabular format was also used to summarize the overrepresented conditions for some of the sites.

4. Suggestions for field observation. A list of items to pay special attention to during the field observation and potential countermeasures are suggested for each site based on the accident analysis results.

District 2 (Fort Worth)

Tarrant County

Urban Interstate Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - INTERSTATE
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP TARRANT COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT COUNTY	BEGINNING MILEPOINT CONTROL-SECTION	BEGINNING MILEPOINT MPT	ENDING MILEPOINT COUNTY	ENDING MILEPOINT CONTROL-SECTION	ENDING MILEPOINT MPT	ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL-ITIES	INJ ACCS	INJ-URIES	PDO ACCS
1	2	IH 0035W	TARRANT	0014-16	5.9	TARRANT	0014-16	7.9	1075	1575.82	3	3	264	384	808
2	2	IH 0030	TARRANT	1068-01	18.1	TARRANT	1068-01	20.1	756	1288.08	2	2	197	277	557
3	2	IH 0035W	TARRANT	0014-16	3.7	TARRANT	0014-16	5.7	579	1193.61	2	2	143	216	434
4	2	IH 0030	TARRANT	1068-01	22.0	TARRANT	1068-01	24.0	769	1056.06	2	2	183	257	584
5	2	IH 0035W	TARRANT	0014-16	1.1	TARRANT	0014-16	3.1	495	1039.21	2	2	124	174	369
6	2	IH 0020	TARRANT	0008-12	7.4	TARRANT	0008-13	9.4	507	1002.92	3	4	131	188	373
7	2	IH 0020	TARRANT	0008-12	5.3	TARRANT	0008-12	7.3	305	698.09	2	2	81	132	222
8	2	IH 0030	TARRANT	1068-02	14.3	TARRANT	1068-02	16.3	363	639.97	5	7	116	169	242
9	2	IH 0035W	TARRANT	0014-16	8.0	TARRANT	0014-16	10.0	255	553.15	3	4	69	97	183
10	2	IH 0020	TARRANT	0008-13	9.5	TARRANT	0008-13	11.5	235	471.67	2	2	71	99	162
11	2	IH 0030	TARRANT	1068-01	15.1	TARRANT	1068-01	17.1	158	456.62	0	0	50	63	108
12	2	IH 0030	TARRANT	1068-02	18.7	TARRANT	1068-02	20.7	168	364.43	2	2	65	85	101
13	2	IH 0035W	TARRANT	0014-16	11.9	TARRANT	0014-16	13.9	102	356.90	0	0	35	47	67
14	2	IH 0820	TARRANT	0008-13	25.2	TARRANT	0008-13	27.2	210	342.26	3	3	49	72	158
15	2	IH 0030	TARRANT	1068-02	27.3	TARRANT	1068-02	29.3	160	330.59	4	5	78	128	78
16	2	IH 0030	TARRANT	1068-02	25.0	TARRANT	1068-02	27.0	166	328.13	2	3	82	115	82
17	2	IH 0020	TARRANT	0008-13	13.2	TARRANT	2374-05	1.6	142	294.06	3	3	43	56	96
18	2	IH 0030	TARRANT	1068-02	16.4	TARRANT	1068-02	18.4	153	290.69	0	0	52	72	101
19	2	IH 0030	TARRANT	1068-02	22.3	TARRANT	1068-02	24.3	126	268.43	2	2	51	71	73

Tarrant County, Interstate

Rank 1 - IH 35W, Control Section 14-16, Milepoint 5.9 to 7.9

Total number of accidents = 1,075 (3 fatal and 264 injury accidents)
Accident rate = 1,576 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. The results are summarized in the following table, with the numbers indicating the order of significance.

		Accident Time			
Accident Type	Horizontal Alignment	Rush Hour	Non-Rush Hour	Weekend Day Time	Evening or Night
Sideswipe	Curve	1	2	7	
	Straight	10	6		
Rear End	Curve	4	3	9	
	Straight				
Angle or Head on	Curve	5			
	Straight			11	
Single Vehicle Fixed Object	Curve		8		
	Straight				

2. Multi-vehicle sideswipe accidents during day time are overrepresented at curves less than 2 degrees (89 observed versus 20 expected) and, to a lesser extent, at straight alignments. Rear-end accidents are also overrepresented during day time at curves less than 2 degrees (54 observed versus 12 expected). This suggests a possible problem with merging and weaving areas, particularly on curves.

3. Multi-vehicle angle or head-on accidents and single vehicle fixed object accidents are also overrepresented at curve sites.

4. The milepoints with the highest number of accidents are 6.2 and 7.3.

Suggestions for field observations:

1. Check merging and weaving areas, particularly those on curves, for possible improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control, etc.

2. Check if the signing and delineation can be improved to better warn motorists of the curves. Also, check if traffic speed is excessive for the curves and consider potential speed control measures, such as increase in the level of enforcement, if excessive speed is found to be a problem.

3. Pay special attention to milepoints 6.2 and 7.3.

Tarrant County, Interstate

Rank 2 - IH 30, Control Section 1068-1, Milepoints 18.1 to 20.1

Total number of accidents = 756 (2 fatal and 197 injury accidents)
Accident rate = 1,288 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. The results are summarized in the following table, with the numbers indicating the order of significance.

Horizontal Alignment	Accident Time	Accident Type: Sideswipe	Rear-End	Angle or Head-On	Single Vehicle Fixed Object
Curve	Rush Hour	3	9		
	Non-Rush Hour	1	5		8
	Weekend Day Time	4			
	Evening or Night	6	11		2
Straight	Rush Hour				
	Non-Rush Hour	7	10		
	Weekend Day Time				
	Evening or Night				

2. Accidents are overrepresented on curves with 2 degrees or more. The types of overrepresented accidents are:

   a. Multi-vehicle sideswipe accidents,
   b. Single vehicle fixed object accidents during evening or night and non-rush hours,
   c. Multi-vehicle rear-end accidents.

   This indicates the presence of one or more sharp curves within the section which are possible problem locations, particularly in conjunction with merging and weaving areas.

2. Fatal and injury accidents are overrepresented on curves with 2 degrees or more during non-rush hours (17 observed versus 2 expected) and during evening or night (20 observed versus 8 expected). This suggests a possible problem with speeds too fast for the curve sections.

3. The accidents are fairly evenly spread out through the entire section with milepoints 18.5, 18.8, and 19.1 slightly higher than the others.

Suggestions for field observations:

1. Identify the locations with the sharp curves, especially merging and weaving areas. Check on the following items:

   a. Check if the signing and delineation can be improved to better warn motorists of the curves.

b. Check if the geometrics and cross-sectional design elements, e.g., superelevation, at the curves can be improved.

c. Check if the traffic speed is excessive for the curves during non-rush hours and evening or night. Speed control measures, such as increase in law enforcement level, may be considered if excessive speeding is found to be a problem.

d. Check if the merging and weaving areas at the curves can be improved, e.g., increase the length of merging and weaving areas, ramp metering or other control.

2. Pay more attention to milepoints 18.5, 18.8, and 19.1, but the accidents are fairly evenly spread over the entire section.

Tarrant County, Interstate

Rank 4 - IH 30, Control Section 1068-1, Milepoints 22.0 to 24.0

Total number of accidents = 769 (2 fatal and 183 injury accidents)
Accident rate = 1,056 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle sideswipe and rear-end accidents are overrepresented at curves of 2 degrees or more during both rush and non-rush hours. Most of these accidents resulted in property damage only. This suggests a possible problem with merging and weaving areas on sharp curves.

2. Single vehicle fixed object accidents are overrepresented at curves of 2 degrees or more during evenings or nights. These accidents involved speeding and resulted in more fatal and injury accidents. This suggests a possible problem with excessive speeding at the curves.

3. The milepoints with the highest number of accidents are 22.9 to 23.0 and 23.8 to 24.0.

Suggestions for field observations:

1. Identify the locations with the sharp curves, especially merging and weaving areas. Check on the following items:

    a. Check if merging and weaving areas can be improved, e.g., increase the length of merging and weaving areas, ramp metering or other control.

    b. Check if the signing and delineation can be improved to better warn motorists of the curves.

    c. Check if the geometrics and cross-sectional design elements, e.g., superelevation, can be improved at the curves.

    d. Check if the traffic speed is excessive at the curves during evenings or nights. Speed control measures, such as increase in level of law enforcement, may be considered.

2. Pay special attention to milepoints 22.9 to 23.0 and 23.8 to 24.0.

Tarrant County, Interstate

Rank 8 - IH 30, Control Section 1068-2, Milepoints 14.3 to 16.3

Total number of accidents = 363 (5 fatal and 116 injury accidents)
Accident rate = 640 accidents/100 million vehicle miles.

Summary of findings (in descending order of significance):

1. The results are summarized in the following table, with the numbers indicating the order of significance.

Horizontal Alignment	Accident Time	License Status	Severity: Fatal/Injury	Severity: PDO	DWI or Drugs
Curve	Rush Hour	In State	1	5	
		Out of State			
	Non-Rush Hour	In State		2	
		Out of State			
	Weekend Day Time	In State			
		Out of State			
	Evening/Night	In State	4		
		Out of State			
Straight	Rush Hour	In State			
		Out of State			
	Non-Rush Hour	In State			
		Out of State			
	Weekend Day Time	In State			
		Out of State			
	Evening/Night	In State			
		Out of State	3		6

2. Fatal and injury accidents are overrepresented at curve sites during rush hours (13 observed versus 2 expected). Also, property damage only accidents are overrepresented at curve sites during both rush and non-rush hours.

3. Fatal and injury accidents are overrepresented at curve sites during evenings/nights (21 observed versus 12 expected). This suggests possible problems with excessive speed, poor light conditions, or poor visibility during the hours of darkness.

4. Accidents involving out of State drivers during evenings/nights are overrepresented in fatal and injury accidents (21 observed versus 12 expected) and for drivers under the influence of alcohol or drugs (8

observed versus 3 expected). This suggests the presence of some confusion to drivers who are unfamiliar with the roadway or impaired in their driving ability.

5. The accidents are fairly evenly spread along the entire section with milepoints 14.3, 14.5 to 14.6, 15.1, and 15.9 slightly higher than the other milepoints within the section.

Suggestions for field observations:

1. Identify curve sites within the section.

    a. Check the curves for possible causes of overrepresentation in fatal and injury accidents. Examples of such possible causes are work zones, excessive speeding, limited sight distance, hazardous roadside conditions, etc. Identify appropriate countermeasures once the possible causes are determined.

    b. Check to see the lighting conditions and visibility are adequate during the hours darkness and identify potential improvements, such as improved delineation, raised pavement markers, etc.

2. Check the signing and delineation for possible confusion or miscues to unfamiliar and/or impaired drivers. Also, check for establishments serving out of town motorists along this roadway section for possible sources of alcohol or drugs.

Tarrant County, Interstate

Rank 9 - IH 35W, Control Section 14-16, Milepoint 8.0 to 10.0

Total number of accidents = 255 (3 fatal and 69 injury accidents)
Accident rate = 553 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents on curves for passenger cars are overrepresented for out of State drivers (7 observed versus 2 expected) while in-State drivers are overrepresented in speeding (10 observed versus 4 expected).

2. Accidents involving vans or pickups driven by out of State drivers are overrepresented, some of which are also speeding. Truck accidents involving out of State drivers are also found to be overrepresented.

   The results suggest that excessive speeding is a problem for this roadway section. Also, the large number of accidents involving out of State drivers indicates possible problems with signing or delineation, resulting in confusion to unfamiliar drivers.

3. The milepoints with the highest number of accidents are 8.0 to 8.2, 9.0 to 9.1, and 9.9 to 10.0.

Suggestions for field observations:

1. Check the roadway section for excessive speeding, especially at curves. Speed control measures, such as increase in the level of law enforcement, can be considered if excessive speeding is found to be a problem.

2. Check the roadway section for signing and delineation that may cause confusion to unfamiliar drivers, particularly at interchanges.

3. Pay special attention to milepoints 8.0 to 8.2, 9.0 to 9.1, and 9.9 to 10.0.

District 2 (Fort Worth)

Tarrant County

Urban Non-Interstate Freeway Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - NON INTERSTATE URBAN FREEWAY
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP TARRANT COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL-ITIES	INJ ACCS	INJ-URIES	PDO ACCS
			COUNTY	CONTROL-SECTION	MPT	COUNTY	CONTROL-SECTION	MPT							
1	2	US 0287	TARRANT	0172-06	21.0	TARRANT	0172-06	23.0	184	706.04	1	1	53	67	130
2	2	SH 0121	TARRANT	0364-01	19.2	TARRANT	0363-03	2.0	424	627.58	1	1	112	151	311
3	2	SH 0360	TARRANT	2266-02	5.9	TARRANT	2266-02	7.9	277	609.56	0	0	117	171	160
4	2	SH 0199	TARRANT	0171-04	1.4	TARRANT	0171-04	3.4	88	563.05	2	2	32	61	54
5	2	SH 0121	TARRANT	0364-01	10.4	TARRANT	0364-01	12.4	44	524.12	0	0	17	25	27
6	2	SH 0360	TARRANT	2266-02	9.3	TARRANT	2266-02	11.3	132	416.64	0	0	56	86	76
7	2	SH 0360	TARRANT	2266-02	1.2	TARRANT	2266-02	3.2	112	365.30	1	2	46	65	65
8	2	SH 0360	TARRANT	2266-02	3.7	TARRANT	2266-02	5.7	121	363.49	1	1	45	71	75
9	2	SH 0121	TARRANT	0363-03	6.2	TARRANT	0363-03	8.2	167	328.92	3	3	55	79	109
10	2	SH 0121	TARRANT	0364-01	14.8	TARRANT	0364-01	16.8	141	328.77	2	2	44	60	95
11	2	US 0287	TARRANT	0172-06	23.1	TARRANT	0172-06	25.1	79	303.13	1	1	27	42	51
12	2	SH 0183	TARRANT	0094-02	2.2	TARRANT	0364-05	1.9	188	282.59	2	2	70	99	116
13	2	SH 0121	TARRANT	0364-01	3.6	TARRANT	0364-01	10.2	43	243.41	0	0	13	21	30
14	2	SH 0121	TARRANT	0364-01	17.1	TARRANT	0364-01	19.1	158	221.65	1	4	58	82	99
15	2	SH 0183	TARRANT	0008-12	0.7	TARRANT	0008-12	2.7	96	219.73	3	3	34	54	59
16	2	US 0287	TARRANT	0172-06	25.6	TARRANT	0172-09	20.7	43	209.77	1	1	13	16	29
17	2	SH 0121	TARRANT	0363-03	3.4	TARRANT	0363-03	5.4	87	192.38	1	1	29	46	57
18	2	SH 0183	TARRANT	0364-05	2.0	TARRANT	0094-02	11.7	90	126.64	1	1	28	41	61
19	2	SH 0121	TARRANT	0364-01	12.5	TARRANT	0364-01	14.5	7	69.26	0	0	2	2	5

Tarrant County, Non-Interstate Freeway

Rank 1 - US 287, Control Section 172-6, Milepoint 21.0 to 23.0

Total number of accidents = 184 (1 fatal and 53 injury accidents)
Accident rate = 706 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented under adverse weather/surface condition. This suggests a possible problem with skid resistance and/or drainage.

2. Under adverse weather/surface condition, the overrepresented accident types are: single vehicle fixed object accidents (51 accidents observed versus 13 accidents expected); and multi-vehicle sideswipe accidents (25 observed versus 13 expected). These suggest a possible problem with roadside conditions; and merging or weaving areas.

3. The milepoints with the highest number of accidents are 21.3 and 21.4.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage.

2. Check roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

3. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

4. Pay special attention to milepoints 21.2 to 21.5.

Tarrant County, Non-Interstate Freeway

Rank 2 - SH 121, From Control Section 364-1, Milepoint 19.2 to Control Section 363-3, Milepoint 2.0

Total number of accidents = 424 (1 fatal and 112 injury accidents)
Accident rate = 627 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. The overrepresented accident types are multi-vehicle sideswipe accidents (15 observed versus 3 expected) and rear-end accidents (11 observed versus 1 expected) during rush hours resulting in property damages only. Also, horizontal curves are overrepresented. This suggests a capacity problem with heavy merging and weaving traffic, especially in combination with horizontal curves.

2. The milepoints with the highest number of accidents are 19.7, and 20.4 to 20.6.

Suggestions for field observations:

1. Check the merging and weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control, etc., especially at locations with horizontal curves.

2. Pay special attention to milepoints 19.7 and 20.4 to 20.6.

Tarrant County, Non-Interstate Freeways

Rank 4 - SH 199, Control Section 171-4, Milepoint 1.4 to 3.4

Total number of accidents = 88 (2 fatal and 32 injury accidents)
Accident rate = 563 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle and head-on accidents are overrepresented (28 observed versus 8 expected), especially for fatal and injury accidents (16 observed versus 3 expected). This indicates the presence of at-grade intersections which is not consistent with the classification of freeways.

2. Drivers both under 21 and over 55 are overrepresented.

3. The milepoints with the highest number of accidents are 1.5, 1.9, and 2.4.

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high for freeway conditions. It appears that there are at-grade intersections at milepoints 1.5, 1.9, 2.4 and perhaps 3.2.

Tarrant County, Non-Interstate Freeways

Rank 5 - SH 121, Control Section 364-1, Milepoint 10.4 to 12.4

Total number of accidents = 44 (17 injury accidents)
Accident rate = 524 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle and head-on accidents are overrepresented (16 observed versus 5 expected). This indicates the presence of at-grade intersections which is not consistent with the classification of freeway.

2. Multi-vehicle sideswipe accidents are also overrepresented (19 observed versus 11 expected). This suggests a possible problem with merging or weaving areas.

3. The milepoint with the highest number of accidents is 12.3 (26 out of the total of 44 accidents occurred at this milepoint).

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high for freeway conditions. It appears that there is a major at-grade intersection at milepoint 12.3.

2. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

Tarrant County, Non-Interstate Freeways

Rank 10 - SH 121, Control Section 364-1, Milepoint 14.8 to 16.8

Total number of accidents = 141 (2 fatal and 44 injury accidents)
Accident rate = 329 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. The only significant factor is adverse weather/surface condition (51 observed versus 27 expected). This indicates a possible problem with skid resistance and/or drainage.

2. The milepoints with the highest number of accidents are 16.3 and 16.8.

Suggestions for field observation:

1. Check pavement condition for low skid resistance and/or poor drainage.

2. Pay special attention to milepoints 16.3 and 16.8.

District 12 (Houston)

Harris County

Urban Interstate Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - INTERSTATE
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP HARRIS COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT COUNTY	BEGINNING MILEPOINT CONTROL-SECTION	BEGINNING MILEPOINT MPT	ENDING MILEPOINT COUNTY	ENDING MILEPOINT CONTROL-SECTION	ENDING MILEPOINT MPT	ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL-ITIES	INJ ACCS	INJ-URIES	PDO ACCS
1	12	IH 0045	HARRIS	0500-03	37.0	HARRIS	0500-03	39.0	1453	1130.27	6	6	388	598	1059
2	12	IH 0045	HARRIS	0500-03	20.5	HARRIS	0500-03	22.5	1371	1042.51	4	4	355	511	1012
3	12	IH 0610	HARRIS	0271-17	33.2	HARRIS	0271-17	35.2	1473	947.33	6	6	439	628	1028
4	12	IH 0045	HARRIS	0500-03	15.3	HARRIS	0500-03	17.3	1043	807.90	3	3	275	443	765
5	12	IH 0010	HARRIS	0271-07	28.0	HARRIS	0508-01	1.9	535	755.15	6	6	170	238	359
6	12	IH 0610	HARRIS	0271-15	5.6	HARRIS	0271-16	20.7	567	650.51	5	5	185	253	377
7	12	IH 0045	HARRIS	0500-03	22.8	HARRIS	0500-03	34.8	729	642.62	2	2	204	270	523
8	12	IH 0610	HARRIS	0271-14	5.5	HARRIS	0271-14	7.5	538	632.06	4	4	179	246	355
9	12	IH 0045	HARRIS	0500-03	18.4	HARRIS	0500-03	20.4	826	608.50	7	9	239	364	580
10	12	IH 0045	HARRIS	0500-03	34.9	HARRIS	0500-03	36.9	634	589.21	4	4	198	287	432
11	12	IH 0010	HARRIS	0271-07	18.8	HARRIS	0271-07	20.8	838	584.34	1	1	216	287	621
12	12	IH 0045	HARRIS	0500-03	41.0	HARRIS	0110-06	33.0	696	574.87	7	8	185	268	504
13	12	IH 0610	HARRIS	0271-17	37.8	HARRIS	0271-14	1.8	859	570.11	6	6	239	345	614
14	12	IH 0010	HARRIS	0508-01	34.3	HARRIS	0508-01	36.3	444	566.58	6	7	134	198	304
15	12	IH 0010	HARRIS	0508-01	39.5	HARRIS	0508-01	41.5	287	512.92	9	10	100	152	178
16	12	IH 0610	HARRIS	0271-16	9.6	HARRIS	0271-17	31.5	546	487.90	2	6	135	198	409
17	12	IH 0010	HARRIS	0271-07	16.1	HARRIS	0271-07	18.1	623	480.94	2	3	163	224	458
18	12	IH 0045	HARRIS	0500-03	11.5	HARRIS	0500-03	13.5	438	476.19	4	5	152	210	282
19	12	IH 0610	HARRIS	0271-15	3.3	HARRIS	0271-15	5.3	383	464.09	3	3	150	232	230

Harris County, Interstate

Rank 3 - IH 610, Control Section 271-17, Milepoint 33.2 to 35.2

Total number of accidents = 1,473 (6 fatal and 439 injury accidents)
Accident rate = 947 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle sideswipe and rear-end accidents are overrepresented during weekday non-rush hours and during weekend daytime.

2. Angle or head-on collisions during weekday non-rush hours are overrepresented on curves and involving passenger cars.

3. Single vehicle fixed object accidents involving DWI or DW drugs are over-represented during evenings or nights.

4. The milepoints with the highest number of accidents are 33.8, 34.4 to 34.5, and 34.7 to 34.8.

Suggestions for field observations:

1. There appears to be a potential problem with merging or weaving areas, particularly on curves, during non-rush hours when the traffic volume is approaching capacity and traffic speeds are relatively high. Check the merging or weaving area for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

2. Check for excessive speeding. Speed control measures, such as increased level of law enforcement, may be considered if excessive speed is found to be a problem.

3. Check the roadway section for potential sources of alcohol or drugs. Increased level of law enforcement during evening and nights, such as a STEP program, may be considered.

4. Pay special attention to milepoints 33.8, 34.4 to 34.5, and 34.7 to 34.8.

Harris County, Interstate

Rank 3 - IH 610 - Control Section 271-17, Milepoint 33.2 to 35.2

Accident Type	Accident Time	Degree of Curve		Vehicle Type			Speeding	DWI/Drugs	Out-of-State License
		Straight	$<2^{o}$	Car	Pickup/Van	Truck			
Sideswipe	Weekday Rush								
	Weekday Non-Rush	148/215	34/55	96/133	77/99		97/156		92/120
	Weekend Day	61/90	13/25	49/91			41/70		
	Evening/Night						99/118		
Rear-End	Weekday Rush	76/96		56/71					
	Weekday Non-Rush	82/130	16/25	50/81	42/52	15/22	64/103		48/69
	Weekend Day	38/57	8/14	29/55			32/48		
	Evening/Night								
Angle or Head-On	Weekday Rush								
	Weekday Non-Rush		3/7	7/12					
	Weekend Day								
	Evening/Night								
Single Vehicle Fixed Object	Weekday Rush								
	Weekday Non-Rush								
	Weekend Day								
	Evening/Night							21/30	

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Interstate

Rank 6 - IH 610, Control Section 271-15, Milepoint 5.6 to Control Section 271-16, Milepoint 20.7

Total number of accidents = 567 (5 fatal and 185 injury accidents)
Accident rate = 651 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents on curves are overrepresented, especially under adverse surface/ weather conditions.

2. The milepoints with the highest number of accidents are Control Section 271-15, milepoints 5.7 and 5.9, Control Section 502-1, Milepoints 20.8, 21.1, and 21.8, and Control Section 271-16, Milepoint 20.7.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage, particularly at curve sites.

2. Check if there is any unusual situation with the curves. Also, check if the curves are properly signed with adequate advance warning.

3. Pay special attention to Control Section 271-15, milepoints 5.7 and 5.9, Control Section 502-1, Milepoints 20.8, 21.1, and 21.8, and Control Section 271-16, Milepoint 20.7.

Harris County, Interstate

Rank 6 - IH610, Control Section 271-15, Milepoint 5.6
to Control Section 271-16, Milepoint 20.7

Degree of Curve	Weather/Surface Condition	Accident Time			
		Weekday Rush	Weekday Non-Rush	Weekend Day	Evening/ Night
Straight	Adverse				
	No Adverse				
$<2^{o}$	Adverse	15/33	5/12		
	No Adverse			7/14	
$\geq 2^{o}$	Adverse	2/10	4/13	2/10	4/14
	No Adverse	9/22		4/9	

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Interstate

Rank 13 - IH 610, Control Section 271-17, Milepoint 37.8 to Control Section 271-14, Milepoint 1.8

Total number of accidents = 859 (6 fatal and 239 injury accidents)
Accident rate = 570 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle sideswipe and rear-end accidents are overrepresented on curve site(s), particularly during rush hours and during evenings and nights. Speeding is found to be higher than average for these accidents. Also, out-of-state drivers are overrepresented in these accidents.

2. The accidents are fairly evenly distributed over the entire roadway section with slightly higher number of accidents at Control Section 271-14, milepoints 0.7 to 0.9 and 1.4.

Suggestions for field observations:

1. There appears to be a potential problem with merging or weaving areas on curves. Check the merging or weaving area for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

2. Check for excessive speeding. Speed control measures, such as increased level of law enforcement, may be considered if excessive speed is found to be a problem.

3. The overrepresentation of out-of-state drivers may reflect some confusion on the part of unfamiliar drivers. Check the traffic control and signing associated with the curves and the merging and weaving areas for any potential improvements, such as advance warning of curves, additional guidance signs, etc.

Harris County, Interstate

Rank 13 - IH 610, Control Section 271-17, Milepoint 37.8
to Control Section 271-14, Milepoint 1.8

Degree of Curve	Accident Type	Accident Time				Driver Age			Speeding	Out-of-State License
		Weekday Rush	Weekday Non-Rush	Weekend Day	Evening Night	<21	21-55	>55		
Straight	Sideswipe					145/164				
	Rear-End									
	Angle/Head-On									
	Single Vehicle									
$<2^{0}$	Sideswipe		16/26							
	Rear-End									
	Angle/Head-On									
	Single Vehicle									
$>2^{0}$	Sideswipe		9/25	11/26	11/33	16/44	15/28	5/17	17/40	17/39
	Rear-End		5/22		7/14	8/27		3/11	13/25	8/21
	Angle/Head-On									
	Single Vehicle									

Legend: Expected No. of Accidents/Observed No. of Accidents

District 12 (Houston)

Harris County

Urban Non-Interstate Freeway Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - NON INTERSTATE URBAN FREEWAY
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP HARRIS COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT COUNTY	BEGINNING MILEPOINT CONTROL-SECTION	BEGINNING MILEPOINT MPT	ENDING MILEPOINT COUNTY	ENDING MILEPOINT CONTROL-SECTION	ENDING MILEPOINT MPT	ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL-ITIES	INJ ACCS	INJ-URIES	PDO ACCS
1	12	SH 0146	HARRIS	0389- 5	0.9	HARRIS	389- 5	2.9	120	1046.03	2	2	36	74	82
2	12	US 0059	HARRIS	0027-13	6.3	HARRIS	27-13	8.3	1518	966.06	2	2	400	536	1116
3	12	US 0059	HARRIS	0177-11	5.1	HARRIS	177-11	7.1	818	918.48	9	11	264	407	545
4	12	SH 0225	HARRIS	0502- 1	7.1	HARRIS	502- 1	10.7	252	860.86	4	4	75	123	173
5	12	US 0059	HARRIS	0027-13	8.4	HARRIS	27-13	10.4	978	722.61	4	5	293	426	681
6	12	US 0059	HARRIS	0177-11	2.4	HARRIS	177-11	4.4	681	691.02	6	6	180	256	495
7	12	SH 0201S	HARRIS	0389-13	1.4	HARRIS	389-13	3.4	66	658.73	2	2	24	33	40
8	12	US 0059	HARRIS	0177- 7	8.8	HARRIS	177-11	1.0	489	578.47	2	2	145	229	342
9	12	US 0059	HARRIS	0027-13	4.1	HARRIS	27-13	6.1	863	562.95	6	7	230	351	627
10	12	SH 0146	HARRIS	0389-12	9.9	HARRIS	389- 5	0.8	85	494.43	1	1	28	46	56
11	12	US 0059	HARRIS	0027-13	1.8	HARRIS	27-13	3.8	617	488.56	5	5	207	293	405
12	12	SH 0146	HARRIS	0389- 5	3.6	HARRIS	389- 5	5.6	48	485.44	1	1	12	15	35
13	12	US 0059	HARRIS	0177-11	7.5	HARRIS	27-13	1.0	472	457.27	1	1	173	245	298
14	12	US 0059	HARRIS	0027-13	10.5	HARRIS	27-13	12.5	440	428.39	1	1	138	186	301
15	12	SH 0225	HARRIS	0502- 1	14.4	HARRIS	502- 1	16.4	73	396.83	1	1	28	43	44
16	12	SH 0225	HARRIS	0502- 2	4.9	HARRIS	502- 1	1.7	226	382.44	2	3	68	96	156
17	12	SH 0225	HARRIS	0502- 1	11.1	HARRIS	502- 1	13.1	87	351.04	2	2	32	52	53
18	12	SH 0225	HARRIS	0502- 1	2.6	HARRIS	502- 1	4.6	200	346.36	1	3	72	110	127
19	12	SH 0008S	HARRIS	3256- 3	2.9	HARRIS	3256- 3	4.9	33	336.10	1	1	8	14	24

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - NON INTERSTATE URBAN FREEWAY
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP HARRIS COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL-ITIES	INJ ACCS	INJ-URIES	PDO ACCS
			COUNTY	CONTROL-SECTION	MPT	COUNTY	CONTROL-SECTION	MPT							
20	12	US 0290	HARRIS	0050- 9	36.0	HARRIS	50- 9	38.0	412	317.25	4	5	106	158	302
21	12	US 0059	HARRIS	0177- 7	6.5	HARRIS	177- 7	8.5	264	310.42	5	6	97	150	162
22	12	US 0059	HARRIS	0177- 7	2.2	HARRIS	177- 7	4.2	148	241.36	5	6	52	80	91
23	12	SH 0225	HARRIS	0502- 1	4.7	HARRIS	502- 1	6.7	88	229.62	0	0	22	33	66
24	12	US 0059	HARRIS	0027-13	12.6	HARRIS	27-13	14.6	206	227.76	6	7	69	105	131
25	12	US 0059	HARRIS	0177- 6	3.3	HARRIS	177- 7	1.3	112	213.24	3	3	37	52	72
26	12	SH 0008S	HARRIS	3256- 2	8.7	HARRIS	3256- 2	10.7	73	209.21	0	0	27	31	46
27	12	SH 0288	HARRIS	0598- 1	4.9	HARRIS	598- 1	6.9	76	205.95	2	2	32	50	42
28	12	SH 0288	HARRIS	0598- 1	0.6	HARRIS	598- 1	2.6	74	188.77	0	0	29	41	45
29	12	SH 0288	HARRIS	0598- 1	9.1	HARRIS	598- 1	11.1	32	181.51	2	2	11	17	19
30	12	US 0059	HARRIS	0177- 7	4.3	HARRIS	177- 7	6.3	112	163.22	4	4	37	62	71
31	12	SH 0008S	HARRIS	3256- 2	13.5	HARRIS	3256- 3	2.1	27	152.21	0	0	10	17	17
32	12	US 0290	HARRIS	0050- 9	33.9	HARRIS	50- 9	35.9	117	128.58	2	2	48	62	67
33	12	US 0059	HARRIS	0177- 6	1.2	HARRIS	177- 6	3.2	70	115.60	1	1	25	35	44
34	12	SH 0288	HARRIS	0598- 1	7.0	HARRIS	598- 1	9.0	29	113.67	3	3	6	12	20
35	12	SH 0288	HARRIS	0598- 1	2.7	HARRIS	598- 1	4.7	37	82.75	0	0	16	22	21
36	12	SH 0008S	HARRIS	3256- 2	10.8	HARRIS	3256- 2	12.8	12	42.15	0	0	5	7	7
37	12	SH 0146	HARRIS	0389- 5	5.7	HARRIS	389- 5	7.7	1	7.54	0	0	1	2	0

Harris County, Non-Interstate Freeway

Rank 1 - SH 146, Control Section 389-5, Milepoint 0.9 to 2.9

Total number of accidents = 120 (2 fatal and 36 injury accidents)
Accident rate = 1,046 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle or head-on accidents are overrepresented (64 observed versus 8 expected), especially for fatal and injury accidents (20 observed versus 2 expected). This indicates the presence of at-grade intersections which is not consistent with the classification of freeways.

2. Single vehicle accidents involving passenger cars are overrepresented during evenings and nights.

3. The majority of the accidents occurred at milepoint 1.1 (81 out of the total of 120 accidents), indicating a major at-grade intersection at this point.

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high and too concentrated at one milepoint (1.1) for freeway conditions.

2. The overrepresentation of single vehicle accidents during evenings and nights may indicate problems with excessive speed, night visibility and lighting conditions, and roadside conditions.

Harris County, Non-Interstate Freeway

Rank 1 - SH146, Control Section 389-5, Milepoint 0.9 to 2.9

Accident Type	Accident Time				Vehicle Type			Fatal/ Injury
	Weekday Rush	Weekday Non-Rush	Weekend Day	Evening/ Night	Car	Pickup/ Van	Truck/ Bus	
Sideswipe								
Rear End								
Angle/Head-On	2/15	2/26	1/12	3/11	4/21	3/36	1/7	2/20
Single Vehicle				4/8	4/9			

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 4 - SH 225, Control Section 502-1, Milepoint 7.1 to 10.7

Total number of accidents = 252 (4 fatal and 75 injury accidents)
Accident rate = 861 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle or head-on accidents are overrepresented (60 observed versus 10 expected), especially for fatal and injury accidents (26 observed versus 5 expected). This indicates the presence of at-grade intersections which is not consistent with the classification of freeways.

2. Multi-vehicle sideswipe accidents involving speeding are overrepresented for pickup trucks/vans (27 observed versus 20 expected) and trucks/buses (13 observed versus 5 expected), resulting in higher than average fatal and injury accidents for pickup trucks and vans (40 observed versus 30 expected).

3. The milepoints with the highest number of accidents are 7.1 to 7.2, 10.1 and 10.5. It appears that there are at-grade intersection at these milepoints.

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high for freeway conditions. Check for at-grade intersections at milepoints 7.1, 10.1, and 10.5.

2. Check for excessive speeding by pickup trucks/vans and trucks/buses. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

Harris County, Non-Interstate Freeway

Rank 4 - SH225, Control Section 502-1, Milepoint 7.1 to 10.7

Accident Type	Vehicle Type	License: In-State	License: Out of State	Speeding	Fatal/ Injury
Sideswipe	Car				
	Pickup/Van			20/27	30/40
	Truck/Bus	6/15			
Rear End	Car				
	Pickup/Van				
	Truck/Bus				
Angle/Head-On	Car	5/25	3/7		3/8
	Pickup/Van	4/28			2/18
	Truck/Bus	1/7			
Single Vehicle	Car				
	Pickup/Van				
	Truck/Bus				

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 7 - SH 201S, Control Section 389-13, Milepoint 1.4 to 3.4

Total number of accidents = 66 (2 fatal and 24 injury accidents)
Accident rate = 659 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle or head-on accidents are overrepresented on straight alignment (24 observed versus 4 expected), especially for fatal and injury accidents (12 observed versus 1 expected). This indicates the presence of at-grade intersections which is not consistent with the classification of freeways.

2. Single vehicle fixed object accidents are overrepresented on curve(s) of over 2 degrees (eight observed versus 1 expected). The resulting severity is much higher than average (8 observed fatal/injury accidents versus 3 expected). Also, speeding is overrepresented for single vehicle fixed object accidents (14 observed versus 6 expected). Other single vehicle accidents are also overrepresented on straight alignment (8 observed versus 3 expected).

3. The milepoints with the highest number of accidents are 1.5, 1.8, and 3.4.

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high for freeway conditions. Check for at-grade intersections at milepoints 1.5, 1.8, and 3.4.

2. Check curve site(s) for factors relating to single vehicle fixed object accidents, including:

   a. Excessive speed. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

   b. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

   c. Potential improvements to traffic control and delineation measures, such as advance curve warning, improved delineation, raised pavement markers, etc.

Harris County, Non-Interstate Freeway

Rank 7 - SH201S, Control Section 389-13, Milepoint 1.4 to 3.4

Accident Type	Degree of Curve			Fatal/ Injury	Speeding
	Straight	$<2^{o}$	$\geq 2^{o}$		
Sideswipe					
Rear-End					
Angle/Head-On	4/24			1/12	
Single Vehicle Fixed Object			1/8	3/8	6/14
Other Single Vehicle	3/8				

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 10 - SH 146, Control Section 389-12, Milepoint 9.9 to Control Section 389-5, Milepoint 0.8

Total number of accidents = 85 (1 fatal and 28 injury accidents)
Accident rate = 494 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Single vehicle fixed object accidents are overrepresented under adverse weather/surface conditions. Speeding is cited much more frequently than the average (11 observed versus 2 expected). Multi-vehicle rearend accidents are also overrepresented during adverse weather/surface conditions.

2. Single vehicle accidents not involving fixed objects are overrepresented under no adverse weather/surface conditions.

3. The majority of accidents occurred at Control Section 389-12, milepoints 9.9 and 10.7 (34 and 26 out of a total of 85 accidents, respectively). Such high concentration of accidents at these milepoints usually indicates presence of at-grade intersections or crossovers or some highly unusual situations.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage.

2. Check roadway section for factors relating to single vehicle accidents, including:

   a. Excessive speed. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

   b. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

   c. Potential improvements to traffic control and delineation measures, such as improved delineation, raised pavement markers, etc.

3. Check to make sure that this roadway section is correctly identified as freeway. The high concentration of accidents at milepoints 9.9 and 10.7 usually indicates the presence of at-grade intersections or crossovers. On the other hand, multi-vehicle angle or head-on collisions are not found to be overrepresented. Other possibilities are merging and weaving areas with some highly unusual situations.

Harris County, Non-Interstate Freeway

Rank 10 - SH 146, Control Section 389-12, Milepoint 9.9
to Control Section 389-5, Milepoint 0.8

Weather/Surface Condition	Accident Type	Driver Age			Vehicle Type			Speeding
		<21	21-55	>55	Car	Pickup/ Van	Truck Bus	
Adverse	Sideswipe							
	Rear-End		2/8					
	Angle/Head-On							
	Single Vehicle Fixed Object		2/11		2/9			2/11
	Other Single Vehicle							
No Adverse	Sideswipe							
	Rear-End							
	Angle/Head-On							
	Single Vehicle Fixed Object							
	Other Single Vehicle		3/8				1/7	

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 16 - SH 225, Control Section 502-2, Milepoint 4.9 to Control Section 502-1, Milepoint 1.7

Total number of accidents = 226 (2 fatal and 68 injury accidents)
Accident rate = 382 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. The only overrepresented factor at this site is accident time with accidents during weekday rush hours overrepresented (69 observed versus 47 expected). This indicates a capacity problem for this roadway section during rush hours.

2. The accidents are fairly evenly spread over the entire section with slightly higher number of accidents at Control Section 502-1, milepoints 1.0, 1.5, and 1.7.

Suggestions for field observations:

1. Accidents as a result of over-capacity during rush hours are generally not affected by safety-related improvements. Check for potential means of increasing the capacity and improved traffic flow.

Harris County, Non-Interstate Freeway

Rank 16 - SH225, Control Section 502-2, Milepoint 4.9
to Control Section 502-1, Milepoint 1.7

Accident Time

Weekday Rush Hours	47/69

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 20 - US 290, Control Section 50-9, Milepoint 36.0 to 38.0

Total number of accidents = 412 (4 fatal and 106 injury accidents)
Accident rate = 317 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented during weekday rush hours (116 observed versus 67 expected) and during evenings and nights (156 observed versus 119 expected).

2. The accident types overrepresented are multi-vehicle sideswipe (191 observed versus 148 expected) and rear-end (120 observed versus 90 expected).

3. Younger drivers of under 21 years of age are overrepresented (167 observed versus 130 expected). Speeding is also found to be overrepresented (200 observed versus 172 expected).

4. The milepoints with the highest number of accidents are between 37.6 to 37.9, particularly milepoint 37.9.

Suggestions for field observations:

1. Multi-vehicle sideswipe and rear-end accidents as a result of over-capacity during rush hours are generally not affected by safety-related measures. Check for potential means of increasing the capacity and improved traffic flow. Also, check merging and weaving areas for potential improvements to reduce conflicts, such as lengthening the merging and weaving areas, ramp metering, etc.

2. Check the night visibility and lighting conditions for potential improvements, such as additional lighting and improved delineation treatments, raised pavement markers, etc.

3. Check for excessive speed on the roadway section, particularly during evenings and nights. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

4. Pay special attention to milepoints 37.6 to 37.9.

Harris County, Non-Interstate Freeway

Rank 20 - US 290, Control Section 50-9, Milepoint 36.0 to 38.0

Accident Time	
Weekday Rush	67/112
Evening or Night	119/156
Accident Type	
Sideswipe	148/191
Rear-End	90/120
Driver Age	
Under 21	130/167
21-55	146/178
Speeding	171/200

Legend: Expected No. of Accidents/Observed No. of Accidents

Harris County, Non-Interstate Freeway

Rank 34 - SH 288, Control Section 598-1, Milepoint 7.0 to 9.0

Total number of accidents = 29 (3 fatal and 6 injury accidents)
Accident rate = 114 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Single vehicle accidents not involving fixed objects are overrepresented (7 observed versus 2 expected).

2. Over half of the accidents occurred during evenings or nights (18 out of a total of 29 accidents versus 11 expected).

3. Accidents involving trucks or buses are overrepresented (5 observed versus 2 expected).

4. The milepoint with the highest number of accidents is 7.9 which accounted for over one-third of total accidents (11 out of 29).

Suggestions for field observations:

1. Check for potential causes and remedial measures for single vehicle accidents during evenings or nights, particularly for trucks or buses:

   a. Night visibility and lighting conditions. Potential improvements include additional lighting and improved delineation treatments, such as addition of edge lines if not already present, post-mounted delineators, raised pavement markers, etc.

   b. Excessive speed. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

2. Pay special attention to milepoint 7.9. The high concentration of accidents at that milepoint is indicative of some unusual conditions at that point.

Harris County, Non-Interstate Freeway

Rank 34 - SH 288, Control Section 598-1, Milepoint 7.0 to 9.0

Accident Type	
Single Vehicle (other than fixed object)	2/7
Accident Time	
Evening or Night	11/18
Vehicle Type	
Truck or Bus	2/5

Legend: Expected No. of Accidents/Observed No. of Accidents

District 15 (San Antonio)

Bexar County

Urban Interstate Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - INTERSTATE
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP BEXAR COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL- ITIES	INJ ACCS	INJ- URIES	PDO ACCS
			COUNTY	CONTROL- SECTION	MPT	COUNTY	CONTROL- SECTION	MPT							
1	15	IH 0035	BEXAR	0017-10	22.4	BEXAR	0017-10	24.4	980	1420.60	1	1	332	479	647
2	15	IH 0035	BEXAR	0017-09	19.9	BEXAR	0017-10	21.9	737	1061.61	4	4	246	394	487
3	15	IH 0010	BEXAR	0072-12	23.2	BEXAR	0072-12	25.2	723	998.40	2	2	240	370	481
4	15	IH 0035	BEXAR	0017-09	17.7	BEXAR	0017-09	19.7	381	727.41	1	2	156	252	224
5	15	IH 0410	BEXAR	0521-04	20.5	BEXAR	0521-04	22.5	731	706.43	3	3	262	380	466
6	15	IH 0410	BEXAR	0521-04	16.3	BEXAR	0521-04	18.3	651	700.53	2	3	233	314	416
7	15	IH 0035	BEXAR	0017-10	33.1	BEXAR	0016-07	35.1	361	682.57	5	5	108	135	248
8	15	IH 0010	BEXAR	0072-12	17.6	BEXAR	0072-12	19.6	431	648.09	1	1	154	249	276
9	15	IH 0410	BEXAR	0521-06	30.6	BEXAR	0521-06	32.6	151	567.49	2	2	67	87	82
10	15	IH 0010	BEXAR	0072-12	20.9	BEXAR	0072-12	22.9	345	511.47	5	5	121	188	219
11	15	IH 0037	BEXAR	0073-08	10.3	BEXAR	0073-08	12.3	346	511.30	1	1	129	196	216
12	15	IH 0035	BEXAR	0017-10	29.7	BEXAR	0017-10	31.7	317	500.28	5	6	124	202	188
13	15	IH 0410	BEXAR	0521-04	9.1	BEXAR	0521-04	11.1	246	499.98	3	5	106	153	137
14	15	IH 0035	BEXAR	0017-10	24.5	BEXAR	0017-10	26.5	321	492.41	3	3	118	167	200
15	15	IH 0035	BEXAR	0017-02	12.2	BEXAR	0017-09	13.3	46	489.05	3	3	20	24	23
16	15	IH 0410	BEXAR	0521-04	18.4	BEXAR	0521-04	20.4	491	460.37	2	2	174	272	315
17	15	IH 0035	BEXAR	0016-07	35.5	BEXAR	0016-07	37.5	195	457.79	4	4	69	102	122
18	15	IH 0037	BEXAR	0073-08	8.2	BEXAR	0073-08	10.2	241	449.47	0	0	97	144	144
19	15	IH 0410	BEXAR	0521-06	37.5	BEXAR	0521-06	39.5	49	420.57	3	7	15	25	31

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - INTERSTATE
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP BEXAR COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL- ITIES	INJ ACCS	INJ- URIES	PDO ACCS
			COUNTY	CONTROL-SECTION	MPT	COUNTY	CONTROL-SECTION	MPT							
20	15	IH 0410	BEXAR	0521-04	22.6	BEXAR	0521-04	24.6	363	414.38	1	1	145	208	217
21	15	IH 0010	BEXAR	0072-12	15.0	BEXAR	0072-12	17.0	163	405.24	3	3	67	91	93
22	15	IH 0410	BEXAR	0521-06	32.8	BEXAR	0521-06	34.8	93	402.52	2	2	38	52	53
23	15	IH 0010	BEXAR	0072-12	25.3	BEXAR	0025-02	2.1	236	391.15	6	6	78	114	152
24	15	IH 0035	BEXAR	0016-07	37.6	BEXAR	0016-07	39.6	106	384.14	2	3	46	68	58
25	15	IH 0035	BEXAR	0017-09	15.5	BEXAR	0017-09	17.5	98	371.41	2	5	30	51	66
26	15	IH 0010	BEXAR	0025-02	25.0	BEXAR	0025-02	27.0	87	370.69	2	2	40	54	45
27	15	IH 0410	BEXAR	0521-06	41.1	BEXAR	0521-06	43.1	32	359.75	2	2	18	29	12
28	15	IH 0410	BEXAR	0521-04	25.0	BEXAR	0521-04	27.0	225	359.44	2	2	81	112	142
29	15	IH 0037	BEXAR	0073-08	1.7	BEXAR	0073-08	3.7	49	334.95	0	0	22	35	27
30	15	IH 0410	BEXAR	0521-06	44.7	BEXAR	0521-05	46.7	27	332.46	3	3	8	17	16
31	15	IH 0410	BEXAR	0521-05	3.7	BEXAR	0521-05	5.7	64	316.67	1	1	25	38	38
32	15	IH 0037	BEXAR	0073-08	4.5	BEXAR	0073-08	6.5	59	314.97	0	0	32	46	27
33	15	IH 0410	BEXAR	0521-04	14.2	BEXAR	0521-04	16.2	205	284.52	3	4	62	86	140
34	15	IH 0035	BEXAR	0017-10	26.9	BEXAR	0017-10	28.9	160	283.18	1	1	58	81	101
35	15	IH 0010	BEXAR	0072-08	10.2	BEXAR	0072-08	12.2	51	273.97	0	0	32	49	19
36	15	IH 0010	BEXAR	0072-08	12.9	BEXAR	0072-12	14.9	82	269.37	2	4	34	46	46
37	15	IH 0410	BEXAR	0521-05	6.4	BEXAR	0521-04	8.2	116	266.84	3	3	42	71	71
38	15	IH 0410	BEXAR	0521-05	51.1	BEXAR	0521-05	53.1	16	254.56	0	0	6	9	10
39	15	IH 0035	BEXAR	0017-03	8.1	BEXAR	0017-02	10.1	22	227.79	4	4	9	11	9

Bexar County, Interstate

Rank 9 - IH 410, Control Section 521-6, Milepoints 30.6 to 32.6

Total number of accidents = 151 (2 fatal and 67 injury accidents)
Accident rate = 567 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented under adverse weather/surface condition. This suggests a possible problem with skid resistance and/or drainage.

2. Under adverse weather/surface condition, the types of overrepresented accidents are:

   a. Multi-vehicle rear-end (15 observed versus 3 expected) and sideswipe (7 observed versus 3 expected) accidents during weekday rush hours, and

   b. Single-vehicle fixed-object accidents during weekends (8 observed versus 1 expected) and evenings or nights (14 observed versus 5 expected).

   Accidents involving speeding are also found to be overrepresented under these condition.

   This suggests a possible problem with merging and weaving areas, and roadside conditions. Also, speeding during periods of low traffic volume may also be a problem.

3. The milepoints with the highest number of accidents are 30.6 to 30.9 and 31.6.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage.

2. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control.

3. Check roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

4. Check if traffic speed is excessive during weekends and evenings or nights. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

5. Pay special attention to milepoints 30.6 to 30.9, and 31.6.

Bexar County, Interstate

Rank 15 - IH 35, Control Section 17-2, Milepoint 12.2 to
Control Section 17-9, Milepoint 13.3

Total number of accidents = 46 (3 fatal and 20 injury accidents)
Accident rate = 489 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Single vehicle fixed object accidents are overrepresented during evenings and nights (14 observed versus 5 expected). These accidents occurred on straight alignment involving passenger cars and were mostly property damages only.

2. The milepoints with the highest number of accidents are Control Section 17-2, milepoint 12.5, and Control Section 17-9, milepoints 11.9 and 12.2.

Suggestions for field observations:

1. Check the roadway section for factors relating to single vehicle fixed object accidents, including:

   a. Excessive speed during evenings and nights. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

   b. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

   c. Lighting conditions and night visibility for potential improvements, such as improved delineation, raised pavement markers, etc.

2. Pay special attention to Control Section 17-2, milepoints 12.5 to 12.7, and Control Section 17-9, milepoints 11.9 and 12.2.

Bexar County, Interstate

Rank 18 - IH 37, Control Section 73-8, Milepoint 8.2 to 10.2

Total number of accidents = 241 (97 injury accidents)
Accident rate = 449 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented under adverse weather/surface conditions. This suggests a potential problem with skid resistance and/or drainage.

2. Under adverse weather/surface conditions, the following accident types are overrepresented during rush hours:

    a. Multi-vehicle rear-end accidents (29 observed versus 5 expected),

    b. Multi-vehicle sideswipe accidents (20 observed versus 5 expected),

    c. Single vehicle fixed object accidents (9 observed versus 3 expected).

    Accident severities are much higher than average (24 observed versus 4 expected fatal or injury accidents).

3. Single vehicle fixed object accidents are overrepresented during evenings and nights, regardless of weather/surface conditions (47 observed versus 28 expected).

4. Other overrepresented factors under adverse weather/surface conditions are: curves greater than 2 degrees, excessive speeding during both rush hours (29 observed versus 5 expected) and evenings or nights (15 observed versus 10 expected), DWI or DW drugs during evenings or nights (7 observed versus 3 expected), and out-of-State drivers (23 observed versus 8 expected).

5. The milepoints with the highest number of accidents are 9.5 and 9.9 to 10.0.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage, particularly at curves.

2. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control. Keep in mind the usual combination of speeding during rush hours. This suggests that the capacity of the roadway section is not yet exceeded, but very close to the limit, so that the traffic speed remains fairly high even during rush hours, but are subject to frequent disruptions by entering and exiting traffic.

3. Check the roadway section for factors relating to single vehicle fixed object accidents, including:

    a. Excessive speed during evenings and nights. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

    b. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

    c. Lighting conditions and night visibility for potential improvements, such as improved delineation, raised pavement markers, etc.

4. Check the signing and delineation for possible confusion or miscues to unfamiliar drivers.

5. Pay special attention to milepoints 9.5 and 9.9 to 10.0.

Bexar County, Interstate

Rank 19 - IH 410, Control Section 521-6, Milepoint 37.5 to 39.5

Total number of accidents = 49 (3 fatal and 15 injury accidents)
Accident rate = 421 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents during evenings and nights are overrepresented (25 observed versus 12 expected).

2. Single vehicle accidents involving other than fixed objects are overrepresented (16 observed versus 3 expected).

3. Accidents involving trucks or buses are overrepresented (7 observed versus 2 expected).

4. Accidents involving DWI or DW drugs are overrepresented (11 observed versus 3 expected).

5. The milepoints with the highest number of accidents are 39.1 to 39.3.

The accident pattern at this site indicates a potential problem with single vehicle accidents during evenings and nights, particularly for trucks or buses. A significant portion of the drivers are impaired by alcohol or drugs.

Suggestions for field observations:

1. Check the roadway section for factors relating to single vehicle accidents during evenings and nights, including:

   a. Excessive speed, particularly for trucks and buses. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

   b. Lighting conditions and night visibility for potential improvements, such as improved delineation, raised pavement markers, etc.

   c. Impaired drivers. Check the roadway section for potential sources of alcohol or drugs. Increased level of law enforcement, such as a STEP program, may be considered.

2. Pay special attention to milepoints 39.1 to 39.3.

Bexar County, Interstate

Rank 22 - IH 410, Control Section 521-6, Milepoint 32.8 to 34.8

Total number of accidents = 93 (2 fatal and 38 injury accidents)
Accident rate = 403 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented at curve(s) less than two degrees. The overrepresented accident types are:

    a. Single vehicle fixed object accidents under adverse weather/surface conditions (9 observed versus 1 expected). This suggests a potential problem with skid resistance and/or drainage.

    b. Multi-vehicle rear-end (10 observed versus 4 expected) and sideswipe (9 observed versus 4 expected) accidents, but not related to adverse weather/ surface conditions. This suggests a potential problem with merging and weaving areas.

2. The milepoints with the highest number of accidents are 33.6 and 33.7.

Suggestions for field observations:

1. Check pavement condition at curve(s) for low skid resistance and/or poor drainage. Also, check for excessive speed and potential improvement of the roadside condition.

2. Check merging or weaving areas for potential improvements, e.g., increase the length of merging and weaving areas, ramp metering or other control, particularly at curve(s).

3. Pay special attention to milepoints 33.6 and 33.7.

Bexar County, Interstate

Rank 23 - IH 10, Control Section 72-12, Milepoint 25.3 to Control Section 25-2, Milepoint 2.1

Total number of accidents = 236 (6 fatal and 78 injury accidents)
Accident rate = 391 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Pickup truck and vans are overrepresented in multi-vehicle sideswipe type of accidents (51 observed versus 26 expected). Trucks or buses are overrepresented in multi-vehicle rear-end type of accidents (8 observed versus 4 expected).

2. Out-of-State drivers are overrepresented in accidents involving pickup trucks or vans (25 observed versus 12 expected) and passenger cars (40 observed versus 28 expected).

3. The milepoints with the highest number of accidents are Control Section 72-12, milepoints 25.3 to 25.4, and Control Section 25-2, milepoint 0.5.

This suggests a potential problem for unfamiliar drivers in merging or weaving areas. The overrepresentation of pickup trucks or vans in accidents may simply be a reflection of a high percentage of pickup trucks and vans in the traffic mix; otherwise the accident data do not offer any apparent explanation.

Suggestions for field observations:

1. Check if the overrepresentation by pickup trucks and vans is simply a reflection of the exposure (i.e., high percentage of pickup trucks and vans in the traffic mix) or there are specific factors causing their over-involvement.

2. Check merging and weaving areas for potential improvements, e.g. increase the length of merging and weaving areas, ramp metering or other control.

3. Check the signing and delineation for possible confusion or miscues to unfamiliar drivers.

4. Pay special attention to Control Section 72-12, milepoints 25.3 to 25.4, and Control Section 25-2, milepoint 0.5.

Bexar County, Interstate

Rank 26 - IH 10, Control Section 25-2, Milepoint 25.0 to 27.0

Total number of accidents = 87 (2 fatal and 40 injury accidents)
Accident rate = 371 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Accidents are overrepresented under adverse weather/surface conditions (29 observed versus 12 expected). This suggests a potential problem with skid resistance or drainage.

2. The types of accidents that are overrepresented are:

    a. Single vehicle accidents (32 observed versus 16 expected), and

    b. Multi-vehicle rear-end accidents (27 observed versus 18 observed).

3. The accidents are fairly evenly spread throughout the roadway section with milepoints 25.5 to 25.6, 26.3, and 26.5 slightly higher than the other milepoints within the section.

Suggestions for field observations:

1. Check pavement condition for low skid resistance and/or poor drainage.

2. Check the roadway section for excessive speed. Speed control measures, such as increase in the level of law enforcement, may be considered if excessive speeding is found to be a problem.

3. Check the roadway section for conditions leading to sudden stops and rear-end accidents, such as traffic backup on main lanes, poor sight distance, frequent entrance and exit of slow-moving vehicles, etc.

Bexar County, Interstate

Rank 27 - IH 410, Control Section 521-6, Milepoint 41.1 to 43.1

Total number of accidents = 32 (2 fatal and 18 injury accidents)
Accident rate = 360 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Single vehicle accidents are overrepresented (16 observed versus 6 expected), particularly during evenings and nights involving fixed objects (10 observed versus 4 expected). The severities of accidents are higher than average with 20 of the total 32 accidents resulting in fatalities or injuries.

2. The milepoints with the highest number of accidents are 41.6 and 42.1.

Suggestions for field observations:

1. Check the roadway section for factors relating to single vehicle accidents during evenings and nights, including:

    a. Excessive speed. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

    b. Lighting conditions and night visibility for potential improvements, such as improved delineation, raised pavement markers, etc.

    c. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

2. Pay special attention to milepoint 41.6 and 42.1.

Bexar County, Interstate

Rank 32 - IH 37, Control Section 73-8, Milepoint 4.5 to 6.5

Total number of accidents = 59 (32 injury accidents)
Accident rate = 315 accident/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Single vehicle fixed-object accidents are overrepresented at curves during evenings or nights and under adverse weather/surface conditions. The resultant severities are higher than average.

2. The accidents are fairly evenly spread over the entire roadway section with milepoints 5.3, 6.0 and 6.5 slightly higher than the other milepoints in the section.

Suggestions for field observations:

1. Identify curve sites within the section and check for factors relating to single vehicle accidents during evenings and nights under adverse weather/surface conditions, including:

   a. Pavement condition. Check for low skid resistance and/or poor drainage.

   b. Excessive speed. Speed control measures, such as increased level of law enforcement, may be considered if excessive speeding is found to be a problem.

   c. Lighting conditions and night visibility for potential improvements, such as improved delineation, raised pavement markers, etc.

   d. Roadside conditions for possible clearing of roadside objects, shielding of hazardous objects with guardrails, or increasing the clear recovery area.

District 15 (San Antonio)

Bexar County

Urban Non-Interstate Freeway Sites

1982 - 1984 TEXAS ON-SYSTEM ACCIDENTS - NON INTERSTATE URBAN FREEWAY
RANK 50 2-MILE SEGMENTS / MAIN LANE OR ENTRANCE RAMP BEXAR COUNTY

SEGMENTS SORTED BY RANK FOR RATE

RANK	HWY DIST	HIGHWAY	BEGINNING MILEPOINT			ENDING MILEPOINT			ACCS	RATE (ACCS/ 100 MVM)	FATAL ACCS	FATAL- ITIES	INJ ACCS	INJ- URIES	PDO ACCS
			COUNTY	CONTROL- SECTION	MPT	COUNTY	CONTROL- SECTION	MPT							
1	15	US 0281	BEXAR	0073-08	25.7	BEXAR	0073-02	2.4	176	929.80	2	2	56	70	118
2	15	US 0281	BEXAR	0073-08	18.8	BEXAR	0073-08	20.8	169	489.44	3	3	55	70	111
3	15	US 0090	BEXAR	0024-08	6.1	BEXAR	0024-08	8.1	149	353.74	2	2	74	123	73
4	15	US 0281	BEXAR	0073-08	23.6	BEXAR	0073-08	25.6	215	337.95	1	1	80	111	134
5	15	US 0090	BEXAR	0024-08	0.6	BEXAR	0024-08	2.6	109	333.29	1	1	45	82	63
6	15	US 0090	BEXAR	0024-08	3.6	BEXAR	0024-08	5.6	84	265.44	2	2	37	43	45
7	15	SH 0016	BEXAR	0613-01	2.9	BEXAR	0613-01	4.9	16	248.50	0	0	6	12	10
8	15	US 0281	BEXAR	0073-08	20.9	BEXAR	0073-08	22.9	132	229.32	1	1	45	56	86
9	15	US 0090	BEXAR	0024-07	7.4	BEXAR	0024-08	0.4	14	152.21	1	2	4	5	9
10	15	US 0090	BEXAR	0024-07	5.1	BEXAR	0024-07	7.1	5	70.39	0	0	1	2	4
11	15	US 0281	BEXAR	0253-04	12.4	BEXAR	0073-08	18.7	23	69.55	0	0	8	11	15

Bexar County, Non-Interstate Freeway

Rank 7 - SH 16, Control Section 613-1, Milepoint 2.9 to 4.9

Total number of accidents = 16 (6 injury accidents)
Accident rate = 249 accidents/100 million vehicle miles

Summary of findings (in descending order of significance):

1. Multi-vehicle angle or opposite direction accidents are overrepresented (5 observed versus 1 expected). This suggests the presence of at-grade intersections which is not consistent with the classification of freeways or median crossovers.

2. DWI or DW drugs are overrepresented at the site (5 observed versus 2 expected). Also, out-of-State drivers are overrepresented at the site (8 observed versus 3 expected). This suggests the presence of some confusion to drivers who are unfamiliar with the roadway or impaired in their driving ability.

3. The milepoints with the highest number of accidents are 2.9 and 3.7. Also, there were no reported accidents between milepoints 3.8 to 4.9.

Suggestions for field observations:

1. Check to make sure that this roadway section is correctly identified as freeway. The number of multi-vehicle angle and head-on accidents is too high for freeway conditions. If the problem is with median crossovers, assess the possibility of closing off these crossovers.

2. Check the signing and delineation for possible confusion or miscues to unfamiliar and/or impaired drivers. Also, check for establishments serving out of town motorists along this roadway section for possible sources of alcohol or drugs.

3. There were no reported accidents between milepoints 3.8 and 4.9. Thus, only the section from milepoint 2.9 to 3.7 needs to be checked, especially the two ends.