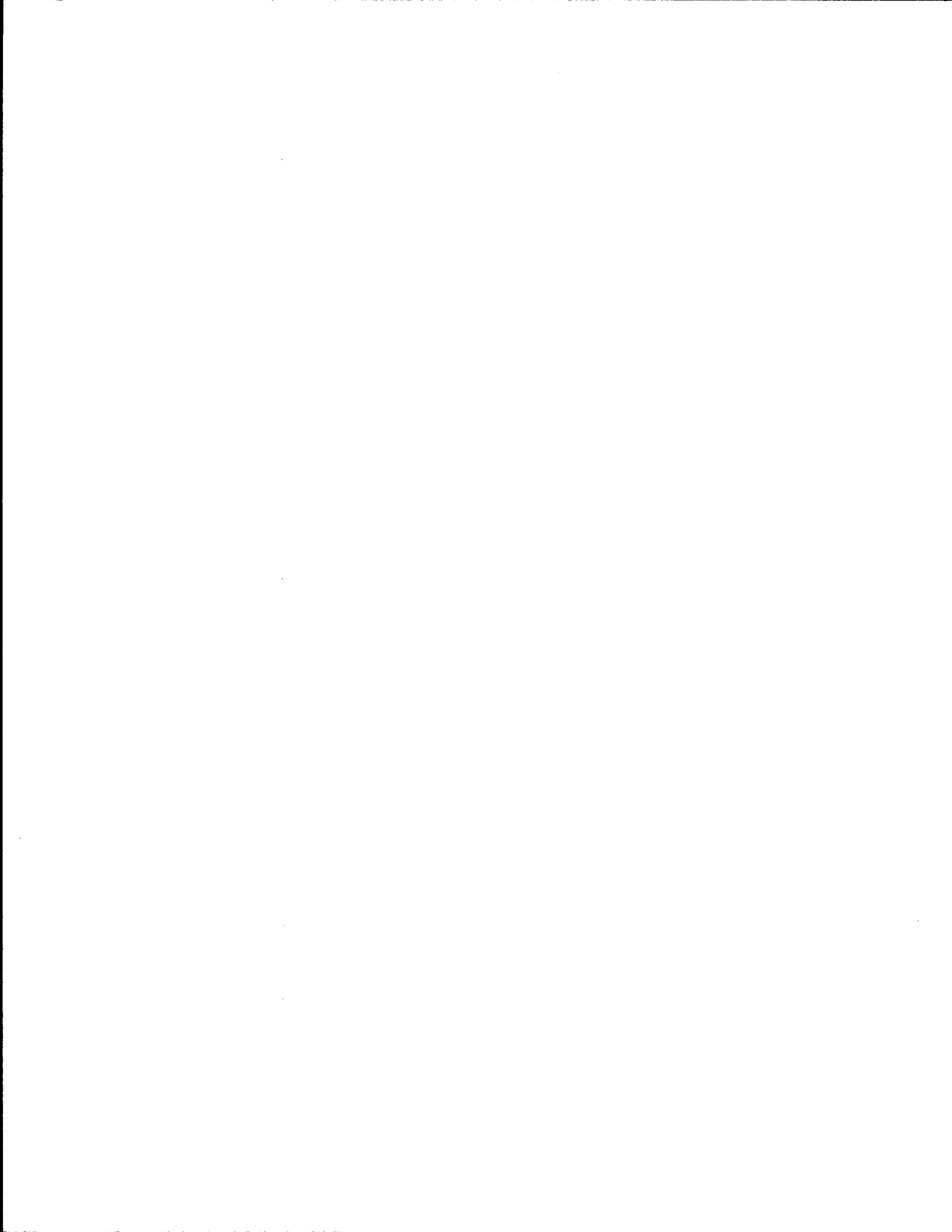


Technical Report Documentation Page

1. Report No. FHWA/TX-94/1345-2F		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle TRAFFIC MANAGEMENT IN RESPONSE TO MAJOR FREEWAY INCIDENTS, VOLUME I				5. Report Date August 1994	
				6. Performing Organization Code	
7. Author(s) Michael A. Ogden, John M. Mounce, Dan R. Middleton, Gerald L. Ullman				8. Performing Organization Report No. Research Report 1345-2F	
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No.	
				11. Contract or Grant No. Study No. 0-1345	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P.O. Box 5080 Austin, Texas 78763-5080				13. Type of Report and Period Covered Final: September 1992 - August 1994	
				14. Sponsoring Agency Code	
15. Supplementary Notes Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. Research Study Title: Development of Guidelines for Traffic Management in Response to Major Freeway Incidents					
16. Abstract A two year study to develop guidelines to respond to major freeway incidents was conducted for the Texas Department of Transportation. The objective of this study was to establish guidelines to be applied statewide in large and small cities for the preparation of an incident management plan or the improvement of an existing incident management plan. This manual is intended to be used as a resource document for transportation related agencies responding to roadway incidents in Texas. In addition, appropriate steps are outlined for effective interagency communication and cooperation in incident response. Guideline results for traffic management response to major freeway incidents were established. These results were used to develop incident management plan guidelines for the Houston, Austin, and Beaumont areas of Texas. Evaluation of these case studies by their respective Traffic Management Teams are documented in this report.					
17. Key Words Traffic Management, Incident Management, Incident Response, Freeway Incident Management			18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 170	22. Price



**TRAFFIC MANAGEMENT
IN RESPONSE TO MAJOR FREEWAY INCIDENTS, VOLUME I**

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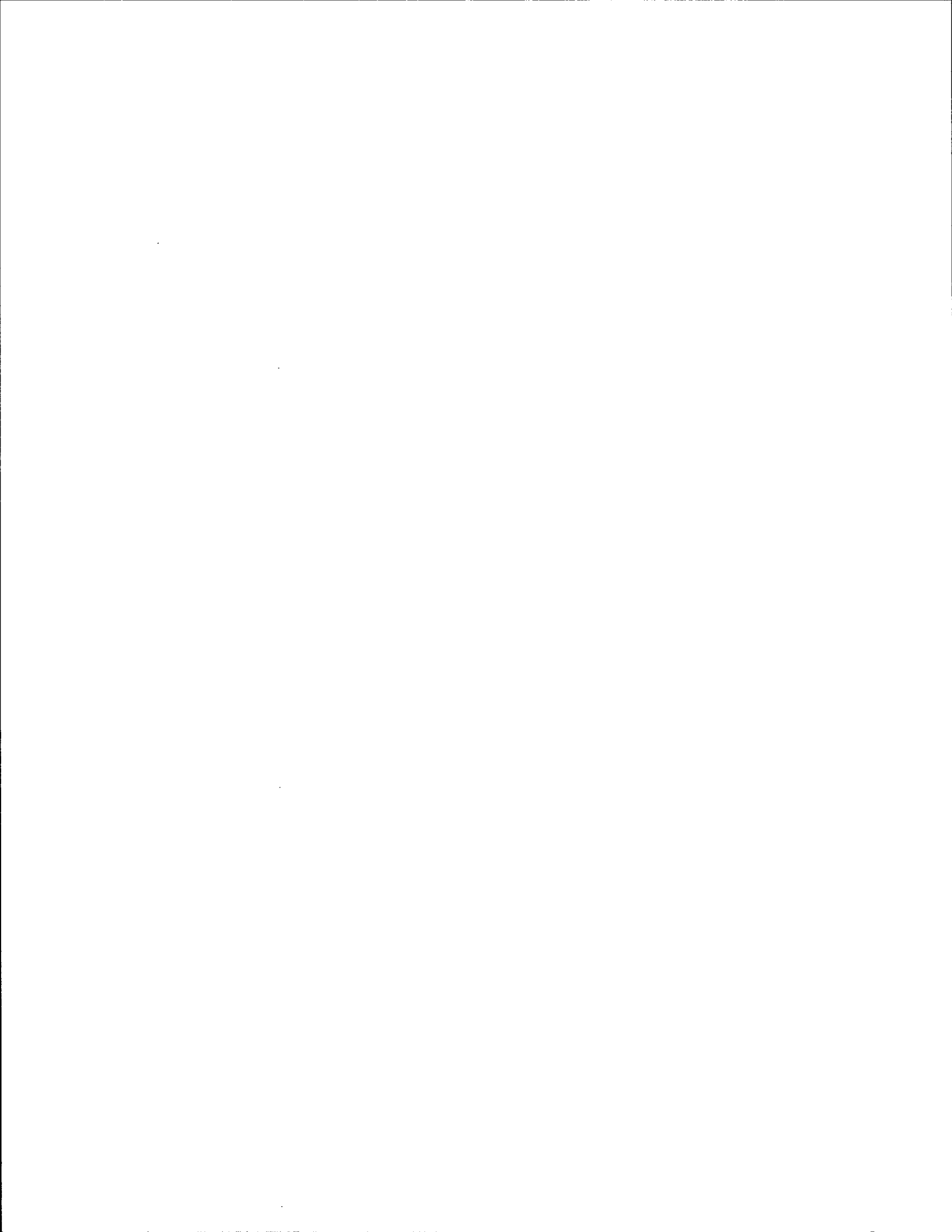
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Research Report 1345-2F
Research Study No. 0-1345
Study Title: Development of Guidelines for Traffic
Management in Response to Major Freeway Incidents

Sponsored by the
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

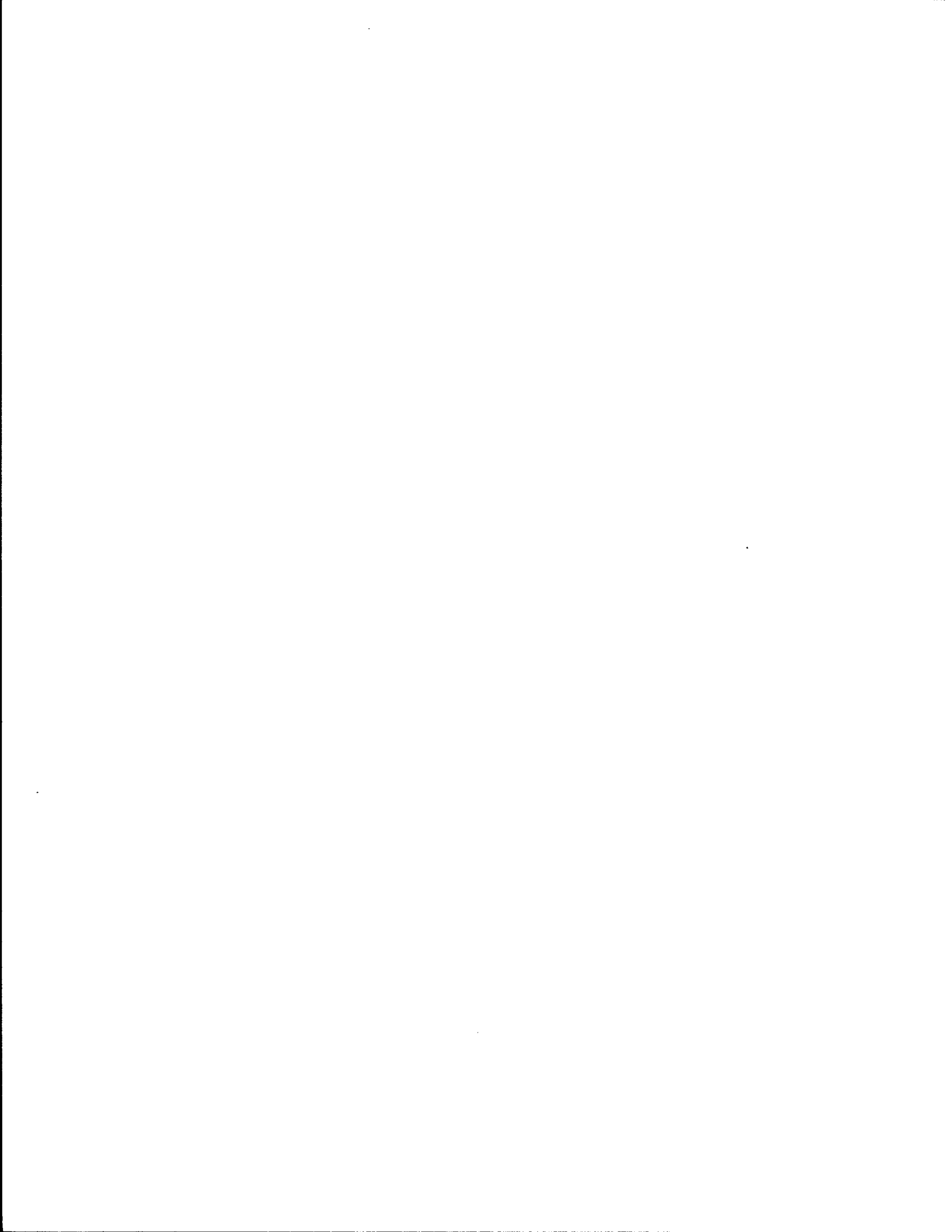
August 1994

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IMPLEMENTATION STATEMENT

This study is sponsored by the Texas Department of Transportation. The major objective of the study to develop guidelines that can be applied statewide in large and small cities for the preparation of an incident management plan or the improvement of an existing incident management plan. These guidelines were utilized in the development and evaluation of incident response plans for three Texas cities which are included in appendices to this report.



DISCLAIMER

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 of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge of the project was Michael A. Ogden, P.E. #77485.

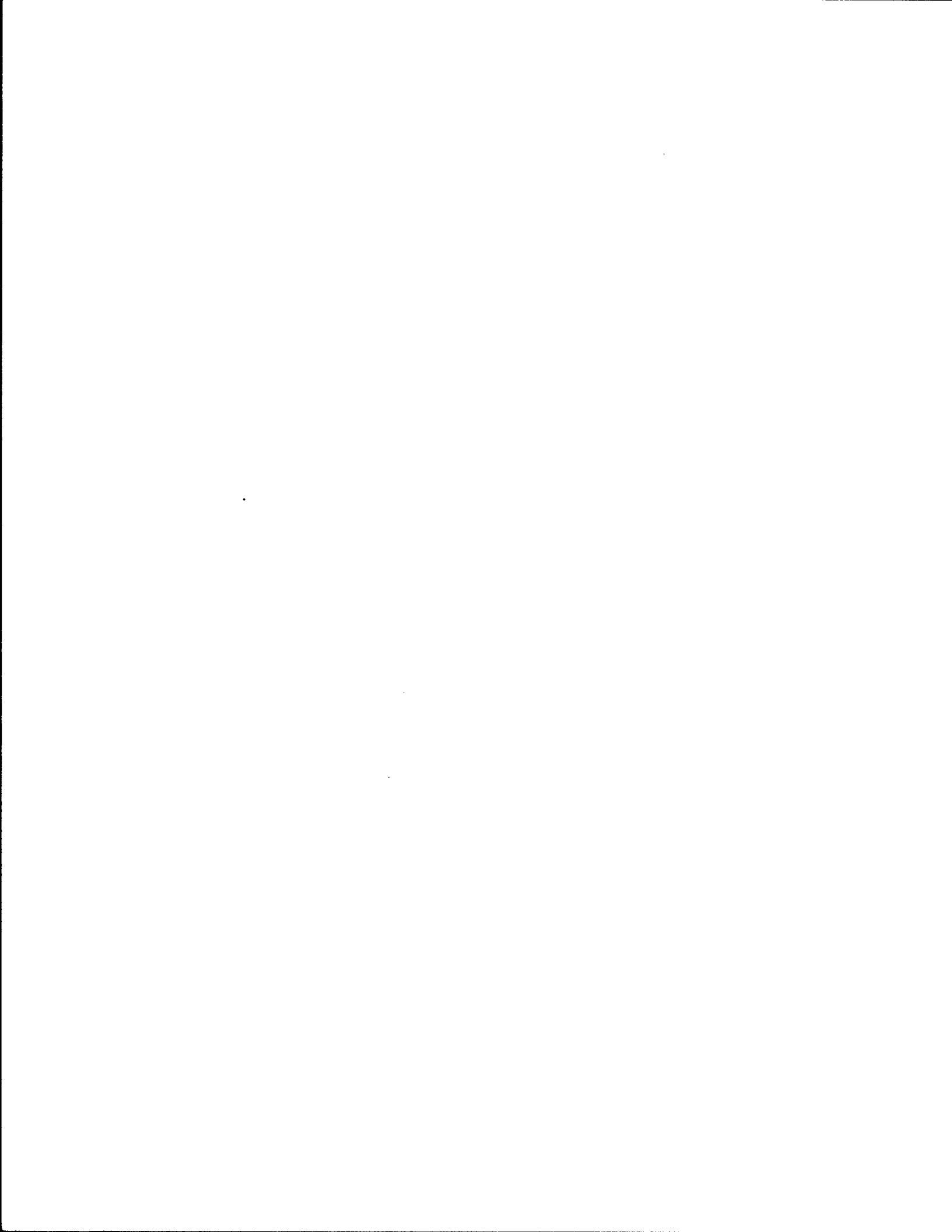


TABLE OF CONTENTS

Volume I

LIST OF FIGURES	xiii
LIST OF TABLES	xvii
SUMMARY	xix
INTRODUCTION	1
LITERATURE REVIEW	5
STATE-OF-PRACTICE IN TEXAS	39
FORT WORTH	39
CORPUS CHRISTI	40
EL PASO	42
AMARILLO	43
BEAUMONT	43
DALLAS	44
AUSTIN	45
SAN ANTONIO	47
HOUSTON	48
INCIDENT RESPONSE QUESTIONNAIRE	50
INCIDENT INVENTORY AND CLASSIFICATION	55
BACKGROUND	55
OBJECTIVES	56
SCOPE OF ANALYSIS	56
DATA COLLECTION	56

TABLE OF CONTENTS (Cont.)

Beaumont Incident Database	57
Austin EMS Database	58
Houston Fire Department (HFD) Hazardous Material Response Database	58
Houston Police Department (HPD) Solo Motorcycle Division Database	59
INCIDENT MANAGEMENT AND RESPONSE REQUIREMENTS	77
INTERAGENCY COORDINATION	85
VEHICLE REMOVAL LEGISLATION	86
ASSISTANCE PATROLS	87
INCIDENT MANAGEMENT SUMMARY	87
APPLICATION OF ADVANCED TECHNOLOGIES	89
GEOGRAPHIC INFORMATION SYSTEMS	89
INCIDENT MANAGEMENT OPERATIONS	90
Incident Response	92
Dynamic Route Guidance	95
Resource Management	97
Incident Database Geographic Query System	99
Roadway Database Geographic Matching System	101
USE OF TOTAL STATIONS	101
Advantages of Total Station Investigation	103
Potential Disadvantages of Total Station Investigation	104

TABLE OF CONTENTS (Cont.)

AUTOMATIC VEHICLE IDENTIFICATION/AUTOMATIC VEHICLE LOCATOR	105
HIGHWAY ADVISORY RADIO	105
CLOSED CIRCUIT TELEVISION	106
CHANGEABLE MESSAGE SIGNS	106
GUIDELINES FOR AGENCY RESPONSE	107
PLANNING FOR MAJOR FREEWAY INCIDENT RESPONSE	107
Establishing Multi-Agency Consensus for Major Incident Planning . . .	108
Identifying Common Incident Classifications	109
Establishing Interagency Cooperation Agreements	110
Developing Interagency Communication Protocols	110
Transportation Agency Preparations	114
Improved Readiness for On-Site Incident Response	115
Site Specific Planning for Incident Response	116
Incident Traffic Management Plans	119
Levels of Incident Response	124
Training	126
RESPONSE GUIDELINES	129
MAXIMIZING TRAFFIC FLOW PAST THE INCIDENT	130
MINIMIZE USE OF FLASHING LIGHTS DURING PEAK PERIODS	130
REMOVAL OF VEHICLES	131
USE EXTREME CAUTION AROUND HAZARDOUS MATERIALS INCIDENTS	132

TABLE OF CONTENTS (Cont.)

PRESERVE THE INCIDENT SCENE AT FATAL OR FELONY ACCIDENTS	133
INCIDENT REPORTING (ON-SITE)	134
INCIDENT REPORTING (AFTER INCIDENT)	135
EVALUATION OF GUIDELINES BY CASE STUDIES	137
RESPONSE PLAN DEVELOPMENT PROCESS	137
Houston	138
Austin	139
Beaumont	140
Evaluation by TMT Members	141
DISCUSSION	143
REFERENCES	147
 Volume II	
APPENDIX A - SELECTED BIBLIOGRAPHY	A-1
APPENDIX B - INCIDENT RESPONSE QUESTIONNAIRE	B-1
APPENDIX C - INCIDENT MANAGEMENT PLAN GUIDELINES - HOUSTON CASE STUDY	C-1
APPENDIX D - INCIDENT MANAGEMENT PLAN GUIDELINES - AUSTIN CASE STUDY	D-1
APPENDIX E - BEAUMONT MAJOR FREEWAY INCIDENT RESPONSE PLAN	E-1

LIST OF FIGURES

Volume I

Figure 1. Early Detection and Rapid Removal Reduced Incident Duration Time for Incidents Requiring a Tow Truck	6
Figure 2. General Incident Tree	7
Figure 3. Incident Management Team Hierarchy	9
Figure 4. Composite Profile of Report Incidents	22
Figure 5. Major Freeway Incident Flow Chart	27
Figure 6. Expert System Overview	28
Figure 7. Distribution of Incident Clearance and Lane Blockage Durations	66
Figure 8. Distribution of Incident Clearance Duration by Vehicle Type	67
Figure 9. Distribution of Lane Blockage Duration by Vehicle Type	68
Figure 10. Average Incident Clearance and Lane Blockage Durations by Number of Vehicles Involved	70
Figure 11. Effect of Incident Clearance and Lane Blockage Duration on Multiple Agency Involvement	71
Figure 12. Incident Report Form	75
Figure 13. Components of Incident Duration	78
Figure 14. Incident Management Framework	79
Figure 15. Small Area Detection, Verification, Response Capabilities	82
Figure 16. Medium Area Detection, Verification, Response Capabilities	83
Figure 17. Large Area Detection, Verification, Response Capabilities	84
Figure 18. System Architecture of an Automated Incident Management Plan Using ARC/INFO GIS Platform	91
Figure 19. List of MAP Van Locations	94

LIST OF FIGURES (Cont.)

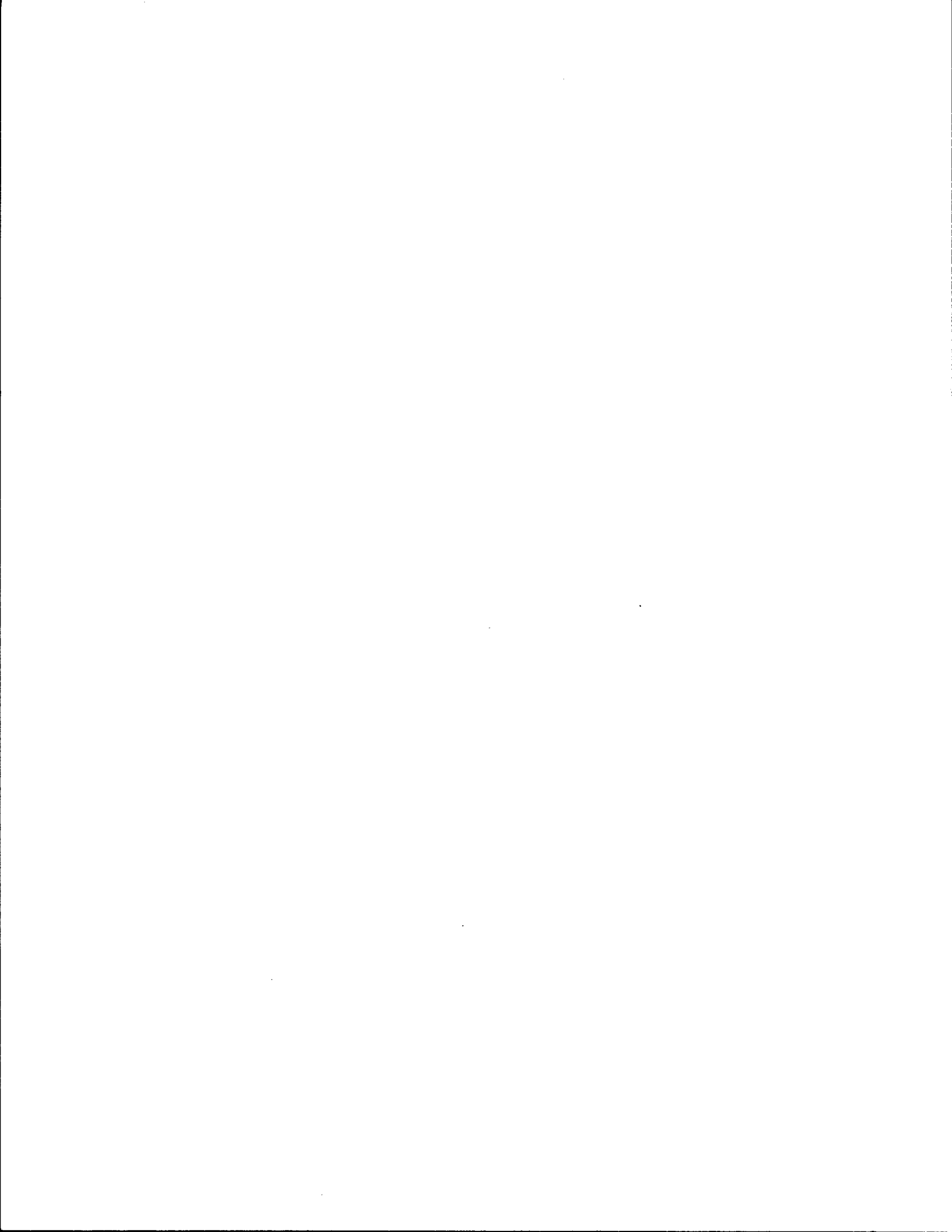
Figure 20. Directions Generated for a Wide Area Route	96
Figure 21. Address of Fire Station Serving Specific Locations	98
Figure 22. Results of a Query on Incident Frequency	100
Figure 23. Example of an Incident Response Flow Chart	112
Figure 24. Example of an Incident Diversion Strategy	113
Figure 25. Use of a Heavy Duty Tow Truck	117
Figure 26. Example of a Major Freeway Incident	118
Figure 27. Example of Freeway Congestion	121
Figure 28. Lane Closure Traffic Control	122
Figure 29. Law Enforcement Traffic Control	123
Figure 30. Example of an Overturned Truck Incident	125

Volume II

Figure C-1. Incident Report Form	C-8
Figure C-2. Example of Incident Diversion Strategies	C-14
Figure C-3. Types of Incidents	C-37
Figure C-4. Container Types	C-39
Figure C-5. Comparison of Fixed Property Use	C-42
Figure C-6. Comparison of Special Properties on Which Hazmat Incidents Occurred	C-42
Figure C-7. Percentage of Hazmat Incidents by City Quadrants in 1991	C-43
Figure C-8. Number of Incidents by Transportation Mode in 1990 and 1991	C-44

LIST OF FIGURES (Cont.)

Figure C-9. Number of Hazmat Incidents on Freeways and Freeway Intersections in 1991	C-45
Figure C-10. Comparison of Release Factors, 1991 to 1990	C-47
Figure C-11. Special Response Actions in 1991	C-48
Figure C-12. EHS Handled by HMRT During 1991	C-49
Figure C-13. Number of Hazmat Incidents During 1991 by 4-Hour Periods of Time	C-50
Figure D-1. Austin Incident Response Flow Chart	D-8



LIST OF TABLES

Volume I

Table 1. Typical Vehicles and Equipment for Handling Over-turned Trucks and Spilled Cargoes	7
Table 2. Get-away Flow Rates	8
Table 3. Incident Management Programs in the United States	13
Table 4. Summary of Research Results on the Characteristics of Large Truck Accidents	17
Table 5. Incident Mitigation Strategies and System Utilization	19
Table 6. Measures for an Ideal Incident Management System	24
Table 7. Planning Framework for Major Transportation Emergencies	26
Table 8. Major Accident Categories	30
Table 9. Impact of Major Incidents in Florida	30
Table 10. Incident Magnitudes	31
Table 11. Incident Management Measures	32
Table 12. Options for Reducing Detection and Verification Time	33
Table 13. Options for Improving Response Time	34
Table 14. Options for Improving Site Management	35
Table 15. Options for Reducing Clearance Time	36
Table 16. Options for Improving Motorist Information	37
Table 17. Major Incident Rates By Freeway	60
Table 18. Interchange and Non-Interchange Incident Rates by Freeway	61
Table 19. Major Incident Rates by Vehicle Type	62
Table 20. Distribution of Incidents by Time-of-Day	63

LIST OF TABLES (Cont.)

Table 21. Average Clearance Times By Location	72
Table 22. Example of An Incident Classification Scheme	81
Table 23. Agencies Represented on Teams in Texas	85
Table 24. Equipment and Materials for Transportation Agency Incident Response	115
Table 25. Response Level Description	125
Table 26. Response Level for Peak Period Incidents (Day)	126
Table 27. Response Level for Peak Period Incidents (Night)	126
Table 28. Training for Incident Response Personnel	127
Table 29. Characteristics of Case Study Locations	138

Volume II

Table C-1. Proposed Incident Classification Scheme for Houston	C-5
Table C-2. Equipment and Materials for Transportation Agency Incident Response	C-10
Table D-1. Incident Classification Levels for Austin	D-5
Table D-2. Equipment and Materials for Transportation Agency Incident Response	D-11
Table E-1. List of Level 3 Incident Locations	E-10

SUMMARY

Travel demands for trucks and automobiles continue to increase while the rate of expansion of the roadway networks decreases. While the rate of incidents may stay constant or, in some cases, even fall, the number of incidents and their impact on mobility and safety will multiply with the increased demands, particularly in urban areas. The safety of the roadway is related to incidents and dependent on their frequency and length of time that they affect traffic operations. The significance of this work is the fact that there exists today the facilities, the equipment, and knowledge to improve incident management. Incident management is a complex problem because it involves many different agencies. Incidents cannot be easily predicted. Likewise, the location and severity can not be known until information is transmitted from the incident scene. However, there are better means of communication to employ quicker procedures for clearing a roadway and a more effective means of controlling traffic approaching an incident. What is needed is a plan to improve the overall response to incidents and commitments on the part of the agencies and the persons involved in incident management to implement the plan. However, it is not realistic to expect that one plan will apply equally well to every area. Therefore, the design of this study will provide guidelines for the development of plans by the local agencies.

The objective of the study is to develop guidelines that can be applied statewide in large and small cities for the preparation of an incident management plan or the improvement of an existing incident management plan in Texas. Likewise, three incident management plan case studies are to be developed for three urban areas in Texas (i.e., small, medium, and large areas).

Early research efforts have been focused on recommendations of incident management procedures or quantifying impacts of incidents (i.e., delay or congestion impacts of incidents). In addition, limited documentation and/or evaluation on the development and implementation of an incident management plan for a given area is available.

Two questionnaires were developed to investigate the state-of-practice and incident response criteria throughout Texas. These questionnaires were administered by phone.

An incident inventory and classification process was done to evaluate the historical data provided in the questionnaires. These included incident rates and incident characteristics (i.e., by frequency, time of day, severity, type, and duration).

Management and response requirements were also identified to identify detection, response, and clearance parameters. A framework (or flow-chart) was also developed to address these criterion for small, medium, and large urban areas in Texas.

The application of advanced technologies for incident response were also investigated to cover: Geographic Information Systems, Total Stations, Automatic Vehicle Identification/Locator, Highway Advisory Radio, Closed Circuit Television, and Changeable Message Signs.

Guidelines for improvement of agency response to incidents were then developed based on the above mentioned information. Specific guidelines are suggested in the areas of incident pre-planning, classification structure, cooperative agreements, and communication protocols. A practical step-by-step process is also outlined for TxDOT response to an incident as well as the identification of documented incident data statistics by each agency for historical reference. Diversion strategies, vehicle/cargo removal policy, and agency training are also discussed.

These results were then utilized to develop Incident Management Plan Guidelines for the Houston, Austin, and Beaumont areas. These plans were evaluated by their local Traffic Management Teams. This report presents the results of this evaluation process.

INTRODUCTION

Urban freeways and highways are highly susceptible to events that reduce roadway capacity and increase travel delays and operating costs to motorists. Studies have determined that random events, such as accidents and vehicle breakdowns, cause 50% or more of the traffic congestion on streets and highways. Incident management, especially for incidents involving large trucks with potentially hazardous cargo, requires coordinated and pre-planned procedures to restore traffic to normal operation through the use of all available human and electronic/mechanical resources. These procedures include: 1) detecting the incident; 2) identifying the extent of the incident (the number and type of vehicles involved, number of lanes affected, the severity of the incident, the time of closure, etc.); 3) identifying the response requirements (which agencies need to respond, the type of equipment needed, the personnel and materials needed to manage traffic, etc.); and 4) providing the appropriate aid to the motorists involved to minimize the effects on the transportation system by clearing the incident area as quickly as possible. The provision of guidelines and the establishment of incident response plans should reduce the amount of time incidents affect traffic and, thus, minimize congestion, reduce traffic delays and fuel consumption, and enhance the overall safety of operations.

The objective of SPR Study 1345 was to develop guidelines that can be applied statewide in large, mid-size, and small cities for the preparation of an incident management plan or the improvement of an existing incident management plan.

A literature review was conducted emphasizing the past 10-12 year period of documentation on the topics of major incident response, incident management, and traffic management including truck related incidents.

An investigation of the State-of-Practice in Texas identified incident procedures and policies as well as data record documentation of response actions. A detailed Incident Response Questionnaire was also administered statewide to professionals involved in traffic management and emergency services. Specific data included communication problems, response times, clearance delays, agency cooperation, and improvement techniques.

An incident inventory analysis was initiated to determine:

- How often a major freeway incident can be expected to occur as a function of traffic and geometric variables;
- The basic characteristics of major incidents in terms of their frequency by time of day, severity, type, and duration; and
- If and how the duration of incidents differs as a function of the incident characteristics.

Incident management and response requirements were developed to deal with small, mid-size, and large urban areas. Specifically, components of incident duration, detection, verification, and response capabilities were identified.

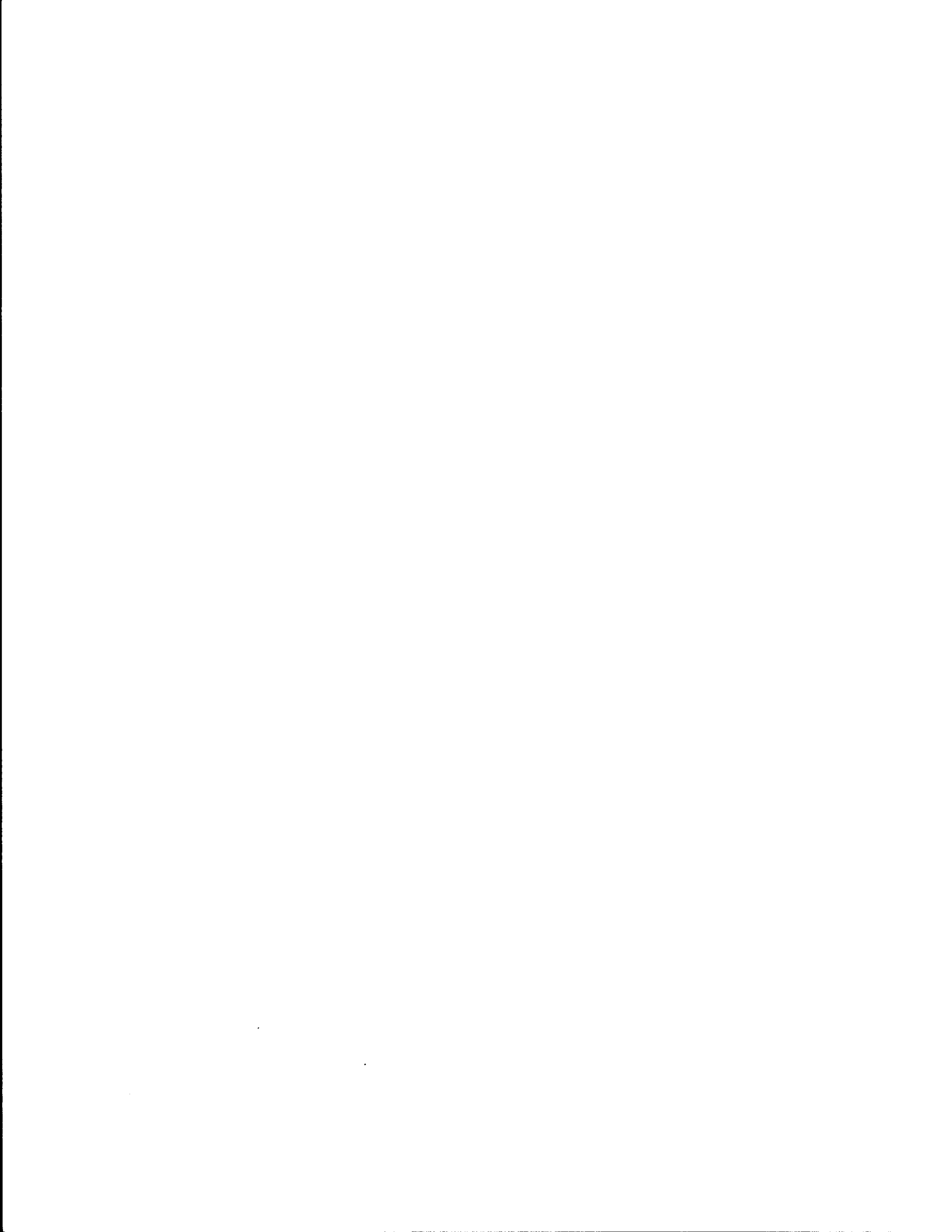
The application of advanced technologies was also investigated to identify any potential ties to incident management and response. Some of the technologies identified include: Geographic Information Systems, Dynamic Route Guidance, Total Stations, Automatic Vehicle Identification, Highway Advisory Radio, Closed Circuit Television, and Changeable Message Signs.

Guidelines for agency incident response were developed to:

- Establish a multi-agency consensus for incident response planning,
- Identify a common incident classification,
- Establish interagency cooperation agreements, and
- Develop interagency communication protocols.

Also identified were agency incident preparations for on-site response, site specific planning, levels of response, and training criteria. Additional response guidelines were developed for maintaining traffic flow, removing disabled vehicles, dealing with hazardous materials, and reporting of incident criteria for evaluation purposes. These guidelines were utilized in the development and evaluation of incident response plan case studies for the Houston, Beaumont,

and Austin areas. The case studies were reviewed by the local Traffic Management teams with comments documented in this report.



LITERATURE REVIEW

As early as 1974 (1), transportation and enforcement agencies in California recognized the utility of early detection and response to freeway incidents. Figure 1 shows the reduction in time necessary to detect, communicate, respond, and service freeway incidents with early detection and rapid removal, facilitated by effective incident management. Electronic detection proved to be effective in the reduction of incident duration time through its ability to detect most congestion causing incidents (85%) in an average of four minutes after occurrence of the incident. The study also concluded that incident management should function through a centralized communication system with direct contact to all field units.

The Federal Highway Administration focused significant research on freeway incident management in 1978 (2). From that research, Figure 2 illustrates a general incident tree categorized by incident location, type of incident, and type of response required. Table 1 indicates typical vehicles involved in incidents and equipment used to handle overturned trucks and cargo spills.

In 1979 the Federal Highway Administration further documented "getaway" flow rates associated with clearing freeway incidents (3). Rates were calculated based on freeway incidents evaluated from Los Angeles and Washington, D.C. Table 2 illustrates that getaway rates vary somewhat by incident type and time of day.

The rates were found to be slightly dependent upon incident type and number of vehicles involved and were also dependent on whether or not the incident occurs during the peak period. These getaway flow rates can be used to evaluate various low cost freeway incident management systems.

CALTRANS District 07 (Los Angeles) was one of the first agencies to formally establish a major-incident-response (MIR) team (4). The MIR team has been successful with an important key being the use of changeable message sign trucks. Equally important is the immediate identification of alternative routes, which involves considerable pre-planning.

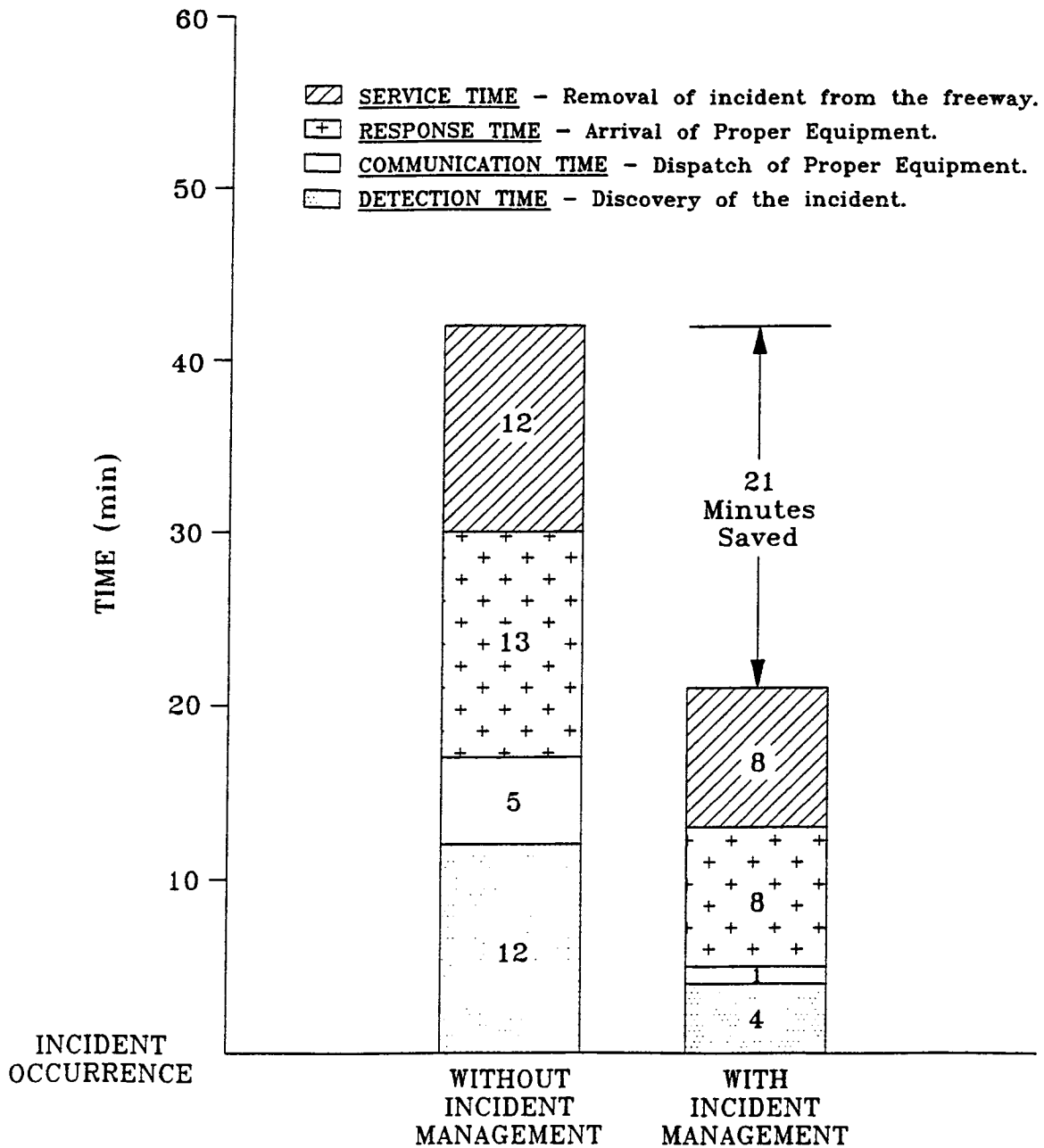


Figure 1. Early Detection and Rapid Removal Reduced Incident Duration Time for Incidents Requiring a Tow Truck

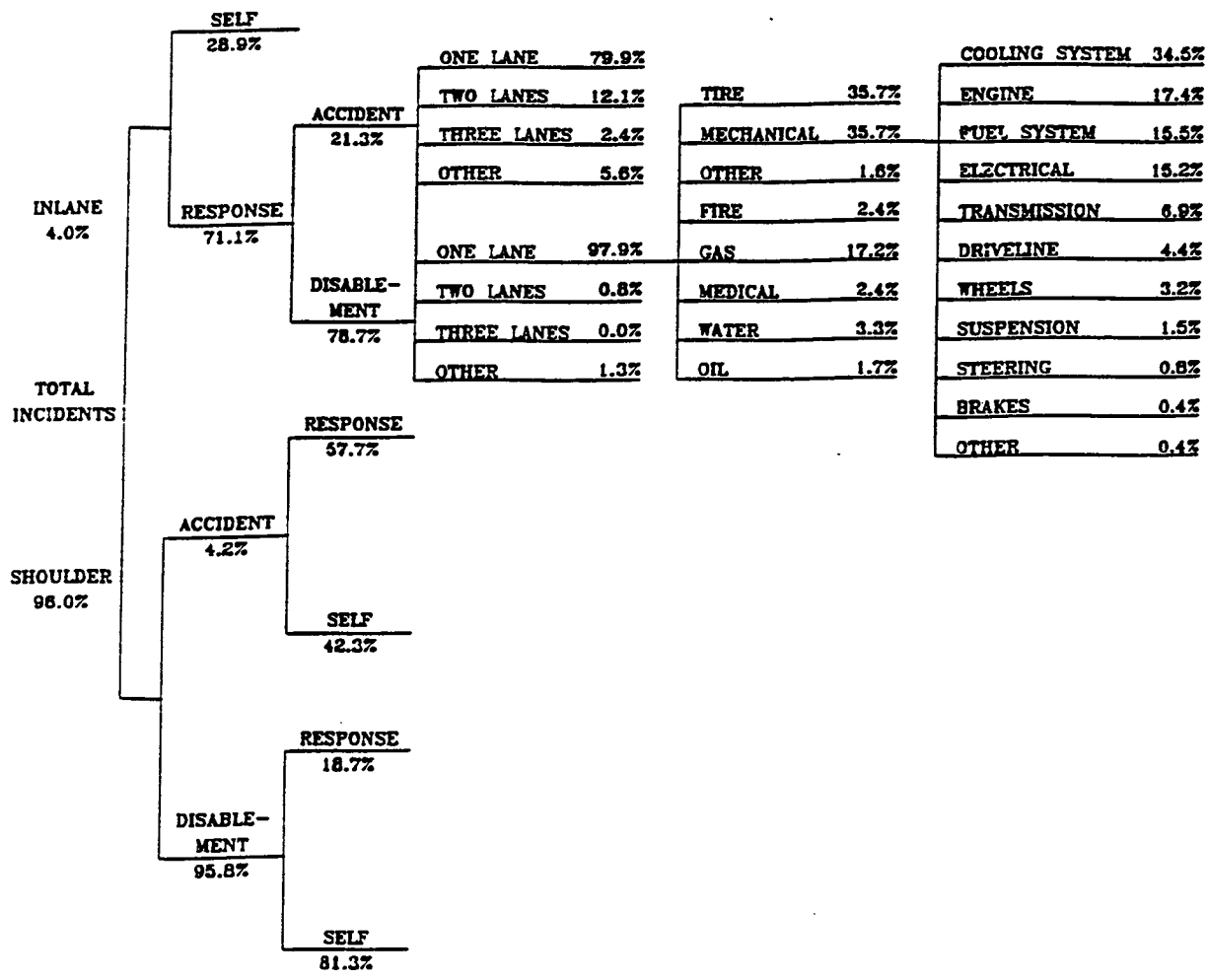


Figure 2. General Incident Tree

Table 1. Typical Vehicles and Equipment for Handling Over-turned Trucks and Spilled Cargoes

Trucks		
refrigerated flatbed	dump platform	tank (dry bulk)
moving van	garbage and refuse collector	concrete mixing
suction pump	auto transport	tractor-trailer
cherry picker	cattlerack (livestock)	steel-carrying
pole and logging	tank (liquid)	heavy duty wrecker
		lowboy
Equipment		
hoses, pumps	sweeper	portable illumination
defueler	cranebulldozer (earthmoving)	front-end loader
skip loader	portable generator	grader

(2)

Table 2. Get-away Flow Rates

Getaway flow rates comparison			
Incident type	Number of incidents	Getaway flow rate (vehicle/lane/hour)	
		Average (vehicle/lane/hour)	Standard deviation (vehicle/lane/hour)
Disabled vehicle	10	1,580	189
Traffic collision			
Two or less vehicles	5	1,562	251
More than two vehicles	5	1,420	87
Peak versus nonpeak getaway flow rates			
Time	Number of incidents	Getaway flow rate	
		Average (vehicle/lane/hour)	Standard deviation (vehicle/lane/hour)
Peak	11	1,634	152
Nonpeak	11	1,425	168

(3)

Over 3,000 maps of the applicable counties were developed to show alternate routes, required signing, closures, responsible individuals and telephone numbers, and any special notes unique to the incident area.

In 1983, the Federal Highway Administration sponsored the preparation and publication of a freeway management handbook (5). The handbook emphasizes interagency coordination for effective response to freeway incidents. Figure 3 illustrates the multi-disciplinary hierarchy of an incident management team.

Recently, the Texas Department of Transportation has taken several steps in the major metropolitan areas in Texas to formalize major incident response authority and procedures. In Ft. Worth (6), the policy and procedure statements outlined below were established for major spills and/or truck turnovers closing an arterial on the state highway system.

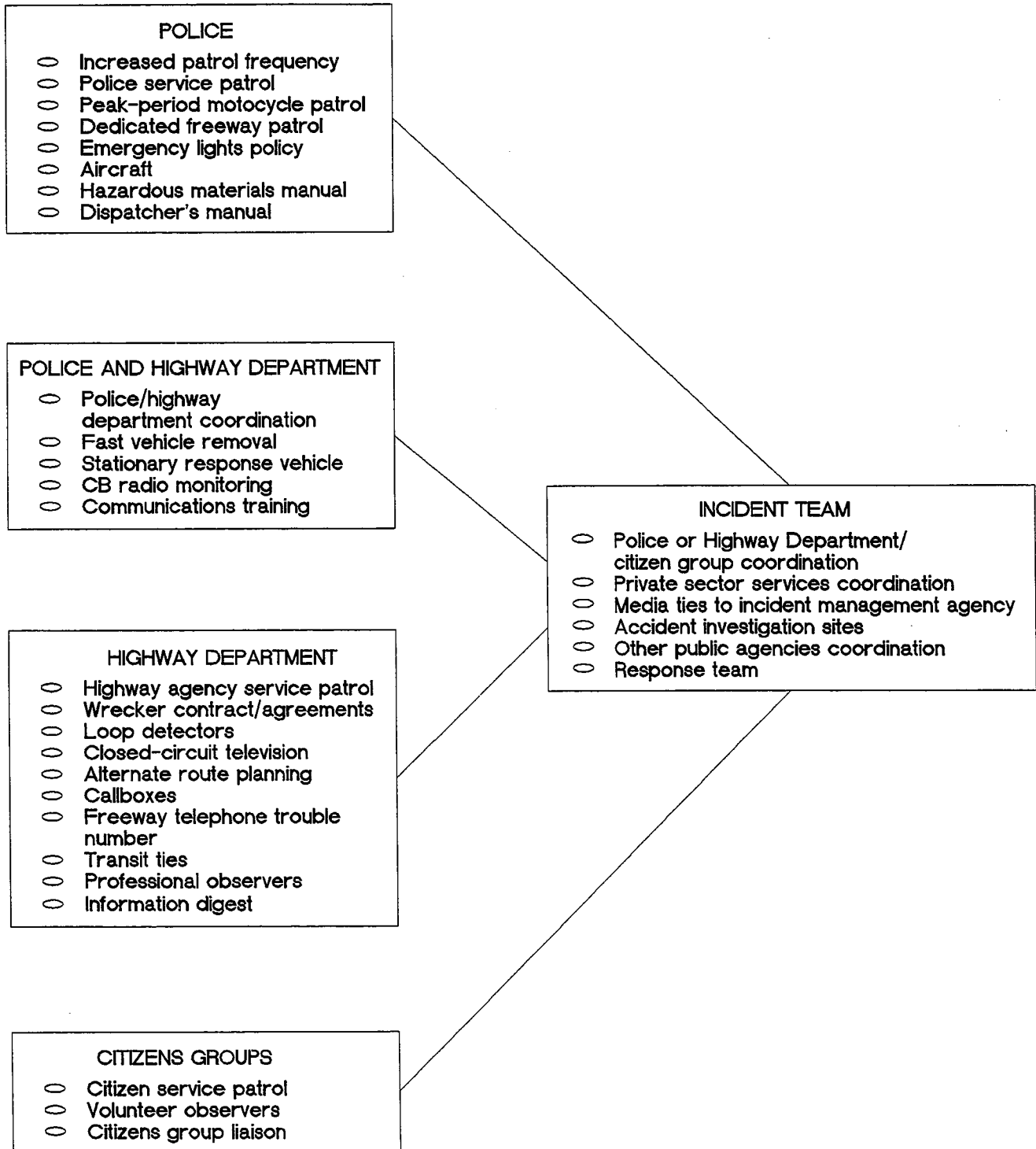


Figure 3. Incident Management Team Hierarchy

1. *The immediate use of the freeway by other drivers will be the utmost concern of the Department's personnel on the scene after the injured have received proper care. State law gives the Department the right to clear debris and property from the system as quickly and efficiently as possible under emergency conditions to ensure the safety and well being of other traffic that has the right to use the roadway.*
2. *The Department will provide traffic control and/or rerouting of traffic by using its Courtesy Patrol and/or maintenance personnel which will include directional arrows, cones, fuses, barricades, etc. throughout duration of closure.*
3. *If the closure is due to a truck turned over but still has its contents intact, measures will be taken to coordinate with wrecker service to provide personnel if available to unload the contents and transfer by that wrecker service to its headquarters; otherwise the Department will provide personnel to accomplish this task.*
4. *If load is damaged to the extent that it is not salvageable, then the Department will remove cargo and cleanup area by means of front-end loader and dump trucks as quickly as possible. Contents will be removed from roadway and stored on State right-of-way or maintenance yard.*
5. *In cases where liquids are spilled, the Department will provide sand to absorb the liquid and the cleanup of such by sweepers, loaders, etc.*
6. *If spill is hazardous, state will attempt to provide all of above upon detection of fire department officials and/or hazardous spill team.*
7. *The Department will have final authority in determining when the closed arterials will be opened.*
8. *It is the intent of the department to provide these services to reduce inconvenience of the motoring public by opening a closed major arterial as quickly as possible in a safe manner.*

The Houston district initiated a similar policy statement for response to incidents closing a section of the state highway system. This is given as follows:

1. *State law gives the Department the right to clear debris and property from the State's Highway System as quickly and efficiently as possible under emergency conditions to ensure the safety and well being of other traffic that has the right to use the roadway. After the injured have received proper care (if appropriate), and after the area has been declared safe to the general public by the appropriate hazardous response agencies, the Department's representative on the scene will*

take appropriate action to clear the roadway for use by other motorists.

2. *The Department's representative will implement a traffic control plan for rerouting traffic, using an incident response team, the Courtesy Patrol Vehicles, Motorist Aid Program Vehicles, and/or maintenance personnel. As appropriate, the Department will use such forces to supplement the police and fire departments engaged in securing the accident site.*
3. *If the closure is due to a truck turnover, but with its contents intact, the Department will attempt to coordinate removal of the truck and its contents with its owner. If, however, the Department determines that the time to do so is excessive in relation to the traffic demands in the area, or that the accident scene constitutes an immediate danger to the public, the Department will take the steps necessary to accomplish timely removal. The truck and its contents will be removed from the roadway and stored on State right-of-way or at maintenance yards.*
4. *If the closure is due to a truck with spilled cargo, the Department will remove the spilled cargo and clean up the area with state-owned or leased equipment as quickly as possible taking precautions appropriate to site conditions to preserve undamaged cargo which will be removed from the roadway and stored on State right-of-way or at maintenance yards. Removal of the truck and any unspilled cargo will be handled as specified in paragraph 3 above.*
5. *In cases where liquids are spilled, the Department will provide sand to absorb the liquid and will clean up the roadway by sweepers, loaders, etc. The sand will be dispatched to the scene as it is evident that the spillage will require this treatment.*
6. *If the spill is hazardous, the Department will attempt to provide all of the above services upon the directions of Houston Fire Department Hazardous Materials Response Team, or other emergency response agencies.*
7. *Although the Department will have the final authority in determining when the closed roadway will be opened, the on-site representatives for the Department will confer with the other emergency response agencies to ensure that their activities have been completed.*
8. *It is the intent of the Department to provide these services to support the other emergency response agencies, so that the motoring public will not be unduly delayed and that the roadway will be reopened as quickly as possible in a safe manner.*

By 1988, incident management programs were being extensively promoted and implemented nationally. Table 3 gives a summary of incident management system types,

locations, detection and verification alternatives, response capabilities, and motorist information communication as reported by the Federal Highway Administration (7).

One particular report (8) by the Federal Highway Administration in 1989 singled out freeway service patrols as an effective element for both incident detection and response. The study compiled data nationally which indicated that 80% of all urban freeway incidents are actually minor, with only 2% of all incidents lasting more than 2 hours.

Table 3. Incident Management Programs in the United States

SYSTEM TYPE AND LOCATION	FIM		DETECTION & VERIFICATION							RESPONSE				MOTORIST INFO			COMMENTS	
	Minor	Major	Operation Center	Service Patrol	Electronic Detection	Closed Circuit TV	CB Radio	Call Boxes	Other	Response Team	Wrecker Agreement	Agency Equipment	Other	Alternate Routes	Hwy Advisory Radio	Media		Variable Message Signs
Areawide Systems																		
Chicago	X	X	X	P	X	X	X				X	X		X	X	X	110 Miles of Freeway	
Los Angeles	X	X	X	P	X	X	X	X	X	X				X	X	X	450 Miles of Freeway	
Transcom - NY/NJ		X	X			P			X					P		X	16 Agencies	
Seattle	P	P	X		X	X				P	P			P	X	X	FAME Project	
Minneapolis/St. Paul	X	P	X	X	X	X	X	P		P	X				X	X		
Detroit	X		X		X	X	X	X			X					X	X	
W. Virginia	X	X	X	X	X	X	X				X					X	X	
Baltimore		X	X											X			X	
Phoenix	P	P	P		P	P			P		X			P			P	20 Year Plan
Ft. Worth	X	P	P	X	P	P			P	X	X		P	P	P	X	P	20 Year - 191 miles fwy
Houston		P	P	X	P	P				X		X		P		X	P	Current activity on HOV
San Antonio	P	P		X	P	P								P			P	
San Diego	P	X								X								
San Francisco	P	P	P		P	P											P	20 year plan
Norfolk Area, VA	P	P	P		P	P						X		P		X	P	Tie fwy systems w/bridge
Miami, FL	X	X	P		P	P				X	X			X	P	X	P	Corridor Mngt Team
Fairfax Co., VA	X	X	X						X		X			P		X		Nonfreeway - Co. Police
Massachusetts Fwys	X	X	P				X	X		P			X	P				Oil overcharge funds
Tampa Bay, FL	X	X	P		P	P				X	X			X	P	X	P	2 Corridor Mngt Teams
Jacksonville, FL	X	X		X						X	X			X		X		Corridor Mngt Team
Corridor Systems																		
Long Island Expy	X	X	X		X	P	X			X	X	X		X		X	X	IMIS - 35 x 5 mi corridor
NJ Turnpike	X	X	X	X	X						X	X		X			X	
Jones Falls, Baltimore			X		X			X										
N. Central Expy, Dallas	X	P	P		P	P								P			P	System replaced/reconst.
I-95/495/Maryland		X		X							X	X		X			P	Capital Beltway
US 48/W Maryland		X								X				X				
I-75/Michigan		X								X				X				DOT District 6

(7)

Table 3. Incident Management Programs in the United States (Cont.)

SYSTEM TYPE AND LOCATION	FIM		DETECTION & VERIFICATION						RESPONSE				MOTORIST INFO			COMMENTS		
	Minor	Major	Operation Center	Service Patrol	Electronic Detection	Closed Circuit TV	CB Radio	Call Boxes	Other	Response Team	Wrecker Agreement	Agency Equipment	Other	Alternate Routes	Hwy Advisory Radio		Media	Variable Message Signs
I-10/El Paso, TX	X	P			P	P					X	X	X	X			X	Const oriented - perm
I-10/Los Angeles	P	P	P		P	P			P	P			P	P		P	P	Smart Corridor Demo
I-4/Orlando	X	X		X	X			X		X	X			X		X		2 Corridor Mngt Teams
I-95/Ft. Lauderdale	X	X																Corridor Mngt Team
US 50/Maryland	X	X		X			X		X		X					X		Beach the Beach Program
I-95/Rhode Island		X							X				X				X	
NY State Thruway	X	X	X	X		P	X		X	X	X		X	X	X	X	X	559 Miles of Toll Road
Bridges, Tunnels & Spot Locations																		
East St. Louis, IDOT	X			X			X	X			X			P	X			
Elis River Tunnels Norfolk/Ports VA	X	X	P	X	P	P	X	X	X		X				X	P		
I-64/Hampton Rd Br and Tunnel, VA	X	X	X	X	X	X	X				X			X	X	X		
SR 17/James Rd Br Newport News, VA	X	X	X	X		X	X	X			X							4 mi of 4-lane divided- no shoulders ADT=23,000
Oakland Bay Br. (SF)	X	X	X	X	X	X					X						X	
Howard Franklin Br. Tampa, FL	X	X	X	X	X	X		X	X	X			X		X	X	X	
Sunshine Skwy Br FL	X	X	X			X		X	X	X			X		X	X		
Escambia Bay Br. (2) FL I-10/US 98	X	X	X					X	X	X							X	
I-90/W Idaho			X			X											X	Roadway Conditions
US 95/Lewiston, ID			X			X												6 esc. ramps - 8mi dwngr
Ft. McHenry Tunnel Baltimore	X	X				X					X		X	X	X	X	X	
Dewey Sq Tnl, Boston														X				HAR override inside tnl
I-90, Montana																	X	Roadway Conditions
I-93/Franconia Notch New Hampshire														X			X	
Lincoln/Holland Tnls NY/NJ	X	X	X	X	X	X				X	X			P			X	
Lehigh Tnl PA, Turnpike	X	X	X	X	X	X		X			X						X	
Tappan Zee Br, NY	X	X	X	X		P	X		X		X		X		X	X	X	3 mile bridge - Hudson
Triborough Br & Tnl Author, NY	X	X	X		P	X		X			X				X	X	X	7 Bridges - 2 Tunnels

(7)

The FHWA study also revealed that about one-third of the total vehicle delay is due to lane blocking accidents, and the other two-thirds is due to minor incidents (those confined mostly to the shoulders and lasting less than 30 minutes). The savings associated with this type of program are shown in Figure 1.

Services patrols perform a variety of functions, but always with an overriding emphasis to maximize safety and minimize the operational impact of freeway incidents. Some of the typical duties that service patrol operators are assigned and trained to handle include:

- *Continuously patrolling a designated area seeking disabled vehicles, stranded motorists, debris in the roadway, spilled loads, accidents, obstructions to traffic, and other potential hazards or abnormal occurrences -- then notifying appropriate highway and enforcement personnel of the location and nature of the situation.*
- *Assisting motorists by towing and/or pushing disabled vehicles out of the roadway, providing gasoline or water, changing tires, providing jump starts with booster cables, performing minor repairs when and if possible, etc.*
- *Notifying enforcement authorities of abandoned vehicles along the roadway -- noting location, make, color, body type, license number, and whether or not the vehicle is impeding traffic. If not impeding traffic, tag the vehicle for removal under local regulations. If it is impeding traffic, notify enforcement personnel that (1) they will remove the vehicle if so authorized, or (2) immediate assistance is required if they are not authorized.*
- *Assisting at freeway accident scenes by providing emergency first aid, notifying enforcement agencies, removing damaged vehicles from the roadway, supplementing or providing traffic control at the scene, assisting in extricating injured motorists, providing and/or coordinating communications at the scene, providing motorist information, traffic reports, etc.*
- *Removing debris from the roadway -- accident or otherwise, or calling for assistance for more complex cleanups.*
- *Assisting in setting up, maintaining, and removing emergency detour routes required because of an incident.*
- *Providing any other assistance as requested by State and/or local enforcement agencies (Highway Patrol, State Police, City Police, Sheriff's Department, etc.).*
- *Maintaining an established service patrol log, completing an entry for each incident encountered and/or handled.*

- *Assisting at major accident scenes and other disasters, providing personnel, equipment, and traffic control support.*

Responding to heavy truck incidents can be particularly difficult for highway agencies. The Minnesota Department of Transportation has spent significant effort focusing on new directions and innovative solutions to heavy truck incident management. One recommendation arising from their efforts was to support the towing industry's efforts to persuade manufacturers to build into trucks a system to unlock their brakes for towing. Another suggestion was to reduce allowable truck speeds on ramps where truck rollovers are more likely to occur. In 1989, trucks comprised about 3% of rush-hour traffic and were involved in 11 to 12% of accidents. On average, it took 50% longer to clear the freeway after a truck incident than after a car accident. Table 4 gives a summary of research results on the characteristics of large truck accidents (9).

Also, accidents occurring from January of 1985 through September of 1988 on 74.8 kilometers (46.5 miles) of urban freeway were inspected. A total of 2,221 accidents were verified by the vehicle identification number and/or the description of the original accident report as involving a truck over 4,536 kilogram (10,000 lb) gross vehicle weight. Accident information was placed into a database file to provide a homogeneous database with the required format to address projects needs. A total of 17,962 accidents involving only passenger vehicles were identified as occurring on the same freeway segments and during the same period. The results presented below are based on analyses of these data.

- *More truck accidents occurred on Friday (468 of the 2,221 truck accidents or 21.1%) than any other day for all types of trucks combined. Tractor/semitrailers experienced a greater percentage of their accidents on Friday than any other day of the week.*
- *Single unit trucks with trailers experienced 32.7% (55 of 168 of all accidents) of their accidents during wet road conditions. This exceeds the wet road surface accident experienced by any other truck-trailer combination.*
- *Nearly three-fourths (74.1%) of tractor/trailer accidents involve at least one other vehicle.*

Table 4. Summary of Research Results on the Characteristics of Large Truck Accidents

Study Area	Facility Type	Summary of Findings
20 States	urban freeways	The accident rate for trucks rises from 37 per 100 MVKmT to over 75 per MVKmT in the proximity of interchanges.
California	urban freeways	Left-hand ramps had the highest average accident rate of 10 ramp types.
6 States	urban freeways	Most truck accidents are not related to interchanges or ramps.
(summarized prior studies)	all types	Doubles are involved over three times as often in single-vehicle accidents and over twice as often in all accidents as singles.
Nationwide	all types	Singles have a lower fatal accident rate than doubles.
Nationwide	all types	Doubles are over involved in every major non-collision accident.
Washington	interstate	Truck configuration was the predominant truck characteristic affecting accident rate.
Nationwide	all types	Straight-trucks, flat beds and tanker type tractor-trailers have high fatality and injury rates.
Nationwide	interstate	Truck involved fatal accidents are greatest in July and on Fridays.
Nationwide	all types	Approximately 40 percent of truck involved fatal accidents occur during darkness on roads with no artificial light.
Indiana	toll roads	Truck accident rates are similar for day and night conditions and lower during rainy conditions.

9)

- *Tractor/semitrailers were involved in 68.9% of the 103 accidents with 4 or more vehicles. These accidents involved a total of 326 vehicles with one accident involving 16 vehicles. Single unit trucks without trailers accounted for 17.5% of all the 4 or more vehicle accidents involving a total of 81 vehicles, the largest accident of which included seven vehicles.*
- *Cargo spillage occurred in 114 of the 2,221 accidents (5.1%). Of these, tractor/semitrailers had the greatest incidence (66.7% or 76 of 114 accidents) of cargo spillage accidents. Tractor-semitrailers were the greatest contributors to incidents of fuel leakage and vehicle fire, although both of these occurrences were relatively rare.*
- *Tractor/semitrailers had 52.5% (843 of 1,605 accidents) of their accidents occur as sideswipes. The largest percentage of single unit truck accidents occurred as rear-end accidents (43.0% or 211 of 491 accidents).*

- *For the 205 accidents which occurred in a right-hand merge area, the truck was on the freeway rather than the ramp in 90.7% of the 205 accidents. Similarly, for those accidents which occurred in a right-hand exit area of the freeway, the truck was on the freeway in 73.0% or 89 of the 122 accidents. This indicates that the truck was not the vehicle performing the merge maneuver when the merge accident occurred.*
- *Tractor trucks with double trailers had the highest fatality rate with an average of 21.7 fatalities per 1,000 accidents. Injury rate by straight trucks with trailers exhibited an average injury rate of 494.0 injuries per 1,000 accidents.*
- *Eleven persons were killed in the 2,221 accidents involving at least one truck. This results in an average of 5 persons killed for every 1,000 accidents involving at least one truck. For the 17,962 accidents involving other vehicles, 39 persons were killed for an average of 2.2 persons per every 1,000 accidents. Similarly, the 2,221 accidents involving at least one truck injured 866 persons, while the 17,962 accidents involving other vehicles resulted in a total of 9,643 persons being injured. The resultant rates are 389.9 persons injured per 1,000 accidents involving at least one truck and 536.9 persons per 1,000 accidents involving passenger vehicles.*
- *An estimate of the total annual cost of urban freeway accidents was determined to be \$1,020,296 per freeway kilometer (\$634,000 per freeway mile). This cost consisted of accident costs of \$292,893, delay costs of \$708,092, clean-up costs of \$4,828, and operating costs of \$14,484 per freeway kilometer. Expanding this estimate to the 3,117 Interstate and 901 freeway kilometers with average daily traffic volumes of over 100,000 vehicles results in a nationwide annual cost of \$1.6 billion.*

In 1990, the Washington State Department of Transportation (10) prepared and published the first report in assessment of incident management strategies nationwide. Table 5 indicates various incident mitigation strategies and utilization by eight major metropolitan areas nationwide. The advantages and disadvantages of each strategy are discussed in the report.

In 1990, the Massachusetts State Police adopted the Incident Command System (ICS) as part of its overall incident management system (11). The ICS is a documented system that has been successfully used in managing available resources in times of emergency incidents, including simple motor carrier accidents which develop into major incidents requiring drastic emergency response measures.

Table 5. Incident Mitigation Strategies and System Utilization

<u>Administrative Options</u>	Chicago	Houston	Detroit	Los Angeles	Seattle	Toronto	Minneapolis	Cincinnati
Vehicle Removal	X	X	X	X	O	X	X	O
Dedicated Patrol	X	X	X	X	X	X	X	X
Emergency Lights/Screens	X	O	O	X	X	O	O	O
Accident Investigation Sites	O	O	O	O	O	O	O	O
Equipment Storage Site	O	O	O	O	O	O	O	O
Removal Crane	X	X	O	O	O	O	O	O
Patrol Car Push Bumpers	X	X	X	X	X	X	X	X
<u>Organizational Options</u>								
<u>Organizational Options</u>	Chicago	Houston	Detroit	Los Angeles	Seattle	Toronto	Minneapolis	Cincinnati
Interagency Agreements	X	X	X	X	O	O	O	O
Traffic Management Teams	X	X	O	X	X	O	O	O
Incident Phone Number	O	O	O	O	X	X	X	X
Variable Message Signs	X	X	X	X	X	X	X	X
Media Ties	X	X	X	X	X	O	O	O
Transit Radio	O	O	X	X	O	O	O	O
Incident Response Teams	X	X	O	X				
<u>Preplanning for Incidents</u>								
<u>Preplanning for Incidents</u>	Chicago	Houston	Detroit	Los Angeles	Seattle	Toronto	Minneapolis	Cincinnati
Alternate routes	X	X	X	X	X	O	O	O
Emergency Vehicle Access	X	X	X	X	X	X	X	X
SURVEILLANCE/CONTROL*								
	Chicago	Houston	Detroit	Los Angeles	Seattle	Toronto	Minneapolis	Cincinnati
Police Patrol	X	X	X	X	X	X	X	X
Motorcycle Patrol	O	O	O	O	X	O	O	O
Tow Truck Patrol	X	X	X	X	X	O	X	X
Aircraft	X	X	X	X	X	O	X	X
CB Monitoring	X	X	X	X	X	O	X	X
Cellular Phone	X	X	X	X	X	O	X	O
Call Boxes	O	X	X	X	X	O	X	O
Highway Advisory Radio	X	X	X	X	X	X	X	X
Volunteer Watch	O	O	O	O	O	O	O	O
Loop Detection	X	X	X	X	X	X	X	X
Video and CCTV	X	X	X	X	X	X	X	X

* (X--In Use, O--Not in Use)

The ICS is a classic military command and control model. The system provides planning functions in advance of incidents, command and control mechanisms for personnel, facilities, equipment, and communications to insure operational effectiveness and coordination, and on-going training.

Of specific importance, the ICS emphasizes evaluation of the incident scene. This is stated as follows:

The initial responsibility of the law enforcement responder is the evaluation (size up) of the incident, and the prompt and accurate relay of information from the scene to the central command and control center. This evaluation must be thorough, and establish priorities for the incident. The type of information communicated from the scene should include the Situation Analysis - Present Status, including:

- The exact location of the incident.
- The severity of damage.
- Existing threats such as fire, explosion, chemical spills, downed electrical wires, structures in danger of collapse, etc.
- The number, types, and severity of injuries.
- The necessity for evacuation or the restriction of vehicular or pedestrian traffic.
- The number and locations of trapped victims.
- The nature and number of resources required.

In addition, this Situation Analysis should include a forecast of incident conditions whenever possible. Examples of this type of information would be:

- *The possibility of hazards spreading to adjacent structure/areas.*
- *Weather influences affecting the incident.*

- *Projected duration of the incident.*
- *Probable effect of the incident on natural resources (drinking water supplies, etc.)*

Communication of this extremely important information allows for the expeditious dispatch of the proper number and types of resources that will be needed at the incident scene.

Also in 1990, Cambridge Systematic, Inc. studied what was being done to deal with incident congestion and recommended actions to reduce the time lost to highway incidents (12). The study concluded that the major impediments to development of comprehensive metropolitan incident management programs were organizational and institutional.

The report outlined the following organizational approaches used by successful incident management programs:

- Traffic management teams;
- Traffic operations centers;
- Dedicated service patrols;
- Incident command systems;
- Contingency planning;
- Quick clearance policies;
- Partnership with commercial radio and television stations; and
- Strong service organization.

The study recommended that states mandate the development of comprehensive metropolitan incident management programs; assign responsibility for implementation of these programs; and establish clear lines of authority for the management of incidents. Also recommended was the need for states to adopt quick-clearance policies and require uniform annual reporting of incidents. Figure 4 provides composite profiles of incidents by type, location, and duration.

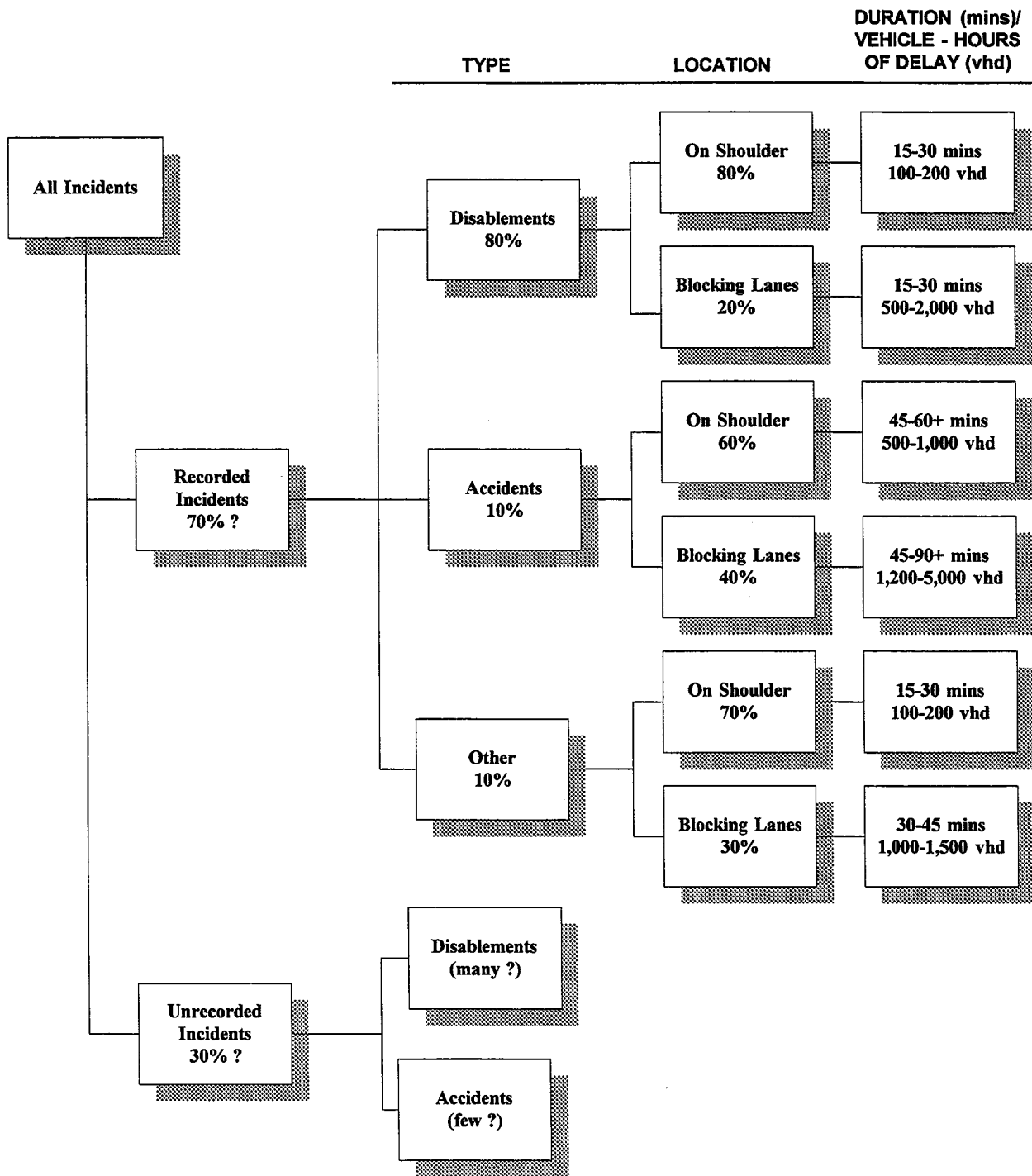


Figure 4. Composite Profile of Report Incidents

A survey conducted in late 1990 among current "active" agencies determined the state-of-the-art in incident response programs across the nation (13). Much variation was apparent in the number of incidents responded to, type of data recorded, and costs. Unresolved problems were stated as follows:

- Providing interagency radio communication for on-scene responders (nearly 300 municipalities in Chicago).
- Lack of proper tow truck sizes for removal of heavy vehicles.
- Inability to make timely response by all the various agencies, and companies making traffic decisions rather than incident decisions.
- Not having an active incident response team on duty around the clock.
- Getting the staffing level of the IRT's increased to provide a 24 hr/day program throughout the area.
- Difficulties with interagency coordination, communication, and response time; upper management support in design and operations.
- Lack of legislation for hazardous waste disposal costs; signing for and use of alternate routes.

The National Cooperative Highway Research Program also published a synthesis report on freeway incident management that same year (14). Table 6 from that study outlines measures for an "ideal" incident management system.

In 1990, the Department of Transportation in the Commonwealth of Virginia prepared the Northern Virginia Freeway Management Team operation manual (15) for agency use. The purpose of this manual was to document an operational plan and certain traffic management procedures for use by agency personnel at the scene of accidents, breakdowns, spills, and hazardous materials incidents that occur on the freeway. These include both the major and minor incidents. The manual includes detailed statements of authority and responsibility, action and equipment checklists, extensive alternative route plan maps, and communication guidelines. It is an excellent example of a major incident response document.

Table 6. Measures for an Ideal Incident Management System

Need	Measures to Address the Need
<p>Detecting and determining the nature of incidents.</p>	<p>Organize existing information sources into a comprehensive network for detection of incidents.</p> <p>Design, build, and maintain an electronic surveillance and detection system.</p> <p>Place closed-circuit television cameras along critical freeway links and at particularly troublesome locations.</p> <p>Use other systems and procedures to gather all available information regarding what is happening on the freeway system.</p>
<p>A focal point for processing data, collecting, and disseminating information.</p> <p>Active management of major incidents to speed removal of incidents, and to manage traffic to minimize congestion throughout the duration of incidents.</p>	<p>Establish a traffic operations center, appropriately equipped and staffed.</p> <p>Use electronic displays, maps, or other means to visually depict freeway operating conditions.</p> <p>Develop communications systems to receive and dispense information.</p> <p>Establish procedures and working relationships to bring about coordinated response efforts by various agencies.</p>
<p>Quick removal of incidents from traffic lanes.</p>	<p>Form incident response teams.</p> <p>Use truck-mounted variable message signs and highway advisory radio systems.</p> <p>Design planned alternative routes.</p> <p>Make use of service patrols that operate with vehicles capable of removing relatively lightweight vehicles from the freeway.</p>
<p>Quick removal of major incidents.</p>	<p>Have heavy service patrol vehicles and/or tow trucks available that are equipped to remove stalled heavy vehicles from traffic lanes.</p> <p>Establish tow truck services to provide needed services in a timely manner.</p>
<p>Provide traffic information to motorists.</p>	<p>Use variable message signs located at key locations throughout the freeway system.</p> <p>Use portable variable message signs that can be positioned and operated in conjunction with incident management.</p> <p>Establish a highway advisory radio system, either ground-mounted or portable.</p> <p>Develop a network of commercial radio stations to broadcast information and develop the means to quickly provide information to those radio stations.</p>
<p>Traffic management for construction, maintenance, and special events.</p>	<p>Create systems to provide information about long-term traffic conditions to print media.</p> <p>Institute the procedures and recruit the staff to develop traffic management plans for major activities.</p> <p>Organize an extensive public information effort for each major event.</p> <p>Apply incident management measures throughout the duration of each event.</p>

A study by the Texas Transportation Institute for the Texas Department of Transportation in 1991 addressed traffic management for major emergencies (16). Table 7 gives a planning framework for major transportation emergencies.

Research by the Pennsylvania Transportation Institute in 1991 led to the development of real-time diversion strategies for incident diversion (17). The user-optional approach reroutes motorists through the shortest alternate paths to their destinations. The system-operational approach affects diversions to optimize the utility of the system facility.

Work has also occurred on the potential application of expert systems to freeway incident management (18). Research at the University of California in 1991 involved the implementation of an artificial intelligence-based real-time expert system to provide operator decision support in responding to non-recurring (incident) congestion on urban freeways. Figures 5 and 6 illustrate a decision flow chart and expert system interface with incident detection, verification, and response functions.

Also in Pennsylvania that same year, the Department of Transportation began implementation of a comprehensive state-of-the-art traffic and incident management system for interstate freeways in the Philadelphia area (19). The components of this new system include:

- Loop detection system
- Ramp metering system
- Accident investigation site system
- Television surveillance system
- Changeable message sign system
- Radio/media advisory system
- Traffic control center
- Communications system
- Intelligent vehicle highway system
- Highway patrol
- Emergency high speed crossovers

Table 7. Planning Framework for Major Transportation Emergencies

Phase of Emergency	Agency Focus of Emergency Responsibilities	Description of Agency Emergency Actions	Preparations to Enhance Agency Actions
Prior to the Emergency	<ul style="list-style-type: none"> • Move to "alert" emergency response status • Prepare the transportation system to facilitate mobility and endure emergency conditions 	<ul style="list-style-type: none"> • Implement an emergency transportation plan • Monitor status of impending emergency conditions 	<ul style="list-style-type: none"> • Evaluate transportation system and develop action plan • Establish person or agency to designate initiation of emergency response efforts
During the Emergency	<ul style="list-style-type: none"> • Maintain mobility of the transportation system to the extent possible • Support other agency roles in efforts to minimize loss of property and life 	<ul style="list-style-type: none"> • Identify and respond to problems in the transportation system as they arise • Notify public of transportation problems • Provide personnel, equipment, and supply assistance to other agencies • Manage outlay of equipment and personnel resources 	<ul style="list-style-type: none"> • Establish interagency coordination and mutual-aid agreements • Establish intra-agency and interagency communication networks • Develop and maintain personnel and equipment resource lists • Develop methods of notifying the public of conditions of the transportation system
After the Emergency	<ul style="list-style-type: none"> • Restore transportation system to pre-emergency conditions • Support region wide clean-up and repair efforts 	<ul style="list-style-type: none"> • Assess damage to transportation system and prioritize repair efforts • Assist other agencies in damage assessments 	<ul style="list-style-type: none"> • Identify protocols and documentation procedures for receiving assistance • Develop mechanism of prioritizing recovery needs in the transportation system

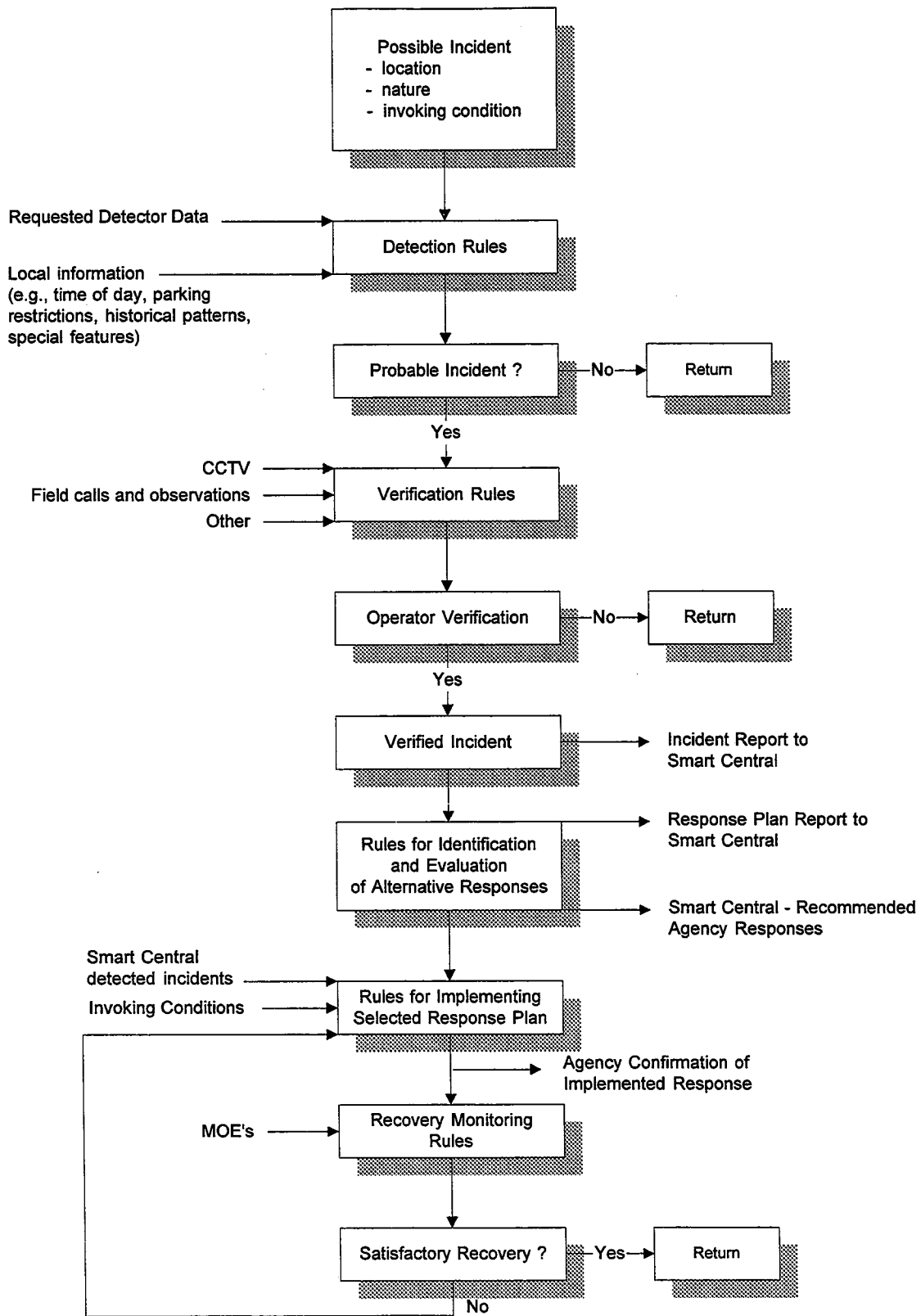


Figure 5. Major Freeway Incident Flow Chart

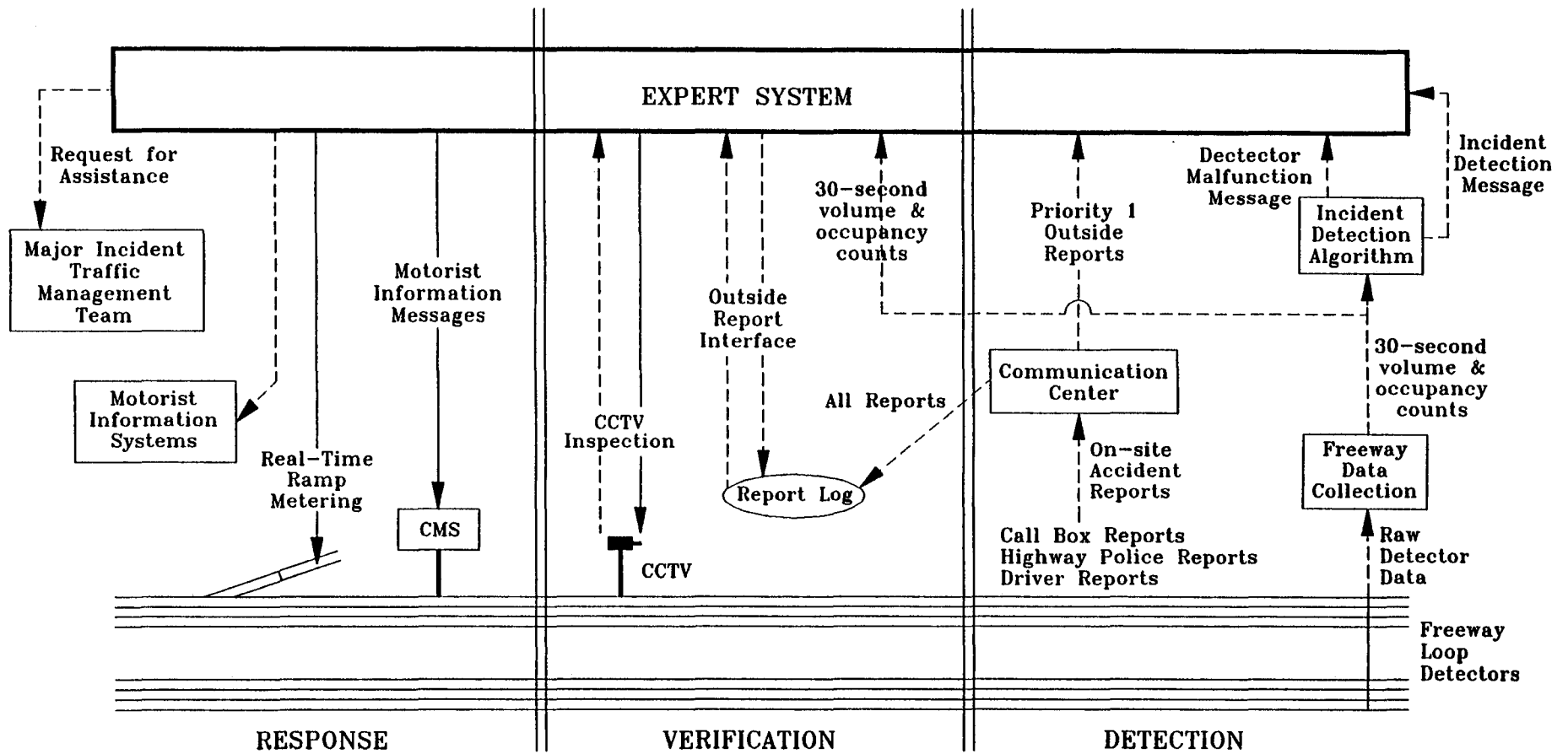


Figure 6. Expert System Overview

- Fire service facilities
- Supplemental signs

A report completed in March of 1991 documents the impacts of two service patrol demonstrations performed in the Puget Sound metropolitan area during the 1990 Goodwill Games (20). As a result of these patrols, substantial decreases in incident duration were measured within the study area during the demonstration. Disabled vehicles were removed more quickly creating less hazard on the roadway.

The Florida Department of Transportation implemented the Major Accident Record System (MARS) in 1991 (21). The system was developed as a database of major accidents, as shown in Table 8. Average delays were calculated for each category. The MARS enables one to quantify the magnitude of the impact of major accidents on users in the study area (Table 9).

The first incident management conference for the Commonwealth of Massachusetts took place in June, 1991 (22). In reviewing exemplary programs, the following list of five steps to creating a successful incident management program were identified:

- A clear mandate for managing incidents and the traffic problems that they create must be established.
- An agency or organization must be assigned the responsibility to set up and coordinate an incident management response (includes traffic patrols and a quick clearance policy).
- Involve the media in the information system.
- Funding should be designated for the incident management program.
- Incident management records and reports must be kept.

The Federal Highway Administration published a freeway incident management handbook in 1991 to serve as a guide for agencies wishing to initiate an effective incident management program (23). It was designed to aid transportation officials with operational responsibility in state and local departments of highways, traffic, or transportation, police, fire, and emergency

Table 8. Major Accident Categories

Accident Category	Description
01	Truck-Hazardous material & fire
02	Truck-Hazardous material
03	Truck-Fire
04	Truck-Fatality
05	Truck-Jackknifed tractor-trailer
06	Truck-Overturned
07	Truck-Injuries
08	Truck-Many vehicles involved
09	Truck-Vehicle disabling
10	Truck-Other
11	Auto-Fire
12	Auto-Fatality
13	Auto-Injury
14	Auto-Many vehicles involved
15	Auto-Simple [minor accident]

(21)

Table 9. Impact of Major Incidents in Florida

FM TEAM	No. of Incidents	Delay (mill vht)	User Cost (mill \$)	Fuel Cost (mill \$)	Total Cost (mill \$)	Fuel Consumed (mill l)/ (mill gal)	Emissions (tonnes)/ (tons)
TAMPA BAY	558	1.9	14.4	7.7	22.0	29.1 (7.7)	139 (137)
Hillsborough	444	1.6	11.7	6.2	17.9	23.5 (6.2)	113 (111)
Pinellas	114	0.4	2.7	1.4	4.2	5.3 (1.4)	26 (26)
JACKSONVILLE	418	1.5	10.9	5.8	16.8	22.0 (5.8)	106 (104)
ORLANDO FMT	240	0.8	5.9	3.1	9.0	11.7 (3.1)	57 (56)
Orange	192	0.6	4.8	2.6	7.4	9.8 (2.6)	47 (46)
Seminole	48	0.1	1.1	0.6	1.6	2.3 (0.6)	10 (10)
BROWARD	545	2.1	15.5	8.3	23.7	31.4 (8.3)	149 (147)
DADE	815	2.5	19.0	10.2	29.2	38.6 (10.2)	184 (181)
PALM BEACH	390	1.2	8.8	4.7	13.6	17.8 (4.7)	85 (84)
TOTAL	2966	9.9	74.6	39.8	114.3	150.7 (39.8)	719 (708)

vht - vehicle hours travelled

(21)

medical services personnel, environmental protection officials, tow truck operators, and administrators involved with managing roadway incidents. Table 10 from this handbook specifies incident magnitudes while Table 11 outlines incident management measures.

Table 10. Incident Magnitudes

Characteristic	Minor	Major
Duration	< 1/2 hour	> 1/2 hour
Blockage	Shoulder area only	One or more travelled lanes
Contribution to Overall Incident Caused Delay	65%	35%

(23)

Also in April 1991, the Washington State Transportation Center prepared a report for the Washington State Transportation Commission which established a framework for developing incident management systems (24). This document noted that incident management systems encompass five basic tasks. These tasks include:

- Incident detection and verification;
- Incident response;
- Incident site management;
- Incident clearance; and
- Motorist information.

Tables 12-16 from this report identify and comment on options to reduce detection/verification time, improve response time, improve site management, reduce clearance time, and improve motorist information. There are many options that provide a very high benefit/cost ratio analysis within each of the incident related options. Some of the options are more optimistic than others, given an area's manpower and budget constraints.

Because of the number of incidents and the magnitude of their consequences, the Virginia Department of Transportation made a concerted effort to ensure that incident management became a top priority and spearheaded an effort to initiate a state-wide incident management program (25). This program was concerned with preventing incidents and with detecting, responding to, and clearing incidents after they occur. Formal incident management programs in three large urban areas in addition to other efforts by the Virginia Department of Transportation, the Virginia State Police, and Fairfax County are summarized. The documentation contained herein can be

Table 11. Incident Management Measures

INCIDENT MANAGEMENT					
Reduce Duration			Restore/Maintain Capacity	Reduce Demand	
Detection	Verification	Response	Removal	Information to Motorists	Traffic Management
Electronic/ computerized detection Enforcement Personnel/patrols Maintenance/ construction/ other personnel Service patrols Fixed observers at strategic locations Transit, taxi, trucking organizations Traffic reporters/ commercial traffic information services Aerial surveillance Motorists • Call Boxes • Cellular telephone/ "hot" lines • CB radio	Assimilate information from: • Enforcement personnel/patrols • Courtesy patrols • Service patrols • Closed-circuit TV • Citizens Band Radio • Traffic Reporters • Aerial surveillance • Cellular telephone • Emergency call boxes • Other Display/record information Communicate information to appropriate agencies	Pre-planning Enforcement Agencies Response teams Service Patrols Fire, medical, environment, maintenance, other Interagency communication Specialty teams (Haz-mat) Tow truck agreements Commercial Alpha-Numeric Pager Strategic location of materials and equipment	Appropriately equipped response vehicles Training of response personnel Service patrols Off-freeway accident investigation sites Push aside/remove later (push bumpers) Defer removal until off-peak Rapid removal policies	Diversion information • Variable message signs - Permanent - Portable • Highway advisory radio - Permanent - Portable • Commercial Alpha-Numeric Pager • Media outlets - Commercial radio - Cable TV - Print Media - Other media	On-scene traffic management • Lane closures/reopenings • Freeway closures/reopenings Implement pre-planned alternate routes

Table 12. Options for Reducing Detection and Verification Time

Type of Program	Potential Benefits	Potential Costs	Comments
Peak Period Motorcycle Patrols	▬▬▬▬▬	\$\$\$>\$\$\$	Roving motorcycle patrols can provide added surveillance along high incident segments of freeway.
Dedicated Freeway/Service Patrols	▬▬▬▬▬▬▬▬▬▬▬	\$\$\$>\$\$\$\$	Roving patrols along high incident segments of the freeway can serve to reduce incident detection times.
Motorist Aid Call Boxes/Telephones	▬▬▬	\$\$\$	May incur added costs or complications because of required utility work.
Incident Phone Lines	▬	\$\$	Requires an initial publicity effort and continued cooperation with media agencies.
Cellular Telephones	▬▬▬▬▬	\$	Information should be distributed to cellular phone users describing proper incident reporting techniques.
Citizen Band (CB) Radio Monitoring	▬▬▬	\$	Information should be distributed to CB radio operators describing proper incident reporting techniques.
Volunteer Watch	▬	\$	Training efforts may be wasted on short-term or non-dedicated volunteers.
Ties with Transit/Taxi Companies	▬▬▬▬▬	\$	Can be expensive to cover all routes or limited to only those who travel on the freeway or other high incident areas.
Aircraft Patrol	▬▬▬▬▬▬▬▬▬▬▬	\$>\$\$\$\$	May be limited by noise or density restrictions.
Electronic Loop Detection	▬▬▬	\$\$\$\$	Can also serve other operations functions, but may give false calls in incident detection.
Video and Closed Circuit TV	▬▬▬▬▬▬▬▬▬▬▬	\$\$\$\$	Can also serve many other operations functions such as volume, speed, and vehicle classification data collection.
Central Information Processing and Control Site	▬▬▬▬▬	\$\$\$	Centralization of information allows for better verification of incidents.

▬ = Minor benefits
 ▬▬▬ = Moderate benefits
 ▬▬▬▬▬ = Substantial benefits
 ▬▬▬▬▬▬▬▬▬▬▬ = Very substantial benefits
 ▶ = Indicates a range of benefit/cost level
 \$ = Minor costs
 \$\$ = Moderate costs
 \$\$\$ = Substantial costs
 \$\$\$\$ = Very substantial costs

Table 13. Options for Improving Response Time

Type of Program	Potential Benefits	Potential Costs	Comments
Personnel Resource List	▬▬▬▬	\$	Can save time in locating specially trained personnel if list is comprehensive (involving all responding agencies) and frequently updated.
Equipment and Materials Resource List	▬▬▬▬	\$	Can save time in locating special equipment or personnel if list is comprehensive (involving all responding agencies) and frequently updated.
Peak Period Motorcycle Patrols	▬▬▬▬	\$\$▶\$\$\$	Motorcycle patrols can provide a direct communications link to request additional response assistance.
Dedicated Freeway/Service Patrols	▬▬▬▶▬▬▬▬▬	\$\$▶\$\$\$\$	Roving patrols can reduce the response times required by response vehicles departing from the freeway.
Personnel Training Program	▬▬▬▬	\$\$	An emphasis on personnel training through knowledge and repetition of tasks can reduce required response times.
Tow Truck/Removal Crane Contracts	▬▬▬	\$	Provides faster access to equipment, but may create dissension with other capable private agencies.
Improved Interagency Radio Communication	▬▬▬▬	▶\$\$\$	Adequate communication between the various responding agencies can help to insure that the closest response vehicle is called to the incident scene.
Ordinances Governing Travel on Shoulder	▬	\$	Can provide additional travel lane for response vehicles during emergencies but may be severely limited by space constraints.
Emergency Vehicle Access	▬▬▬	\$\$	Requires identification of those freeway links which suffer from poor access.
Alternative Route Planning	▬▬▬	\$	If properly planned, can allow quicker access to incident site by response vehicles.
Equipment Storage Sites	▬▬▬	▶\$\$\$	Provides faster access to equipment or materials.
Administrative Traffic Management Teams	▬	\$	Provides a forum to discuss and provide funding for area incident management programs aimed at improving response times.
Public Education Program	▬▬▬▬	\$	Can educate drivers regarding disabled vehicle removal policies and can resolve many incidents without the need for an actual response.
Central Information Processing and Control Site	▬▬▬▬	\$\$\$	Provides a single location for monitoring incidents so data from multiple sources can be used to more quickly determine the appropriate response action.
Closely Spaced Milepost Markers	▬▬▬	\$	Always fast, accurate, easy location of incidents which improves the speed with which response actions can be brought to bear.

▬ = Minor benefits
 ▬▬▬ = Moderate benefits
 ▬▬▬▬ = Substantial benefits
 ▬▬▬▬▬ = Very substantial benefits
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Table 14. Options for Improving Site Management

Type of Program	Potential Benefits	Potential Costs	Comments
Incident Response Teams	►■■■■■	\$►\$\$\$	Highly trained, coordinated response teams can greatly reduce site management delays and can reduce interagency conflicts.
Personnel Training Programs	■■■	\$\$	Highly trained personnel can speed the management process as well as reduce the number of interagency conflicts that may arise.
Peak Period Motorcycle Patrols	■■■■■	\$\$\$►\$\$\$	Motorcycle patrols have more maneuverability in highly congested areas and can access and carry out tasks vital to the incident management process (i.e., traffic control).
Improved Interagency Radio Communication	■■■	\$►\$\$	Direct communication between the various responding agencies can reduce repetitious commands and improve interagency relationships.
Command Posts	■■■	\$	Allows information and instruction to disseminate from a single, central location, improving efficiency and reliability of information.
Identification Arm Bands	■	\$	Allows quick differentiation between respondents and public or media personnel who may also be present.
Properly Defined Traffic Control Techniques	■■■■■	\$	Provides greater safety for motoring public, as well as improving the safety of the respondents
Properly Defined Parking for Response Vehicles	■■■	\$	Ensures that excess lanes are not blocked by response vehicles and smooth operation of incident management processes are not impeded.
Flashing Lights Policy	■	\$	Need to consider safety of respondents, liability, and impacts on normal traffic flow.
Administrative Traffic Management Teams	■	\$	Provides a forum to discuss and provide funding for area incident management programs aimed at improving site management efforts.
Central Information Processing and Control Site	■■■■■	\$\$\$	Central collection and analysis of incident information allows for more coordinated responses to incidents.
Alternative Route Planning	■■■	\$	Serves to improve both response and clearance efforts.
Incident Response Manual	■■■■■	\$	Predetermined chain of command and responses can facilitate decision-making, communications, and site management.

■ = Minor benefits
 ■■■ = Moderate benefits
 ■■■■ = Substantial benefits
 ■■■■■ = Very substantial benefits
 ► = Indicates a range of benefit/cost level

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 \$\$\$\$ = Very substantial costs

(24)

Table 15. Options for Reducing Clearance Time

Type of Program	Potential Benefits	Potential Costs	Comments
Policy Requiring Fast Vehicle Removal	■■■■■	\$	Serves to quickly restore the capacity of the roadway, but may require passage of an ordinance to be used.
Accident Investigation Sites	■	\$\$▶\$\$\$	Serves to improve the safety of the motoring public, as well as improving the safety of the respondents, by removing the incident from the roadway.
Dedicated Freeway/Service Patrol	■■■▶■■■■■	\$\$▶\$\$\$\$	Specially equipped freeway/service patrol vehicles can clear most minor incidents without the assistance of other response vehicles.
Push Bumpers	■	\$	Allows minor incidents to be cleared quickly.
Inflatable Air Bag Systems	■	\$\$	Improves clearance times for incidents usually involving overturned trucks; however, use is severely limited by the truck trailer type involved.
Responsive Traffic Control Systems	■	\$\$\$\$	Can improve clearance efforts by limiting congestion in the immediate area.
Variable Lane Closure	■	\$	Can speed clearance efforts by allowing the interruption of flowing traffic but may require a change in existing policy.
Ordinances Governing Shoulder Travel	■	\$	Can provide additional travel lane for removing disabled vehicles but may be severely limited by space constraints.
Emergency Vehicle Access	■	\$\$	Requires identification of those freeway links which suffer from poor access.
Alternative Route Planning	■	\$	If implemented simultaneously with motorist information programs, can serve to reduce congestion and improve mobility at the incident site by rerouting uninvolved vehicles.
Identification of Fire Hydrant Locations	■	\$	Can greatly speed clearance efforts by allowing the quick location of utilities in incidents involving fire.
Incidents Response Teams	■■■▶■■■■■	▶\$\$\$	Coordinated response teams should be trained in a variety of equipment use to provide greatest clearance capabilities.
Personnel Training Programs	■■■■■	\$\$	An emphasis on personnel training through knowledge and repetition of tasks can reduce required clearance times.
Incident Response Manual	■■■■■	\$	Once developed, should be included in regular training procedures to further clearance efforts.
Hazardous Materials Manual	■■■■■	\$	Once developed, should be included in regular training procedures to further benefit clearance efforts.
Administrative Traffic Management Teams	■	\$	Provides a forum to discuss and provide funding for area incident management programs aimed at improving clearance times.
Public Education Program	■■■■■	\$	Can educate drivers regarding disabled vehicle removal policies and can result in the immediate clearance of disabled vehicles off the freeway.
Total Station Surveying Equipment	■■■■■	\$\$	Can reduce the time required for accident investigation by nearly half.

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 \$\$\$\$ = Very substantial costs

Table 16. Options for Improving Motorist Information

Type of Program	Potential Benefits	Potential Costs	Comments
Improved Media Ties	■	\$	Information disseminated by the media must be effective and accurate and must, therefore, come from a single and central dissemination point.
Highway Advisory Radio	▶■■■	\$▶\$\$\$	Variations include mobile and truck mounted, but in each case must be kept current and accurate to be utilized by the motoring public.
Variable Message Signs	■	\$▶\$\$\$	Variations include flap, matrix, drum, permanent, and portable, but in each case must be kept current and accurate to be utilized by the motoring public.
Radio Data Systems (RDS)	■■■■	\$\$\$\$	Provides information to motorists when they want it, but is still in the early implementation stage.
Externally Linked Route Guidance (ELRG) Systems	■■■■■	\$\$\$\$	Provides the most comprehensive information concerning traffic situations, but is still in development stage.
Central Information Processing and Control Site	■■■■	\$\$\$	A central location which can collect data from multiple sources will be able to provide a more accurate picture of existing traffic conditions.

■ = Minor benefits
 ■■■ = Moderate benefits
 ■■■■ = Substantial benefits
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(24)

used to aid other states in developing incident management programs. Also in 1992, the Federal Highway Administration sponsored workshops focusing on relieving traffic congestion through incident management (26).

In a 1992 report by the Texas Transportation Institute for the Federal Highway Administration on Truck Accident Countermeasures on Urban Freeways (27), incident response management was specifically designated as of critical importance. This document emphasizes that the two primary issues involved in incident response for large trucks is providing a heavy-duty tow truck in a timely manner and clearing the roadway immediately of vehicles and/or spilled loads.

In 1993, a guide of emergency response for highway maintenance managers was available from the Washington State Transportation Center (28). This document was prepared for implementation in the Washington State Department of Transportation emergency management

procedures. This guide describes how agency personnel should respond to and manage emergencies resulting from natural disasters and technological incidents that impact the transportation system and associated physical plants. The guide further describes the organizational roles and responsibilities of agency management in response to disasters and incidents. A selected bibliography of published information relative to major freeway incident response is given in Appendix A (Volume II).

STATE-OF-PRACTICE IN TEXAS

A phone and questionnaire survey was conducted statewide at the beginning of this study. Experienced personnel with city/state transportation agencies, emergency medical service agencies, fire departments, law enforcement agencies, and hazardous material teams were queried regarding major incidents on freeways, investigative procedures and policies, and data record documentation of response actions. The following paragraphs summarize comments given by each city designated.

FORT WORTH

The District Safety Officer in the Ft. Worth District was contacted about information which would be available on major freeway incidents. Courtesy Patrol logs are the best source of information. He offered to allow TTI to use the information contained on the log sheets. Information contained in these log sheets was not sufficient for the study purpose. There were some useful details on the sheets such as services rendered, the amount of time needed to render the service, and notes pertaining to additional maintenance needs. However, the Courtesy Patrol does not remain at the scene of an incident for its duration. The Safety Officer stated that when the TxDOT Courtesy Patrol is the first unit to arrive at an incident, they set up whatever is necessary to make the accident site as safe as possible. If fire or police are already there, the Courtesy Patrol does not stop unless TxDOT needs to make repairs to the roadway.

The TxDOT Safety Officer suggested contacting the Ft. Worth Police Department. He stated that the police officers have work sheets for incidents they have worked which should provide some of the needed information. A Captain of the Ft. Worth Police Department was contacted and asked whether any records are kept on major freeway incidents. He stated that no statistics are kept on freeway lane closures, but stated that he would check with the TRASER software people in the police department to determine if they had any information.

Several persons at the Ft. Worth Fire Department were contacted. A Records Technician stated that a request must be initiated through their section. She stated that perhaps the EMS

department would provide the best source of information. An assistant at EMS stated that they can retrieve information on incidents from their mainframe computer database, but it would be very time consuming. She went on to say that their EMS reports are not very detailed. They would provide information on the patient, the time EMS was notified, and the time they arrived at the scene, but it would not provide information on lane closures or cause of the incident or accident.

Tarrant County EMS called to discuss their data availability. The data they have on file is for EMS calls on city streets only, with the exception of a few freeways. They do not keep records for an extended period of time unless a claim was filed against the city. To get this information, we must know an exact location. The Ft. Worth Police Department was contacted again to follow-up on the previous conversation. The TRASER personnel at the Ft. Worth Police Department do not have information that can be utilized for this study. When asked about his officers' work sheets, the Captain in charge stated that these are 21.6 X 27.9 centimeters (8 ½ by 11 inch) sheets which are completed by the officers for each shift, and they are not computerized. They would contain the time an officer was dispatched to an incident; however, officers who initially respond might have been relieved by another officer before the incident was cleared. He concluded by saying that their worksheets "would not be accurate in many cases." The other considerations with using their worksheets are that any evaluation of them would be extremely time consuming, and they are only kept on file for a period of 60 to 90 days.

CORPUS CHRISTI

The first contact in Corpus Christi was the TxDOT Division of Transportation Operations Supervisor. He stated that law enforcement officers usually report incidents, but information might be available from TxDOT Maintenance Supervisors.

One of the Maintenance Supervisors stated that no records are kept on how long a closure remains. He also stated that he does not think the district keeps records on closures related to incidents. However, he told the research team that most Maintenance Supervisors keep a diary. These diaries probably do not contain the detail that TTI might need unless the incident required

a detour. When asked whether law enforcement would have information on incidents, he replied that they probably keep a dispatcher's log. To use that, the investigator would first need to determine the date of an incident from the Maintenance Supervisor's diary. He remembered a burned bridge incident which occurred approximately 8 to 9 years ago. He mentioned another incident in which an overpass was hit by a large load approximately 8 months ago which forced TxDOT to close two of the total three lanes in one direction for 3 ½ hours. This was the most recent incident which has occurred within his jurisdiction.

The other Maintenance Supervisor stated that he does not keep records, but he described the actions he takes when an incident or an accident occurs on a State roadway within his jurisdiction. He calls the district office and describes the problem once it is detected and tells office personnel the mile point and lane affected. Then he calls them back when the lane is open again. He stated that the District Maintenance Engineer might keep a record of these lane closures. He stated that incidents and accidents on his sections of freeway are sporadic -- there might be two in one month, then none for three or four months. One needed change which he noted was for a form for all incidents, not just those which damage TxDOT property.

The District Maintenance Engineer was contacted by telephone to investigate what information they keep on incidents. He stated that his office did not maintain this information.

The Records Technician at the Corpus Christi Police Department stated that only accident reports are available to provide requested information. Accident information would be available to TTI through her supervisor, who is responsible for central records. However, the accident reports would probably not include all of the information we need. She emphasized that her department would not have the manpower to retrieve this information for TTI, because they are already understaffed. The maintenance supervisor stated that their diaries would contain dates of major incidents. These dates might be used to request detailed information from dispatcher logs. She replied that this would still require a substantial amount of effort, and their staff could not do it.

The Corpus Christi Fire Department was contacted to ask for incident information. The call was transferred to an individual in data records. She stated that their information is stored by street address only, and that their records are not computerized. When asked whether they could provide information on a segment of freeway, she responded that they could not.

EL PASO

The District Traffic Engineer was contacted at the TxDOT District Office, who stated that TxDOT does not keep the information that we need for this study, but he did provide a name and telephone number for the most likely source of the information. He gave the name of the Director for the Office of Emergency Management. Upon calling directory assistance in El Paso a contact was made at the El Paso Fire Department. In a follow-up conversation, he had discussed my request with their computer specialist. He stated that the information would require an enormous amount of time to retrieve. He mentioned that one county emergency response vehicle alone made 50 runs (did not mention time period). He was told that TTI only needed information on major incidents. He replied that the Fire Chief might approve the request if it does not require a large effort.

The El Paso Police Department stated that the only information they would probably have would be an officer's memory of recent incidents. The supervising officer mentioned a snow storm two weeks prior that completely closed the interstate for two hours. He also mentioned a fatality two months prior to that time when an automobile rear-ended a dump truck and caused significant delays to motorists. He stated that no ledger or records are kept of incidents on the freeway. Even their accident reports would not necessarily reflect incidents. The accident report might mention in the narrative description something regarding an incident which had caused the accident, but this would omit some incidents. He mentioned that there are incidents where two of a total of three lanes are closed, but the police are not called to the site. Even if some of their units respond, they do not keep detailed records of lane closures or other details which would be important to our study.

AMARILLO

The District Traffic Engineer for TxDOT was contacted in the Amarillo area. He indicated that their District did not keep track of the major freeway incidents. Furthermore, they have not discussed formal incident management efforts as yet within the Traffic Management Team they have established for the Amarillo area. He did not believe either the Police Department or the City Traffic Engineering Section kept track of major incidents.

The Amarillo Fire Department was contacted to inquire about information they may collect and keep regarding major freeway incidents. The Fire Chief in the training division referred us to the emergency management coordinator for the department. He indicated that they did not keep any type of records on incident characteristics such as frequency, location, duration, etc. He said no one at the department would be able to assist TTI, and suggested that contact be made with the police department. The Police Department was contacted, however; no one could provide the necessary information.

BEAUMONT

The TxDOT District Traffic Engineer was first called regarding major freeway incidents. He stated that the Department did not currently keep track of them. He suggested contacting the Beaumont Traffic Department or the Beaumont Police Department. He did say they were upgrading the HAR (Highway Advisory Radio) system they had and planned to collect incident data when it was activated. This system was scheduled to be operational sometime in early 1993.

The Beaumont City Engineer stated that he had cooperated with the police department to establish an alternate route plan for dealing with incidents occurring during the reconstruction of the US-69/I-10 interchange. This plan is enacted whenever it appears that the incident will require more than two hours to clear and will severely disrupt traffic.

The Beaumont Police Department stated that major incidents in Beaumont occur infrequently, and said they did not keep specific records of major incidents. The supervising

officer said they would have some data from the fatal accidents which occur (they are required to collect more detailed information at these accidents). He agreed to go through the past couple of years worth of records and summarize what information he could send to us regarding time and location of each fatal accident on the freeway, how severe the effect was upon traffic, its duration, and what response actions they employed.

The Beaumont Fire Department Training Division was contacted. The Fire Chief indicated that they maintained an active database which listed each response they made, and he could sort this file to pull out those which occurred on freeways. He is going to do this for the previous two years, if possible. Their records will have some information on the location of each call, the time of day, type of incident, and its duration (the time they went back to the station). However, they will not have any information on the severity of the incident in terms of its effect on traffic.

DALLAS

The North Central Expressway Mobility Task Force Coordinator was contacted regarding incident data for the Dallas area. He indicated that records from the newly-established service patrol on the Expressway might have some data that could be obtained. However, frequently the patrol does not get involved in the major incidents when police, fire, and other agencies have responded. He suggested TTI contact the Dallas Police Department. A subsequent contact with the Dallas Police Department revealed that although the Department had at one time kept some records for major freeway incidents, they had recently been discarded. The Department currently does not maintain a file on major incidents.

A copy of some of the daily logs of the Dallas MAP vans operating on the North Central Expressway was received. Unfortunately, the logs indicate only the time on scene, the approximate location, the basic type of problem (mechanical, tire, accident, etc.), whether or not it blocked a lane (the number of lanes is not noted, however), and whether or not a tow truck was called. It is not possible to determine the types of vehicles involved (or the number involved) nor the duration of the incident. Consequently, this data is not useful to the study.

The Dallas Fire Department was also contacted, specifically the Public Information Officer. She stated they kept information relative to the Department's performance (total number of responses, average response time, etc.), but did not keep information on a response-by-response basis. For example, she could not determine the number of major incidents responded to (involving two or more cars) nor could she subdivide according to roadway type. Likewise, she could pull out the number of responses to hazardous material accidents and spills, but not by roadway type. In addition, no information is kept regarding incident duration, severity, time-of-day, etc. She indicated that no one else within the Department had this information either.

AUSTIN

The City of Austin Traffic Engineer was contacted as a starting point due to his cooperation with the local area Traffic Management Team. The District Traffic Engineer of the Austin area district (TxDOT) was also contacted to investigate the State's involvement in incident response and records. He indicated that the State does not have any centralized database on incident records. However, the maintenance department areas do have disposition logs on their respective response team allocations.

The Austin Police Department was contacted to investigate APD's role within incident response, management, and records. The officer stated that APD only has accidents listed by date and location. In addition, the duration for each incident is acquired through the dispatch logs which are only kept on file for 45 days and then erased. He also suggested that TTI contact the City of Austin Engineering Department as they are working on signal synchronization along I-35.

The Austin Fire Department was contacted about AFD's involvement in incident response in the Austin area. The Fire Department official stated that AFD only keeps individual (hard copy) records for 90 days. After that time they are transferred to their Statistical Analysis Department. This department supplies federal and state agencies with statistical analysis reports of incidents for AFD. He indicated that his records are updated from 1989 to present and could possibly be transferred to computer disk. He would investigate the possibility of this transfer.

The Fire Protection Engineer at the Fire Prevention Division of the Austin Fire Department was contacted regarding information that they maintain on incident responses. He said that the Operations Division of AFD is responsible for reporting the response to incidents, and they use a standard form which is only maintained in hard copy form in chronological order. Their records have such information as the location and date of the incident, the nature of the incident, injuries and deaths, as well as a 75-character description of the incident. Records date back to 1988 with 1991 being the first year with complete files.

The Austin EMS was contacted regarding the records they maintain on incidents on major freeways in Austin. They maintain information on all calls dating back to 1985. The information includes the following specifics: type of call, where the call occurred, which trucks were sent to the site, what happened at the site, and how the call ended (i.e., injury to hospital, death). Since March 1988, EMS went to a computer-aided dispatch system which includes the exact times of dispatch. Austin EMS logs between 35,000 and 40,000 calls each year, a very large portion of which are traffic-related calls. A request was sent for data on major traffic accidents on the following major freeways and facilities in Austin: IH 35, US 290, MOPAC (Loop 1), SH 71, Loop 360, and US 183. The files were sorted according to the request, and a memo field was included in each record in order to access the original dispatch records. The data included approximately 6,500 records.

The City of Austin Signals Department was contacted in order to discuss Austin's plans for altering frontage road and arterial signal cycles in the event of major freeway incidents. The City Traffic Engineer explained that approximately six months ago, the TMT started looking at incident management and the need to devise a plan for IH 35. To date, the project is in the proposal phase for obtaining IVHS funding for future activities. Once the funds are appropriated, they will be able to devote several employees to the project on a full-time basis. As of yet, they have no guidelines established for the plan. She did indicate that a probable designation of the severity of incidents based on lane closures would be as follows:

Level 1	1 lane closed
Level 2	2 lanes closed
Level 3	3 lanes closed.

SAN ANTONIO

The TxDOT District Maintenance Engineer was contacted to investigate the Courtesy Patrol (CAP) operation within the San Antonio area. He indicated that the CAP was established to assist motorists in only minor incidents and breakdown situations (similar to Houston's MAP operation). He also implied that his CAP logs and TxDOT Response Team disposition forms could be accessed. However, they were not in a computer format and could only be sorted by incident (i.e., date and location known). He stated that each maintenance department area had records of their Response Team involvement, but again incident records had to be accessed by date and location.

The San Antonio Police Department was contacted regarding the project. The supervising officer was briefed on the focus of the project, and he indicated that they keep a record of the number of accidents (expressway and local facilities) but do not maintain anything regarding hazardous materials.

The City of San Antonio Department of Public Works was contacted. The public works officer said that the SAPD maintains accident records which are the accident reports filed by the police officers on the scene. Public Works has access to the reports logged into a computer. However, because of the limited capability of the antiquated computer system, it is difficult to access the information. It was his opinion that SAPD had the best access to the files in question. For their personal files, Public Works obtains hard copies of accidents where fatalities are involved for reference regarding intersections. These records also have notations regarding accident type. However, these records are in hard copy form only.

The San Antonio Police Department Accident Records Bureau was contacted. The Records Technician said that they are on the same system as the rest of the city and it would be

next to impossible to access the records in question. The individual facilities would have to be identified, and she would have to pull all of the individual records and provide hard copies.

The EMS Administration with the San Antonio Fire Department also indicated that they were on the same system as the rest of the city. Like the SAPD, only hard copies of individual incidents could be obtained.

The Captain at Hazardous Materials, SAFD, was contacted. He was briefed on the project, and he offered to pull their specific files for 1991 and 1992 since they did not have many incidents. The records have dispatch times, type of incident, equipment sent, procedures, etc. Once he finishes his previous projects, he will print out hard copies of the files and either mail or fax them to TTI. These records were never received.

HOUSTON

The coordinators of the Motorist Assistance Program (MAP) for TxDOT were contacted regarding incident response procedures and records for the Houston area. They indicated that the MAP program's goal is to assist in the clearing of minor incidents and breakdowns within the Houston freeway network. MAP limits its involvement on major freeway incidents to detection of the incident and dispatch communication to the Houston Police Department (HPD). Once HPD is on scene they (MAP) are to continue their patrol in order to assist in any minor secondary incidents that might occur. There are some infrequent cases where MAP deputies might assist HPD in their traffic control activities. MAP records are also kept for every assistance call that is made by the deputies. These records are kept by TxDOT and can be accessed by date and location.

They also stated that HPD would probably have the most comprehensive database within the Houston area since they are the agency typically in charge on the scene. They suggested contacting HPD for access to this data. In addition, HPD does call TxDOT's Response Team to the scene of an incident if:

- There is freeway pavement or guardrail damage,
- There is cargo spill (i.e., liquids that require sand for clean up, cargo that must be moved with heavy equipment, etc.), or
- Assistance is needed to implement diversion strategies or evacuation (i.e., placement of arrow boards, portable changeable message signs, etc.).

TxDOT does keep a log of their Response Team involvement (disposition forms) on file. However, these forms are listed by date and location and do not always include detection, response, and clearance times. This information is possibly in the phone dispatch records for the district and/or with the equipment records within each maintenance department area. All these records could be cross-referenced as long as the date and location of the incident was known.

The Houston Fire Department Hazardous Materials Response Team is called to the scene of any major incident that involves a potentially hazardous cargo spill. In addition, unless TxDOT's MAP or Response Team is involved, the district would have no record of the incident on file.

The Houston Police Department's solo division was contacted to investigate incident response records and procedures for its division. The supervising officer stated that he had been keeping records of all freeway major incidents within the Houston area since 1986. He had initiated this record keeping in response to the city's request for additional officer requirements and current justification of his division. The division keeps all these records on file in a hard copy format.

The Hazardous Materials Response Team at the Houston Fire Department was also contacted regarding records they maintain on responses to hazardous materials incidents on major freeways. The supervising fire official indicated that they maintain records of all their calls dating back to 1980 (both hard copy and computer forms) and include such incident specifics as

the type of incident, the type of materials involved, the location of the incident, the time of day, and the total response time.

The Captain sent a copy of the Hazardous Materials Response Team's Annual Report for 1991 which gave a summary of all activity during that year. After reviewing the report, the Captain was contacted again in order to request hard copies of freeway incidents in 1991 (as mentioned in the Annual Report) and similar incidents in 1992. The number of incidents was small enough to make the hard copy request reasonable.

INCIDENT RESPONSE QUESTIONNAIRE

Approximately six months after the initial State-of-Practice investigation took place, a more intense questionnaire was developed. The design of this questionnaire gives more insight into the controlling factors involved in incident management procedures. Ideally, the research staff wanted to gather representatives from these different transportation agencies in one location to discuss the issues. However, differing schedules and fiscal constraints prohibited this from occurring.

Responses gathered from this peer review panel determined the incident response techniques and issues that were important to this study. These individuals were responsible members of their city's fire department, police department, emergency medical service, or the Texas Department of Transportation. Responses from this group of individuals that were common, or similar in nature, or seemed to be worthy of inclusion for others to use in formulating or improving their own incident response techniques are included in the discussion that follows.

Appendix A (Volume II) details information received from the Incident Response Questionnaire administered statewide to professionals involved in traffic management and emergency services. It includes specific data regarding communication problems, response times, clearance delays, agency cooperation, and improvement techniques.

The components of incident response (IR) that created the greatest delays (or took the longest to complete) before complete clearance for the cities contacted usually involved large truck rollovers, spilled loads, hazardous materials, multiple agency involvement, and serious injuries or fatalities. Many cities have historically been hesitant to immediately clear the roadway following a large spill if some of the load could still be salvaged. However, Ft. Worth has been very aggressive in clearing the roadway to get traffic moving again. Their justification is in being able to avoid or reduce secondary accidents that can occur at the end of the traffic queue and reduction in delay to motorists. Other cities are now realizing the importance of expeditious clearance in lieu of salvaging a load that may be substantially damaged anyway.

An important element of clearance where tractor-semitrailers have rolled over is returning them to their upright position. To do this, there are three companies in Ft. Worth with large air bags that can be placed underneath the overturned vehicle and slowly inflated to return the vehicle to its upright position for towing. Another critical factor is getting the correct equipment to the scene when a heavy-duty tow truck or crane is needed. Cities that use formal contracts with tow truck operators to set controls on maintenance of these vehicles and set limits on response time appear to clear the incident more quickly than if they did not have these controls. Immediate notification using accurate diagnosis of equipment needed results in huge delay savings to blocked motorists. In Ft. Worth, if the TxDOT safety officer knows enough about the incident from the initial telephone call, he immediately dispatches equipment to the scene. Some of the Ft. Worth police officers communicate with him from the scene by means of mobile phones in their patrol cars. Not all patrol cars are equipped with mobile phones, however. In other cities, TxDOT personnel are not confident in the diagnosis of need expressed by police officers and choose to drive to the scene themselves before dispatching equipment. This can result in extended delays.

Hazardous materials typically increase the time necessary to clear an incident, requiring the expertise of trained personnel to diagnose, contain, and remove the material. In many cases, there is delay in clearance due to awaiting another truck or trailer to load material onto and the time required to pump remaining materials from the overturned vehicle.

An innovation that some cities use is having equipment loaded (e.g., a sand truck for spills) at all times and dedicated specifically for immediate dispatch to an incident. Some cities, such as San Antonio and Austin, handle all injuries and the investigation of the incident before calling for assistance with clean-up. This delays getting clean-up initiated and sometimes requires a second request for traffic control to protect the clean-up crew.

Communications on an interagency basis during incidents is problematic in some cases due to a lack of common frequencies or similar radios. In Ft. Worth, TxDOT does not have the proper radios to communicate with police and fire departments, and EMS must be notified by their dispatcher to change frequency in order to communicate with the fire department. Houston needs more of the appropriate equipment available on a 24-hour basis. In Austin, the appropriate agencies do not all currently have the same frequencies.

Coordination between fire, police, and EMS agencies appears to be relatively efficient in most cities because most have dispatchers working in close proximity to each other. In a very high percentage of cases in these cities, the initial notification of an incident occurs by 911 calls. The call goes directly to the police dispatcher who then calls EMS and the Fire Department, if necessary. In cases where TxDOT has communications with police and receives the initial information, they also move immediately toward the scene. In many cases, however, TxDOT is not aware of an incident until a request is received from police.

Control at an incident scene just after it occurs depends upon which agency arrives first. From that point on, control depends upon the specifics of the incident. In most instances, police arrive first and take charge of traffic movement throughout the duration of the incident. In cities where courtesy patrols are used, the units sometime arrive at the scene first and take control until police arrive. Police take control of traffic until the incident is cleared, and they sometimes request support from TxDOT when clearance requires lane closures or other, more permanent traffic control for several hours. If fire or hazardous materials are involved, the fire department and their hazardous materials unit assume overall control of the scene. If there are injuries or fatalities, EMS takes control until casualties are removed from the scene. The Medical Examiner

assumes control of the investigation of fatalities and requires that nothing be disturbed until a complete investigation can be completed.

Contacts in cities involved in this research recognized that improvements could be made to improve the way their own agency responds to incidents. These could be in the form of increased personnel, common accurate maps that are the same among responding agencies, designated chemical routes, increased computer assistance in response vehicles or at least in satellite offices, and staging areas near freeways for removing damaged vehicles. Also, several of the agencies contacted believed that joint training exercises would benefit each of the participating agencies.

There were also comments from agencies regarding how they thought other agencies besides their own could improve their response to incidents. In general, TxDOT personnel consider that fire departments and EMS often block more lanes than are really necessary. Sometimes fire departments and EMS want to completely close the freeway to make the incident scene safer for their personnel, whereas TxDOT wants to keep traffic moving to reduce congestion and delays. One suggestion to expedite the Medical Examiner arriving at the scene of a fatality was to provide transportation to the site in a police vehicle.

Response times required for incident response personnel to arrive at an incident scene depend upon the time of day that the incident occurs, the number of units available, and the location of the nearest unit to the incident at the time of notification. These factors result in response times that are highly variable. For instance, response times for EMS in El Paso vary from 10 to 27 minutes due to relatively few units. By contrast, response times for El Paso Fire Department personnel are less than three minutes anywhere in the city. The current average response time for fire department units in Ft. Worth is 3.5 minutes.

General response times by TxDOT personnel depend on whether the incident happened during daytime or nighttime hours, distance from the nearest maintenance yard, and status of the proper equipment. For TxDOT districts that have a sand truck already loaded, the time required to get to the scene and spread sand on a spill in the daytime is typically 30 to 40 minutes. For

Corpus Christi and El Paso, sand is available to be loaded immediately, but the truck is not kept loaded as it is in Ft. Worth and in one of the Austin maintenance yards. Even if a sand truck is loaded and ready for off-duty response, there is still time required to get a driver to the vehicle. Also, response time of equipment such as heavy-duty tow trucks and equipment from TxDOT for removing debris from the roadway depends upon accurate diagnosis at the scene. Sometimes, entry level police officers cause delays in clean-up by not requesting proper equipment or not doing so in a timely manner. Both Houston and San Antonio TxDOT personnel estimate their typical response time to get to the scene is 30 minutes in the daytime and 60 minutes at night. San Antonio courtesy patrols are usually at the scene in 15 minutes.

Even though most cities using incident management techniques are convinced of their merit, few agencies have separate budgets to cover these activities. Most of them simply lump incident response costs with other activities. An exception is Houston's hazardous materials unit which has a total budget of \$1.6 million, with \$110,000 of that available for the hazardous materials team. To indicate that some of the cities contacted believe that incident management makes a positive difference, agencies have made improvements in response techniques or are considering improvements. These include: highway advisory radio in Beaumont and Houston, development of ice plans in Austin and San Antonio, a route diversion plan in Austin, camera surveillance in Houston and Austin, and automatic vehicle identification in Houston to monitor vehicle speeds.

INCIDENT INVENTORY AND CLASSIFICATION

BACKGROUND

As indicated in an earlier chapter of this report, the vast majority of recorded incidents nationwide (80%) are the result of disabled vehicles. This includes cars and trucks that have run out of gas, had a flat tire, or have been abandoned by their drivers. Nationwide, it has been found that 80% of all disabled vehicles end up on the shoulders of the roadway for an average of 15 to 30 minutes. During periods of high traffic, the presence of a disabled car on the shoulder can slow traffic in the adjacent travel lanes, causing 100 to 200 vehicle-hours of delay to other motorists. The other 20% of disabled vehicles block one or more lanes of traffic for an average of 15-30 minutes. During peak periods, these disabled vehicles can cause between 500 and 2,000 vehicle hours of delay. More recent studies done by the Texas Transportation Institute have found a similar distribution of incidents on the Houston freeways. Of all the incidents responded to by the Houston Motorist Assistance Patrol (MAP), 75% involve vehicles on the shoulders of the freeways while 19% are found on the mainlanes. The location of the other 6% could not be determined.

Accidents account for only 10% of recorded incidents across the nation (29). In the city of Houston, 9% of the incidents responded to by MAP were the result of major or minor accidents. Approximately 40% of all accidents block one or occasionally two lanes of traffic. Each such incident typically lasts 45 to 90 minutes and causes between 1,200 and 2,500 vehicle hours of delay (29). Accidents that include fatalities are especially time consuming.

State and local transportation agencies, law enforcement agencies, and fire departments in several cities were contacted to identify and obtain any records kept regarding major freeway incidents in recent years. Ultimately, the contacts yielded data from four different agencies in three Texas cities: Austin, Beaumont, and Houston.

OBJECTIVES

The incident inventory and classification analyses were designed to accomplish three main objectives:

1. Determine how often a major freeway incident can be expected to occur as a function of traffic and geometric variables;
2. Determine (to the extent possible from the available databases) the basic characteristics of major incidents in terms of their frequency by time of day, by severity, by type (i.e., spilled loads, hazardous material accident, etc.), and by their duration; and
3. Determine if and how the duration of incidents differs as a function of the incident characteristics.

SCOPE OF ANALYSIS

This phase of the study did not include field data collection. Rather, the analysis was limited to the available data kept by the agencies contacted. Given that different agencies have highly distinct goals and objectives when responding to incidents and are, thus, likely to consider different types of information pertinent, the ability to compare across different databases was limited.

DATA COLLECTION

Through telephone calls and personal visits with officials from several agencies statewide, research personnel were able to gather information from the following sources:

- Beaumont Police Department,
- Austin EMS dispatch,
- Houston Fire Department Hazardous Material Response Section, and
- Houston Police Department Motorcycle Patrol Division.

Of these, the information from the HPD motorcycle division was the most complete and directly applicable. In addition, the TxDOT Roadway Inventory (RI) database was accessed to obtain traffic and geometric data from Beaumont and Houston.

Beaumont Incident Database

The Beaumont Police Department provided written summaries and copies of the accident report on each fatal accident occurring on the freeways in their jurisdiction during 1991 and 1992 (detailed information was not kept on any other type of major freeway incident). During this time period, a total of eight fatal accidents occurred on an estimated 22.0 kilometers (13.7 miles) of freeways. Two of the accidents reported by the Beaumont Police Department (25%) involved a large truck, and two more (25%) were the result of an auto-pedestrian collision. In two cases, the vehicle or vehicles left the roadway, and so travel lanes on the freeway remained open. Combining the remaining six accidents with traffic volume information from the TxDOT roadway inventory (RI) file, a freeway-affecting fatal accident rate of 0.708 per 100 MVK_m (1.139 per 100 MVM) was estimated for the Beaumont freeways (equivalent to 0.984 per 100 MVK_m (1.583 per 100 MVM) when considering all 8 accidents). This value is consistent with previous fatal accident rate statistics on urban freeways (29).

Officials with the Beaumont police department estimated that the measurements and other documentation required for fatalities requires at least two hours to complete. The fatal accidents (50%) required all lanes in at least one direction of the freeway to be closed between 2.0 and 3.5 hours (the average duration of closure was 2.75 hours). None of the report summaries mentioned any attempt to open a shoulder or one lane to freeway traffic during the accident investigations to minimize traffic impacts. (Presumably, the volumes present on the freeway allowed all traffic to be handled in the freeway lanes remaining available or to be routed onto the frontage road around the incident). The two remaining accidents required two of three lanes in a given direction to be closed an average of 2.5 hours.

With respect to the time-of-day of incident occurrence, one accident occurred during the A.M. peak period (between 6:00 A.M. and 9:00 A.M.), two of the accidents occurred during the P.M. peak period (taken to be between 4:00 P.M. and 7:00 P.M.), and the remaining five

occurred between 7:00 P.M. and 6:00 A.M. Both accidents involving trucks occurred during normal working hours (between 8:00 A.M. and 5:00 P.M.). Three of the nighttime accidents involved drivers under the influence of alcohol.

Austin EMS Database

One of the objectives of EMS systems is to provide as fast and safe transport of injured persons as possible to appropriate medical facilities. Consequently, it was anticipated that information regarding on-scene and departure times from the scene would be of limited use. However, it was hoped that information regarding accident severity might be documented. In turn, the impact upon the roadway and traffic might be indirectly inferred from the logbook information coded into the database.

Unfortunately, Austin records its data according to the type and level of initial response made by EMS units. Information was available on travel times per call (time of notification until time on scene) and total response durations (time of notification until time back in service). Unfortunately, no information concerning the type of accident or location within the roadway right-of-way was available. Furthermore, it was determined that no information in the EMS database could easily be cross-referenced with the DPS or other accident databases to obtain accident reports or other information. After reviewing summaries of the approximate 6650 entries obtained for the years 1988 through 1992, it was decided that the information would be of little use and further analyses were abandoned.

Houston Fire Department (HFD) Hazardous Material Response Database

The HFD hazardous material (HAZMAT) database included all responses made by that team regardless of where the problem occurred (at a plant, in a building, on the roadway, etc.). Separating out those occurring on freeway facilities in Houston yielded a total of 157 incidents during 1991 and 1992. Although these were designated as occurring on a freeway, it was apparent upon review of the records that many were related to problems that developed on vehicles transporting the material (such as mechanical failures, leaks, etc.). In most cases, these

vehicles were apparently able to leave the freeway mainlanes under their own power, and so could not be categorized as major incidents in terms of their effect on traffic. Also, many of the actual responses were minor in duration so that even if they had involved a lane blockage, it would have had minimal impact on traffic flow. Unfortunately, no information provided in the database could be used to remove those types of incidents. Consequently, discretion should be used in interpreting the values reported in this section.

A total of 98 responses (62.4%) in this HAZMAT database were coded as a collision or overturning of a vehicle transporting hazardous materials on Houston freeways. The mean clearance time of these incidents was 0.98 hours (51 minutes). Because incident clearance times were highly variable, very few meaningful trends could be determined. A large number of responses (102, or 65.0%) involved diesel fuel spills which required an average of 0.6 hours (34 minutes) to clear (although clearance times ranged from near zero to over 6.5 hours). Other notable HAZMAT response clearance times were as follows:

- 189 liters (50 gallons) of inedible tallow, 6 hours
- 379 liters (100 gallons) of gasoline, 4.5 hours
- A mechanical failure (presumably on the transport vehicle) involving natural food lecithin, 4.5 hours
- 3.8 liters (1 gallon) of paraquat dichloride, 4.1 hours
- Toluene Diisocyanate, no release involved (presumably a potential leakage which was monitored), 9.4 hours

It appears from these data that the type of material, the amount of spill or leakage, and the method of clean-up required (scooping, pumping, neutralizing, etc.) affects the clearance times. Unfortunately, the database did not contain this type of information.

Houston Police Department (HPD) Solo Motorcycle Division Database

The HPD motorcycle division provided the most extensive and complete database regarding major urban freeway incidents in Texas for this study. The solo motorcycle division

of HPD has been documenting major incidents occurring within its jurisdiction since 1986. Major freeway incidents as designated by HPD patrols were those which initially had a significant impact on traffic in terms of blocking one or more freeway lanes for a duration longer than 30 to 45 minutes. HPD motorcycle patrols operate between the hours of 4 A.M. and 10 P.M. daily, during the time when 93.3% of all travel occurs in Houston.

Overall, study personnel obtained 612 incident reports covering events which occurred on all of the 10 major freeway segments within HPD jurisdiction from 1986 through 1992. This equates to approximately 87 major incidents per year, or about 1.7 per week.

Incident Rates

Table 17 summarizes incident frequencies by freeway over the six-year span for which data were available. Also shown in the table are the approximate lengths of freeway, average daily traffic (ADT) volumes on each, and the corresponding overall incident rates. On average, 1.176 major incidents occurred per 100 million vehicle miles (MVM) (.731 major incidents per 100 MVK_m) or an incident every 85 MVM (an incident every 137 MVK_m) driven. On a freeway-by-freeway basis, incident frequencies ranged from a low of 0.099 per 100 MVM (Beltway 8) to a high of 2.265 per 100 MVM on I-10E.

Table 17. Major Incident Rates By Freeway

Freeway	Length kilometers (Miles)	Average ADT (1986-1992)	Incidents (1986-1992)	Incident Rate Per 100 MVK _m (Per 100 MVM)
I-10E	17.2 (10.7)	108,200	67	1.407 (2.265)
I-10W	31.1 (19.3)	141,600	72	0.641 (1.032)
I-45N	27.4 (17.0)	144,350	70	0.694 (1.117)
I-45S	33.6 (20.9)	141,350	51	0.420 (0.676)
I-610	61.2 (38.0)	113,350	205	1.158 (1.863)
SH 225	2.9 (1.80)	66,700	4	0.810 (1.304)
SH 288	18.3 (11.4)	51,150	15	0.626 (1.007)
US 290	13.8 (8.6)	130,400	17	0.368 (0.593)
US 59N	31.4 (19.5)	109,700	49	0.557 (0.897)
US 59S	23.5 (14.6)	164,650	61	0.617 (0.993)
Beltway 8	13.2 (8.2)	48,050	1	0.062 (0.099)
Total	273.6 (170.0)	119,800	612	0.731 (1.176)

Incident rate coefficient of variation (c_v) = 0.502

It was hypothesized that incident rates by freeway might be directly related to the presence of major freeway-to-freeway interchanges. To investigate this possibility, incident rates were recomputed using total VMTs on each freeway that occur between major interchanges and within the interchanges (travel within the interchange was computed from the first exit ramp approaching to the last entrance ramp leaving). Incident rates were then recomputed and are provided in Table 18.

Table 18. Interchange and Non-Interchange Incident Rates by Freeway

Freeway	Interchange Incidents (1986-1992)	Interchange Incident Rate Per 100 IMVKm (Per 100 IMVM ^a)	Non-Interchange Incidents (1986-1992)	Non-Interchange Incident Rate Per 100 NIMVKm (Per 100 NIMVM ^b)
I-10E	21	4.107 (6.610)	46	0.554 (0.892)
I-10W	32	3.452 (5.555)	40	0.388 (0.625)
I-45N	15	0.844 (1.359)	55	0.662 (1.065)
I-45S	8	1.439 (2.316)	43	0.371 (0.597)
I-610	83	2.071 (3.333)	122	0.890 (1.433)
SH 225	1	0.500 (0.805)	3	1.022 (1.644)
SH 288	4	0.777 (1.250)	11	0.585 (0.941)
US 290	9	4.721 (7.597)	8	0.487 (0.783)
US 59N	31	2.747 (4.420)	18	0.235 (0.378)
US 59S	2	0.271 (0.436)	59	0.645 (1.038)
Beltway 8	0	0.000 (0.000)	1	0.062 (0.099)
Total	206	1.952 (3.142)	406	0.546 (0.878)

^a IMVM = Interchange vehicle miles travelled

^b NIMVM = Non-interchange vehicle miles travelled

Interchange incident rate $c_v = 0.838$

Non-interchange incident rate $c_v = 0.505$

On average, incident rates were 3.5 times greater within interchange areas than they were between interchanges. However, segregating the data in this manner did not reduce the amount of freeway-to-freeway variability in rates. This was checked statistically using the coefficient of variation (c_v), the standard deviation of a sample divided by the mean value of that sample. For the values in Table 17, the c_v was 0.502. In Table 18, higher c_v values were computed for both interchange and non-interchange rates (0.838 and 0.505, respectively). It is possible that some of the incidents were categorized incorrectly, as it was very difficult on some freeways to accurately determine the limits of the interchanges by block numbers. Nevertheless, the categorization process did not reduce the variability in incident rates from freeway to freeway. This suggests that roadway design and/or adjacent land use on each freeway tend to have some effect on incident frequencies.

Incident Frequency by Vehicle Type

Of the 612 major incidents included in the database, 498 (81.5%) involved trucks (even though truck traffic accounts for only 7.7% of the total VMT on Houston freeways). Incident rates for trucks are shown in Table 19, again separated by freeway. As before, the rates vary considerably by freeway (the coefficient of variation was computed to be 0.82). Systemwide, the truck incident rate was computed as 7.19 per 100 MVKm (11.57 per 100 MVM) (equivalent to having a major incident every 5.4 MVKm (8.7 MVM) of truck travel).

Table 19. Major Incident Rates by Vehicle Type

Freeway	Truck-Related Incidents	Truck Incident Rate per 100 MVKm (per 100 MVM)	Auto-Related Incidents	Auto Incident Rate per 100 MVKm (per 100 MVM)
I-10E	53	4.20 (6.76)	14	0.16 (0.26)
I-10W	55	3.55 (5.72)	17	0.15 (0.24)
I-45N	60	9.36 (15.06)	10	0.10 (0.16)
I-45S	46	8.26 (13.29)	5	0.04 (0.07)
I-610	172	11.92 (19.19)	33	0.19 (0.30)
SH 225	4	17.76 (28.58)	0	0.00 (0.00)
SH 288	12	19.67 (31.66)	3	0.12 (0.20)
US 290	12	4.57 (7.36)	5	0.11 (0.17)
US 59N	35	6.77 (10.90)	14	0.16 (0.26)
US 59S	48	8.48 (13.64)	13	0.13 (0.21)
Beltway 8	1	1.65 (2.66)	0	0.00 (0.00)
Total	498	7.19 (11.57)	114	0.14 (0.22)

Truck incident rate $c_v = 0.82$

Auto incident rate $c_v = 0.47$

It is important to realize that these numbers only indicate the expected frequency of a major freeway truck incident, not the likelihood of a truck incident being classified as a major incident. There were approximately 7300 accidents in the Houston area between 1986 and 1992 that involved trucks (about 10.7% of all accidents during that period). The database of 498 major incidents in which trucks were involved thus represented only 6.7% of the total number of truck-related accidents in the database. Furthermore, the HPD database does not necessarily include spilled loads or other incidents where injuries and major property damage did not occur. Therefore, the majority of truck-related incidents on the freeway are not significant enough in duration or in extent of traffic impact to be classified as major incidents.

The database does illustrate that those truck mishaps that turn out to be major incidents very likely involve either a lost load or a overturned truck (or both). Of the 498 truck incidents, 198 (40.0%) were overturned trucks, and 233 (46.8%) involved a spilled load of some type. Although these two categories are not mutually exclusive, the results reflect the fact that such incidents require special heavy-duty equipment to clear, which increases incident duration.

Incident Frequency By Time-of-Day

Table 20 summarizes the distribution of major incident frequencies by time-of-day. Also shown is the distribution of freeway traffic volumes by time-of-day in urban areas. This distribution is based on limited TTI count data collected on several Houston freeways in 1990. As the table indicates, the incident distribution is more closely related to the distribution of truck traffic than auto traffic by time-of-day. This is not surprising given the large number of truck incidents that make up the total incident sample. Whereas only 38.5% of automobile travel occurs during the midday off-peak period, over 53% of truck travel occurs during this time. Correspondingly, nearly two-thirds (63.2%) of the incidents documented by HPD occurred in this time frame. Fortunately, major incidents were less likely to occur during either the A.M. or P.M. peak period, when the traffic impacts are most severe. This most likely reflects a tendency of large truck drivers to avoid travel during peak-periods as well.

Table 20. Distribution of Incidents by Time-of-Day

Time Period	Number of Incidents	Percent of Total	Time of Day Distribution of Traffic Volumes (Percent)	
			Autos	Trucks
Night (7-10 P.M., 4-6 A.M.)	70	11.5	20.4	17.0
A.M. Peak (6-9 A.M.)	80	13.1	20.9	17.0
Midday (9 A.M.-4 P.M.)	386	63.2	38.5	53.3
P.M. Peak (4-7 P.M.)	75	12.3	20.2	12.7

Incident Severity

A total of 23 fatal accidents were included in this database, yielding a fatal incident rate of 0.027 per 100 MVKm (0.044 per 100 MVM). Another 206 (33.7%) of the 612 incidents involved some type of injuries, equivalent to 0.245 per 100 MVKm (0.394 per 100 MVM). These values are much lower than estimated for Beaumont and national statistics for urban freeways. It is hypothesized that many fatal accidents were not included in the database because they occurred late at night (when HPD motorcycle officers were not on duty). It is also possible that many of the deaths were not reported on the HPD forms because they did not occur until after the accident victim had been transported to a hospital. Regardless of the actual reasons, this discrepancy in rates illustrates how the definition of "major" incidents may differ by region. In Beaumont, any fatality that occurs becomes a major incident for agencies in that region; in Houston, that is not always the case.

Another measure of severity is the number of vehicles involved in the incident. The majority (70.5%) of incidents in the HPD database were single-vehicle mishaps. Another 17.7% of the incidents involved two vehicles, and three vehicles were involved in 7.2% of the incidents. The remaining 4.6% of the incidents involved four or more vehicles.

Agency Involvement

The majority of incidents required multi-agency involvement (25.5% of the reported incidents only involved the HPD). For 38% of the incidents, one other agency had to respond. An additional 24.6% required two additional agencies, 9.2% required responses from three other agencies, and 2.7% of the incidents involved four or more other agencies in the response. It appears that wrecker services were the most common agency required (although it is recognized that such services are not truly "agencies"). TxDOT was the second most common agency involved, participating in 47.5% of the responses. Meanwhile, services of the Houston Fire Department were required in 36.3% of the incidents.

Hazardous Material Incidents

Of the 612 major incidents documented in Houston, HPD officers identified 77 (12.4%) as involving hazardous materials. This equates to about one every five weeks in Houston, or one every 1088 MVKm (676 MVM). The small sample size did not allow for meaningful analyses of frequencies by freeway or location.

Incident Duration

One of the more important efforts in this analysis was the computation of incident durations. Initial analyses showed that the response time to incidents (time of alarm to time of arrival) averaged 15 to 20 minutes. This value was fairly consistent over the various freeways and independent of incident type, severity, and time-of-day. Therefore, two other times were of primary interest, namely, the clearance time (on-scene arrival to on-scene departure) and the amount of time that travel lanes were actually blocked. Considering all incidents together, median clearance times were nearly 2.5 hours, as illustrated in Figure 7. Meanwhile, the median time that lanes were actually blocked was slightly more than 1.5 hours. As might be expected, the distribution of incident durations was significantly skewed to the right, as several incidents lasting as long as six to eight hours were reported (these were generally hazardous material).

Comparing all automobile incidents to all truck incidents, it appears that there was little difference in either clearance times or duration of lane blockages. However, if only those truck incidents that involved an overturned vehicle are considered, incident clearance time was significantly longer (although not shown, the effect of spilled loads from tractor-trailers was similar). As shown in Figure 8, the median clearance time for overturned truck incidents was slightly more than 3 hours, compared to a 2.2 hour median clearance time for auto incidents and a 2.4 hour time for all truck incidents combined. Similar differences were found with respect to the duration of lane blockages (Figure 9), with the median duration for overturned truck incidents being nearly 3 hours in direct contrast to the 1.75 hour median duration for auto incidents.

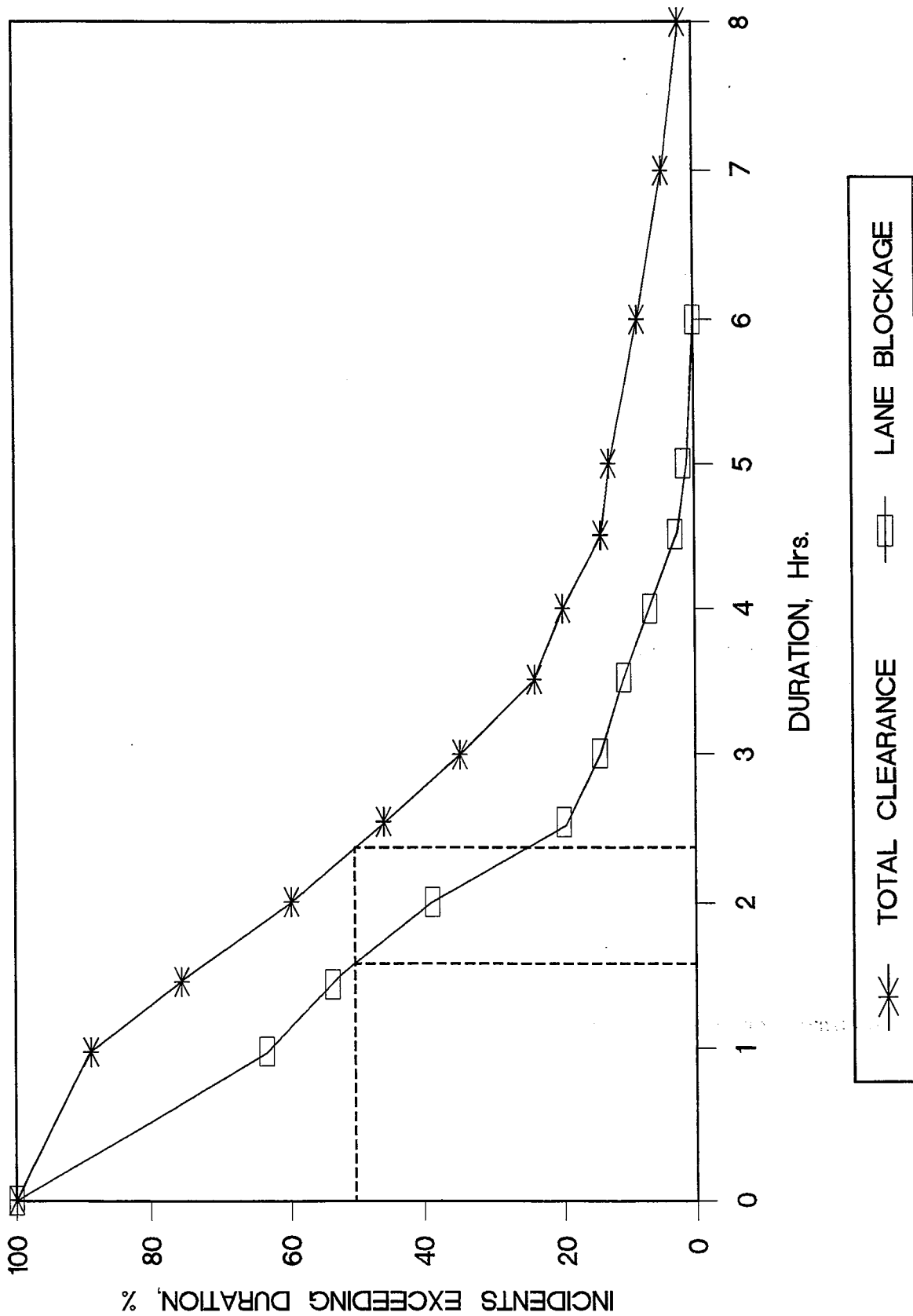


Figure 7. Distribution of Incident Clearance and Lane Blockage Durations

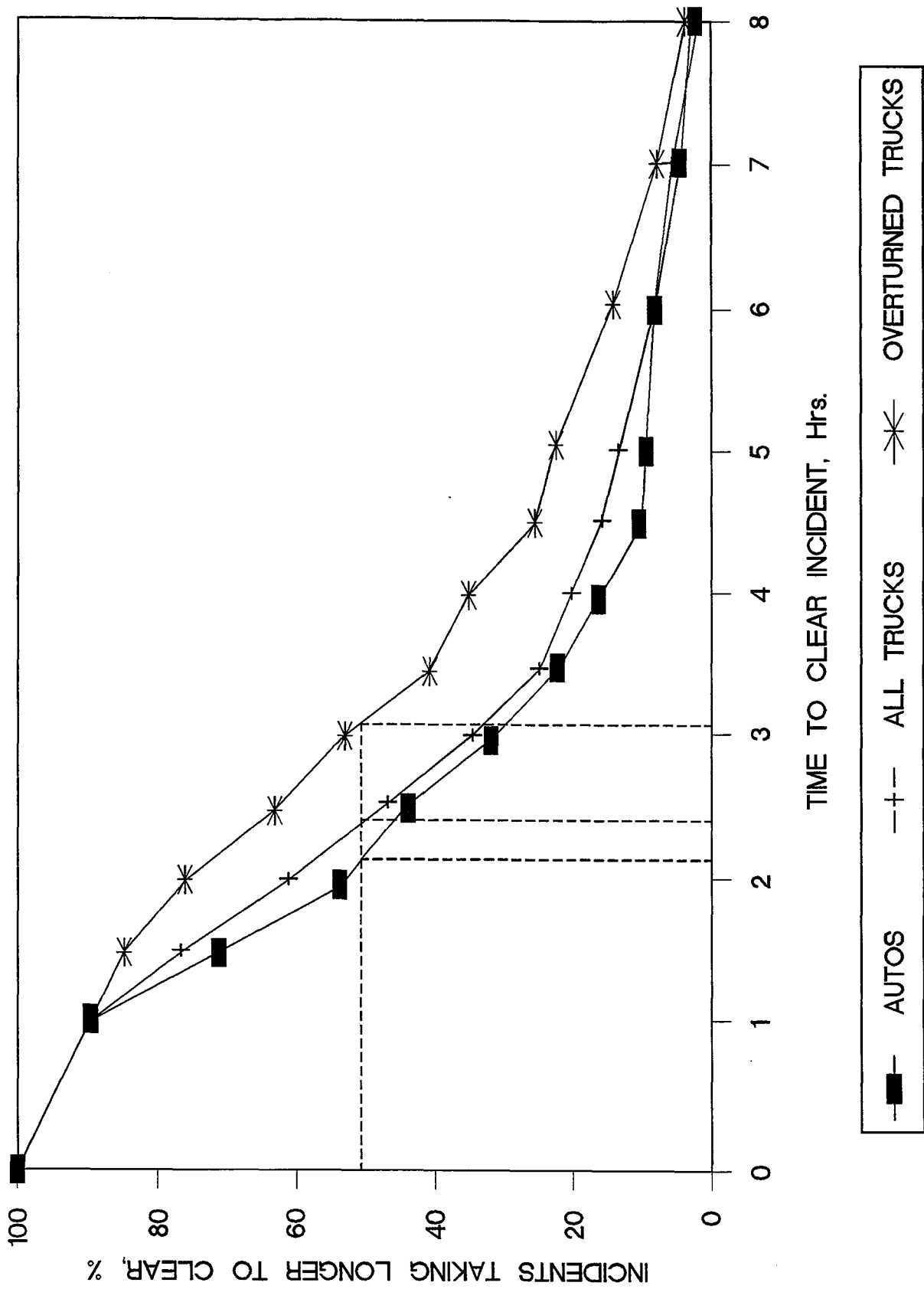


Figure 8. Distribution of Incident Clearance Duration by Vehicle Type

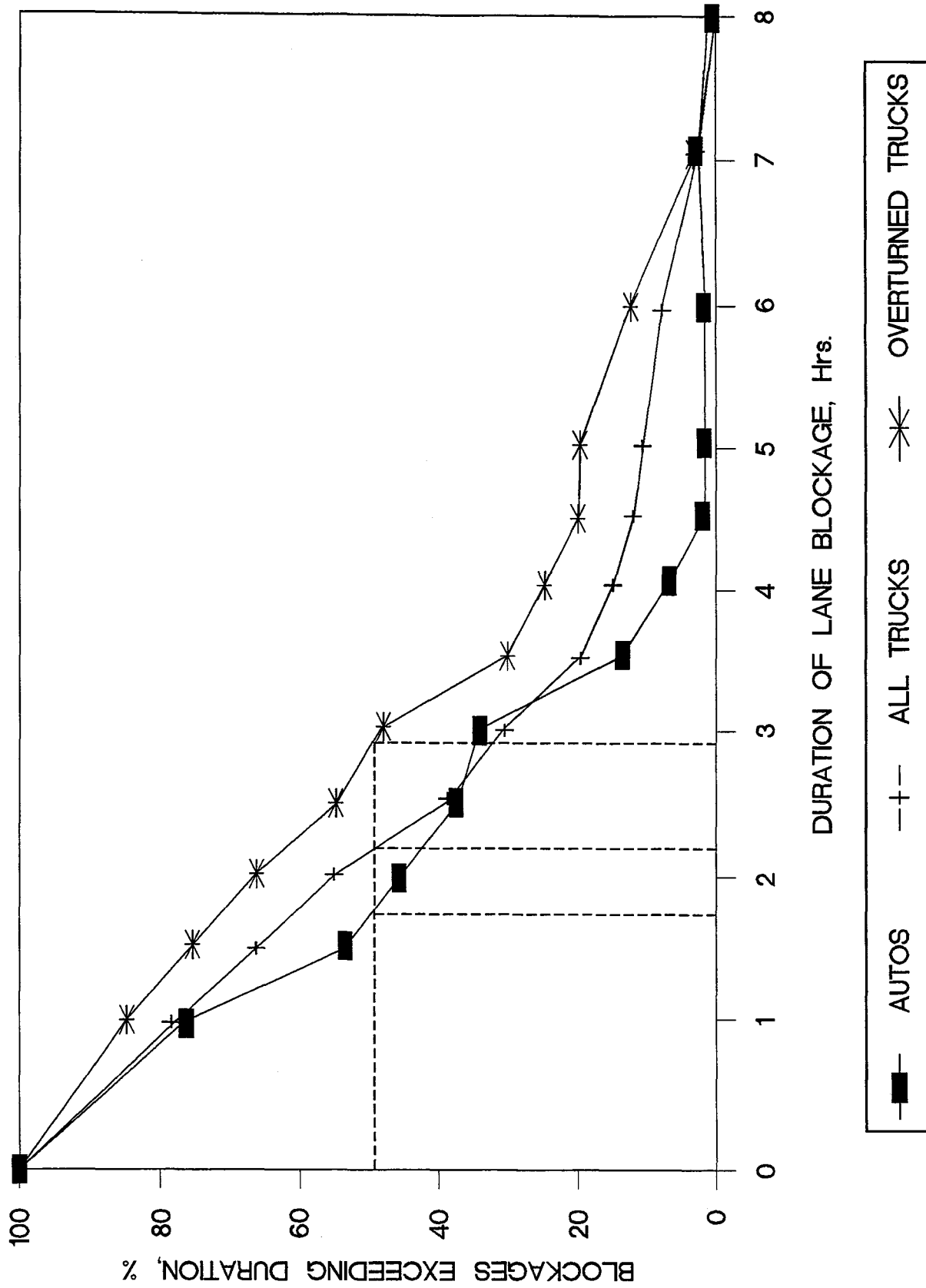


Figure 9. Distribution of Lane Blockage Duration by Vehicle Type

Whereas the overturned truck incidents significantly increased incident clearance and lane blockage durations, the total number of vehicles involved in a given incident did not appear to have such a consistent effect. Figure 10 presents the average clearance and lane blockage durations as a function of the number of vehicles involved. As shown by the trend lines, average durations are independent of the number of vehicles involved.

Incident duration also differed slightly depending on where it occurred (i.e., at an interchange or a non-interchange location). Table 21 summarizes average clearance times categorized by location and freeway. Although there are minor deviances in the data from freeway to freeway, the general trend was for incidents to be slightly longer (by 0.23 hours, or about 14 minutes) at interchange locations. This could be due to an increase in truck overturns and spills associated with interchange ramp curves, to generally higher traffic demands that increased congestion and made it more difficult for response vehicles to get to and from the scene, or to the lack of available right-of-way within the interchange proper where debris could be quickly pushed off the freeway. Unfortunately, such causal information was not available from the data.

Figure 11 illustrates the effect of clearance times and lane blockage durations upon the number of additional agencies required to be involved in the incident. Intuitively, those incidents that require coordination and multi-jurisdictional response should be more complex and should correlate with longer durations. The trend lines in Figure 11 support this contention, showing that the number of agencies required at an incident increases as both clearance and lane blockage times increase.

Approximately 65% of the incidents coded as involving hazardous materials were cross-referenced with the Houston Fire Department (HFD) HAZMAT response database discussed previously. Comparing the average clearance times of the police department and fire department files (for those incidents which could be cross-referenced), the police department clearance time was 46.5 minutes longer than the HFD HAZMAT team.

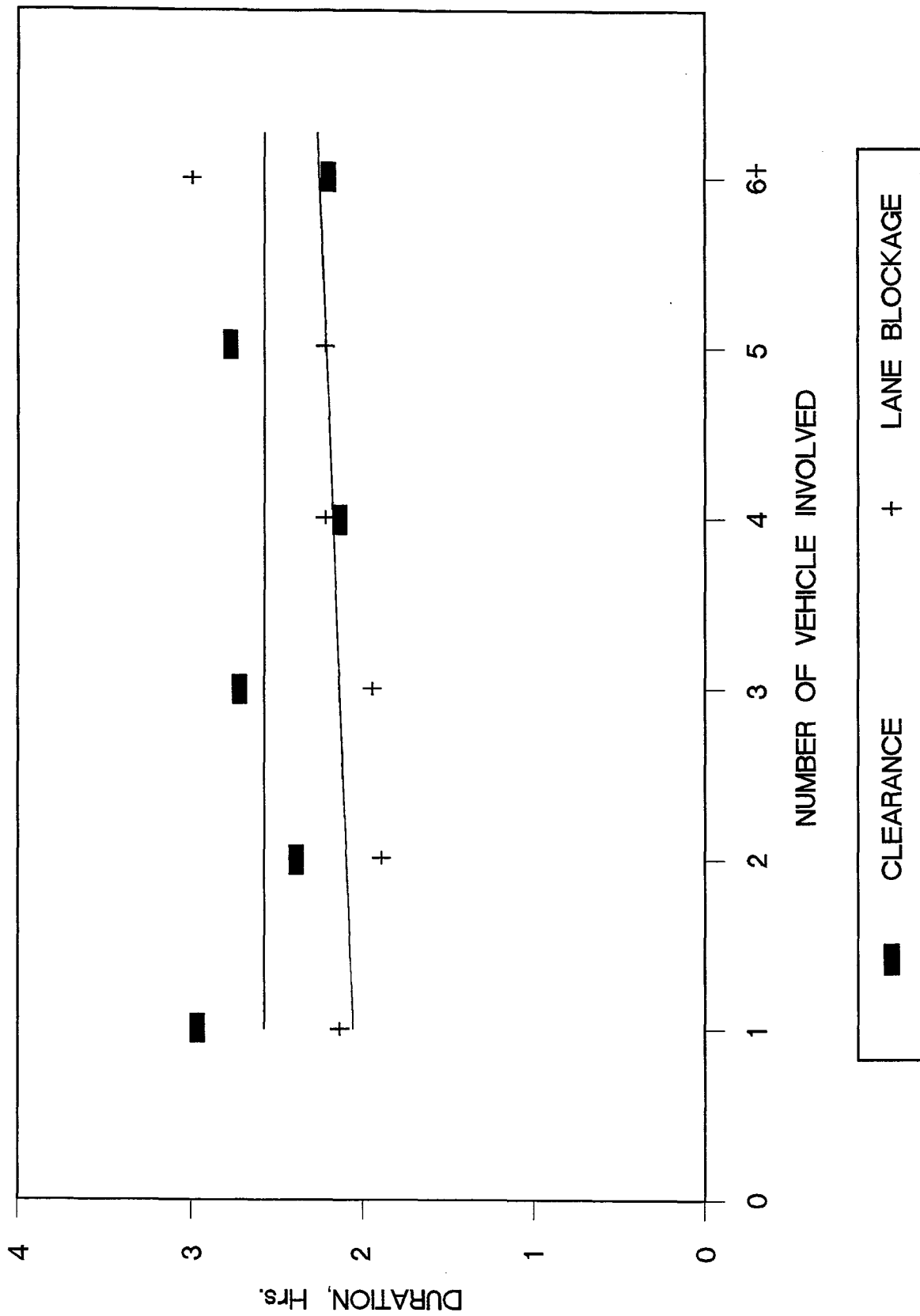


Figure 10. Average Incident Clearance and Lane Blockage Durations by Number of Vehicles Involved

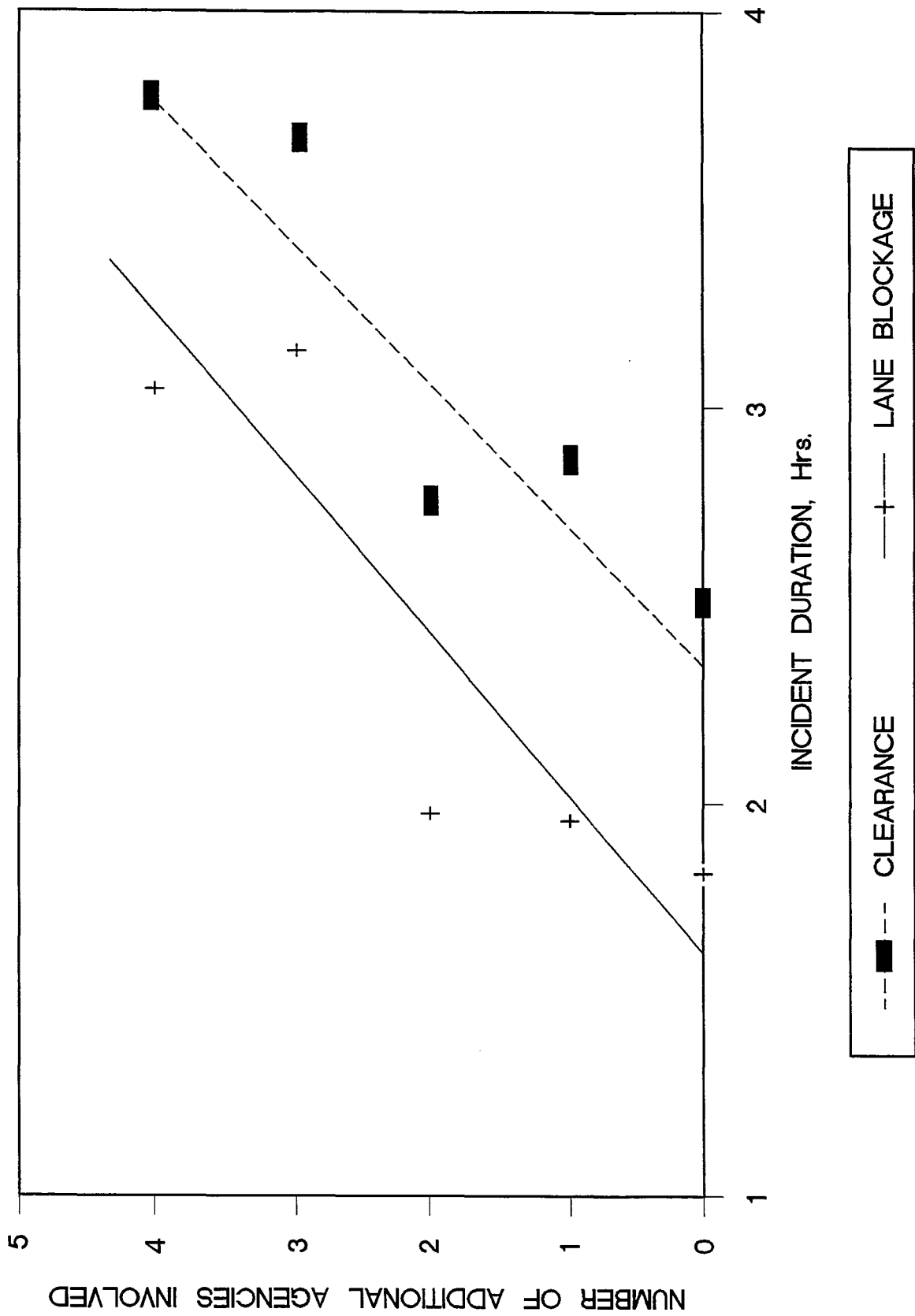


Figure 11. Effect of Incident Clearance and Lane Blockage Duration on Multiple Agency Involvement

Table 21. Average Clearance Times By Location

Freeway	Average Clearance Time (Hours)	
	Interchange	Non-Interchange
I-10E	3.72	2.20
I-10W	2.56	2.93
I-45N	2.88	2.85
I-45S	3.54	3.35
I-610	2.95	2.73
SH 225	1.75	3.11
SH 288	3.38	2.79
US 290	2.62	1.58
US 59N	2.91	2.51
US 59S	3.33	2.71
Total	2.97	2.74

Other Incident Characteristics

One of the goals of the analysis was to estimate the impact of the incidents upon traffic in terms of number of lanes closed. Unfortunately, these data were not consistently documented. Likewise, information on any special traffic management techniques employed during the incidents (i.e., temporary shoulder usage, mandatory diversion to adjacent frontage roads, etc.) were not available.

Of those incidents where the number of lanes closed was documented, 32.5% were single lane blockages; 39.3% blocked two lanes; 21.5% blocked three lanes; and 6.8% blocked four or five lanes. In addition, 6.4% of the incident reports specifically stated that the incident blocked all lanes. Unfortunately, since the normal roadway cross-section at each site was not documented, it was not possible to determine the magnitude of capacity reduction caused by most of the lane blockages.

Database Summary

Four information sources on major freeway incidents in Texas were examined. Of these, the HPD motorcycle patrol division provided data which was most complete and germane to the study. However, the other sources did provide a few specific bits of information. The following is a synopsis of the results of the analysis:

- Overall, a major freeway incident (blocking at least one lane for one hour or more) can be expected to occur in Houston once every 137 MVKm (85 MVM) of travel.
- Major incidents are 3.5 times more likely to occur at freeway-to-freeway interchanges than between them. Whereas incidents occur at a rate of one per every 183 MVKm (114 MVM) of travel between interchanges, they occur at a rate of one per 51 MVKm (32 MVM) in interchange areas. Differences between interchange designs and other factors affect this rate, however, such that significant variation exists from site to site.
- Most major freeway incidents involve trucks. On a rate basis, truck incidents occur once every 14 MVKm (8.7 MVM) of truck travel. This is in sharp contrast to major incidents involving automobiles only, which occur once every 731 MVKm (454 MVM) of automobile travel.
- Although major incidents (if they occur) are more likely to involve trucks, very few truck incidents turn out to be major freeway incidents.
- Because the majority are truck-related, the frequency of major incidents by time-of-day mimics overall truck travel patterns. Specifically, most incidents occur during the daylight off-peak hours (9 A.M. to 4 P.M.) when most truck travel occurs as well.
- Estimates of incident severity appear to depend somewhat on the definition of such incidents by the operating agencies. For example, if all fatal accidents are treated as major incidents, a rate of one per 102 MVKm (63.2 MVM) of travel can be expected (equivalent to 0.98 fatal incidents per 100 MVKm (1.58 per 100 MVM) as was documented in Beaumont). If, however, the agency does not consider or document all fatal accidents as major incidents, a much lower rate will result (as was computed for Houston).
- Another measure of incident severity is the number of vehicles involved in each. In Houston, 70.5% of the incidents involve only one vehicle, 17.2% involve two vehicles, and the remaining 12.3% of the major incidents involve three or more vehicles.
- Most (74.5%) major freeway incidents involved multiple agencies. For 36.5% of the incidents in Houston, HPD worked jointly with two or more agencies in the response. Not considering the private towing companies, TxDOT was the agency most frequently involved in major incident response (47.5% of the time), followed by the HFD (36.3% of the time).
- Incidents involving hazardous materials occurred once every 1088 MVKm (676 MVM) of total vehicle travel in Houston, or about one every 90 MVKm (55.9 MVM) of truck travel.

- The median clearance time (arrival to departure) of a major freeway incident was approximately 2.5 hours, with travel lanes blocked for about 1.75 hours of that time. However, 30% of the incidents lasted 3 hours or more, and 20% lasted 5 or more hours.
- Incident durations were about equal for automobile and truck incidents overall. However, incidents where trucks overturned or spilled a load were significantly longer in duration. Whereas, the median automobile and overall truck incident clearance time was slightly less than 2.5 hours, overturned truck incidents required a median clearance time of over 3 hours.
- Incident clearance times did not appear to affect the number of vehicles involved in the incident or whether it involved a hazardous material. However, clearance times were slightly dependent upon basic roadway geometrics (being slightly longer at interchange locations than at locations between them). Also, longer incident durations generally required more agencies to be involved in the response.

Figure 12 presents an example incident report recommended for complete and effective documentation of the important parameters associated with an incident response. This information will allow the production, over time, of a useful database for the inventory and classification of major freeway incidents.

INCIDENT REPORT

DATE OF INCIDENT: _____ LOCATION: _____
 DIRECTION OF TRAVEL: _____ NUMBER OF LANES BLOCKED: _____ NUMBER OF LANES AVAILABLE: _____
 TIME OCCURRED: _____ TIME CLEARED: _____
 INCIDENT DESCRIPTION: _____

(ADDITIONAL SPACE ON BACK - INCLUDE DIAGRAM)

SHOULDER USED AS TRAVEL LANE: _____ (IF YES SPECIFY) _____
 TYPE & NUMBER OF VEHICLES INVOLVED: _____ PASS. CAR _____
 LIGHT TRUCK _____ MOTORCYCLE _____ SEMI-TRACTOR TRAILER _____
 VAN _____ VEHICLE WITH TRAILER _____ OTHER (SPECIFY) _____
 IF APPLICABLE - LOAD/CARGO INVOLVED: _____
 HOW AFFECTED: _____ LOST _____ SPILLED _____ SHIFTED _____ HAZARDOUS MATERIAL: _____
 (IF YES - GIVE TYPE) _____
 ROAD CONDITION: _____ DRY _____ WET _____ OTHER (SPECIFY) _____
 FWY. UNDER CONSTRUCTION? _____ (IF YES - SPECIFY) _____
 CONDITION: _____ LIGHT _____ DARK _____ LIGHT RAIN _____ HEAVY RAIN _____ OTHER
 (SPECIFY) _____
 NUMBER OF PEOPLE INJURED _____ NUMBER OF FATALITIES _____
 CITY OR STATE PROPERTY DAMAGES? _____ (IF YES - SPECIFY) _____

AGENCY	TIME			ACTION TAKEN	EQUIP. USED
	NOTIFIED	ON-SCENE	CLEARED		

TOTAL FWY CLOSURE NECESSARY? _____ TIME STARTED: _____ TIME ENDED: _____
 DETOUR OR ROUTE DIVERSION USED? _____ (IF YES - SPECIFY) _____

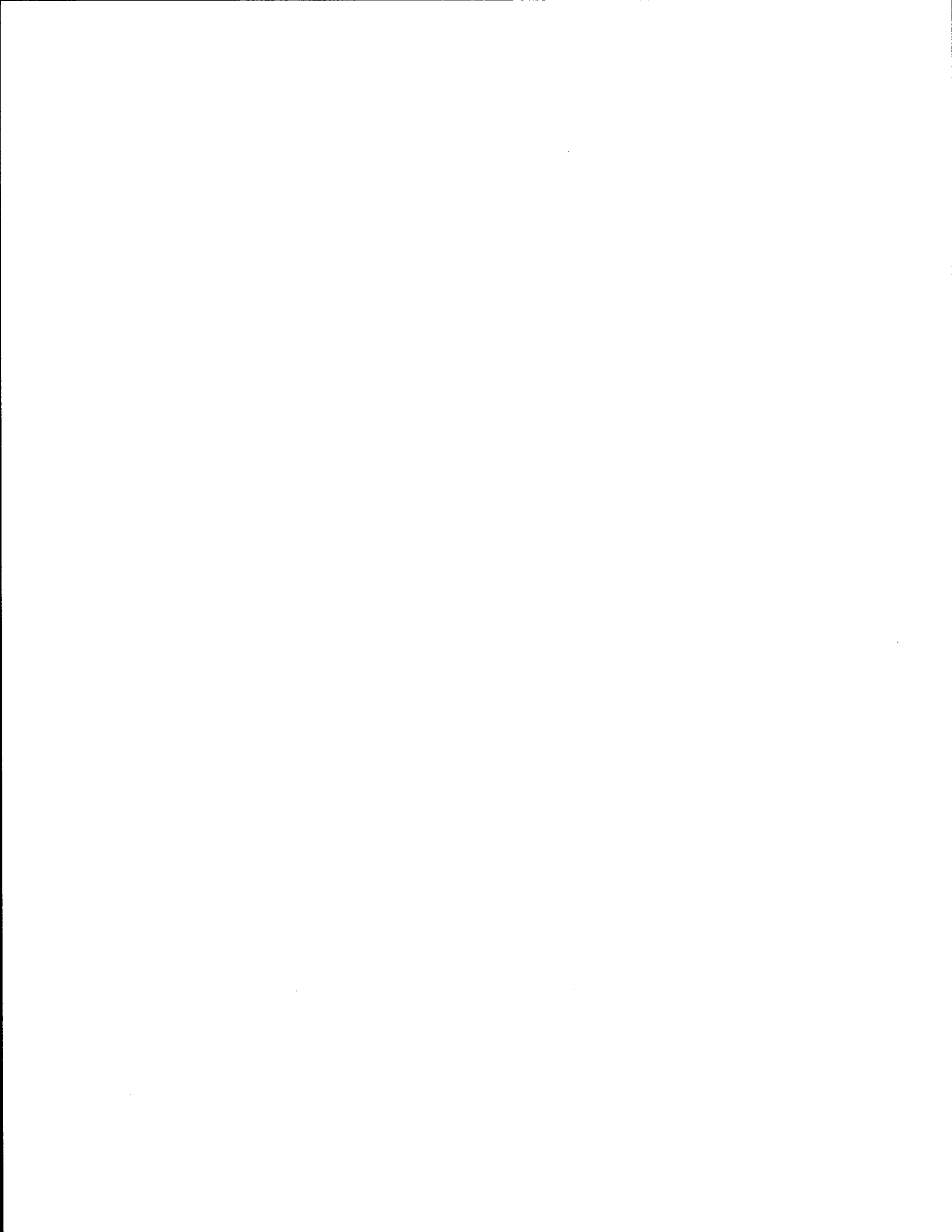
ANY EXCESSIVE DELAYS IN AGENCY NOTIFICATION, RESPONSE OR EQUIPMENT? _____ (IF YES-SPECIFY)

ADDITIONAL INFORMATION: _____

REPORT PREPARED BY: _____ AGENCY: _____ DATE PREPARED: _____

** PLEASE USE BACK OF REPORT TO SUPPLY ADDITIONAL INFORMATION

Figure 12. Incident Report Form



INCIDENT MANAGEMENT AND RESPONSE REQUIREMENTS

Incident management procedures and requirements were identified to deal with the different parameters necessary in agency response activities. These procedures should be directed to a specific urban area with specific agency responsibilities. The time saved by an incident management program (IMP) depends upon how well the four stages of an incident (detection, response, clearance, and recovery) are managed.

The four stages of an incident are sequential. First, a response will not be initiated until an incident is detected. Secondly, an agency cannot begin to clear an incident until it can respond. Finally, although all incidents are eventually cleared, clearance time may be unnecessarily extended if the appropriate agency does not respond in a timely manner.

Response is the activation, coordination, and management of the appropriate personnel and equipment necessary to clear an incident. Incident response time can be considered to be the sum of three time elements: (1) the time required to determine the appropriate emergency equipment and personnel needed to remove the incident, (2) the time needed to report these needs to the appropriate agencies, and (3) the travel time of the emergency vehicles and personnel to the incident site.

Clearance is the safe and timely removal of the incident in order to facilitate restoration of the roadway to its full capacity. A number of factors affect incident clearance time, including: the severity of the incident, the response provided, the surrounding traffic conditions, and the coordination of response personnel and equipment at the incident site.

The contributions of the response and clearance stages of an incident to the total incident duration can be seen in Figure 13. Incident response and clearance procedures are implemented by agencies with the intent of reducing the incident duration. This can have a dramatic affect on the congestion (and also total delay) caused by incidents which occur during periods when traffic volumes are at or near capacity.

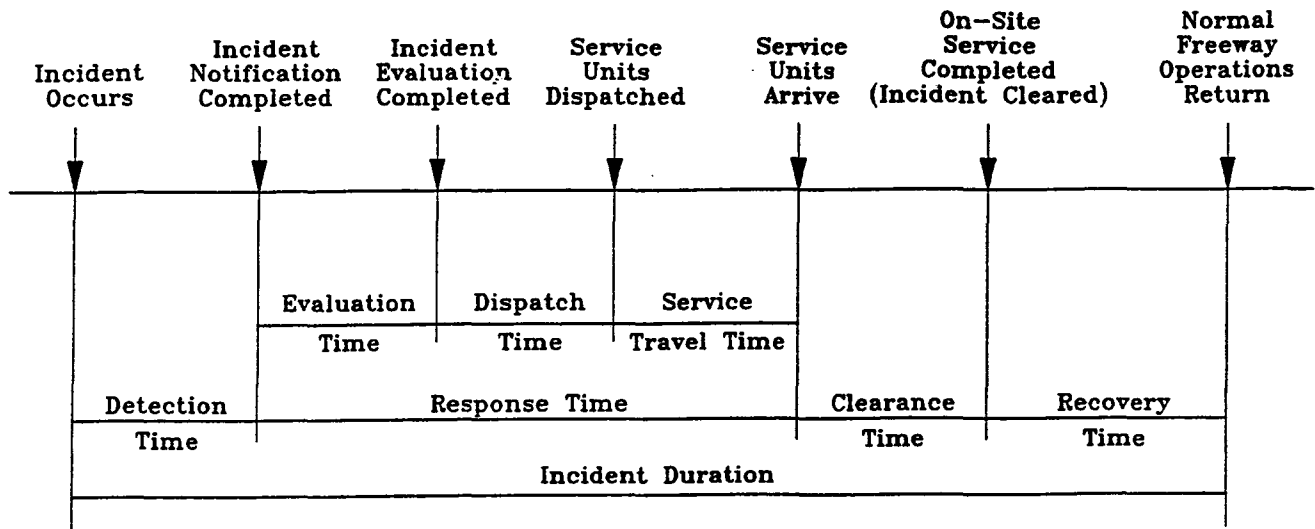


Figure 13. Components of Incident Duration

Figure 14 illustrates an incident management framework encompassing the central traffic control activities associated with detection and verification. Once adequate information has been received for incident verification, incidents should be classified to allow communication of appropriate coordinated responses by all agencies. Table 22 shows such a classification process.

Detection, verification, and response capabilities vary by size of city and urban area. Figures 15-17 illustrate these differences by small ($\leq 100,000$ population), medium (100,000-500,000 population), and large ($\geq 500,000$ population) area categories.

By introducing the proper procedures, an agency can also reduce the magnitude and severity of adverse impacts such as vehicle emissions and secondary accidents. In Texas, four procedures which TxDOT has worked most diligently towards are: (1) freeway corridor surveillance and control systems, (2) traffic and incident management teams, (3) fast removal policies, and (4) motorist assistance patrols.

Freeway corridor surveillance and control systems focus on managing the traffic in the travel lanes surrounding or adjacent to an incident as well as on incident detection and

INCIDENT MANAGEMENT FRAMEWORK (DECISION TREE)

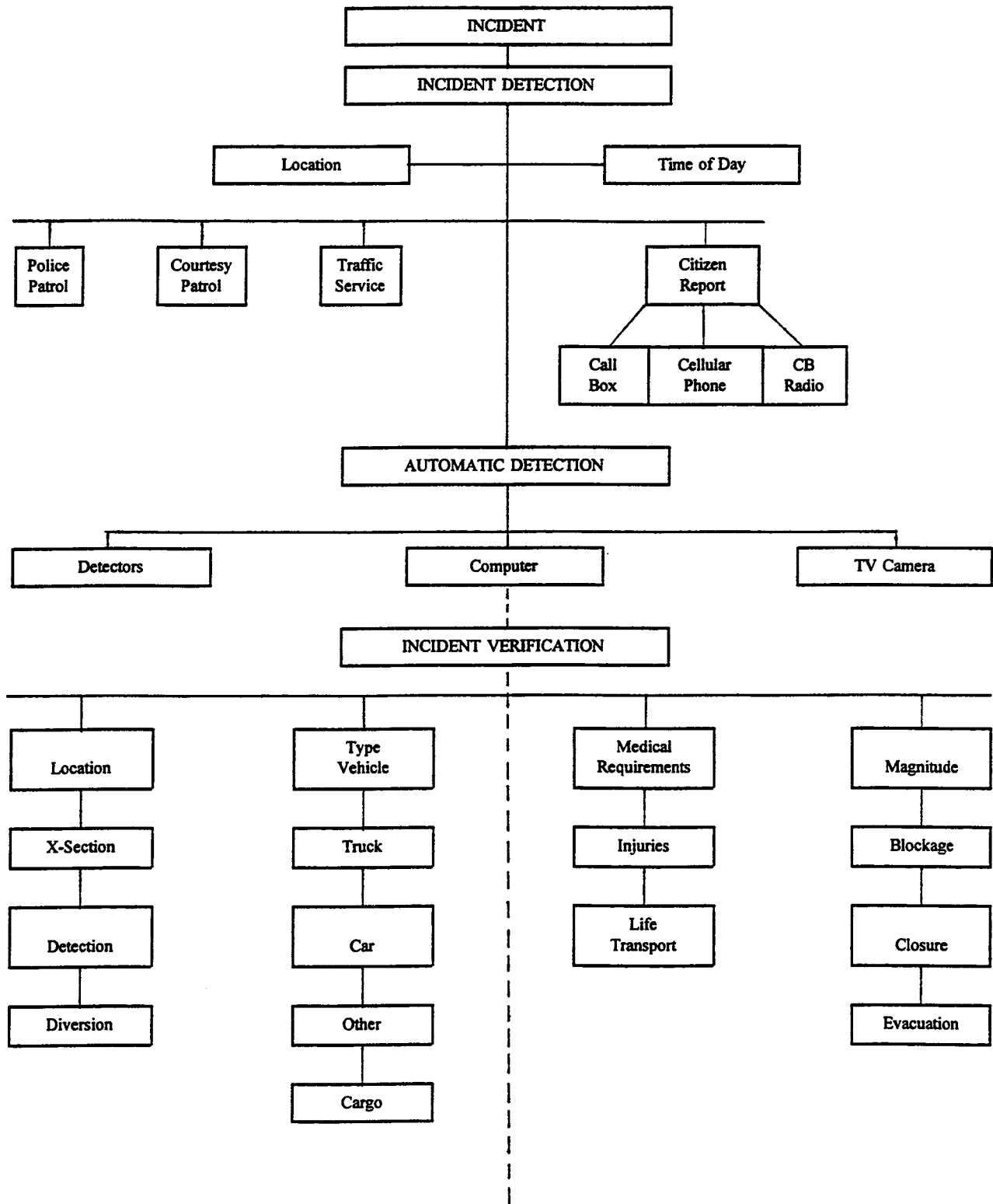


Figure 14. Incident Management Framework

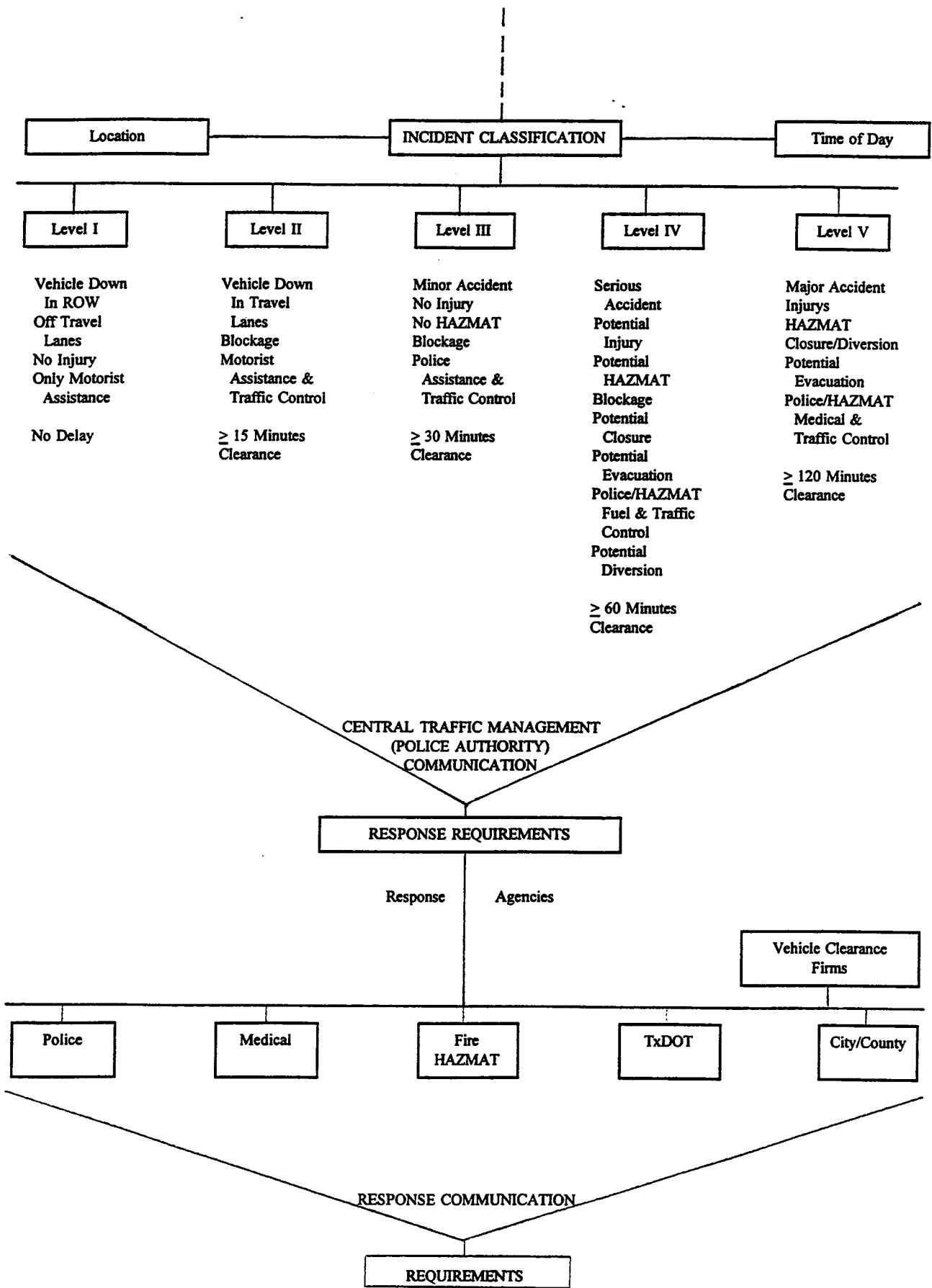


Figure 14. Incident Management Framework (Cont.)

Table 22. Example of An Incident Classification Scheme

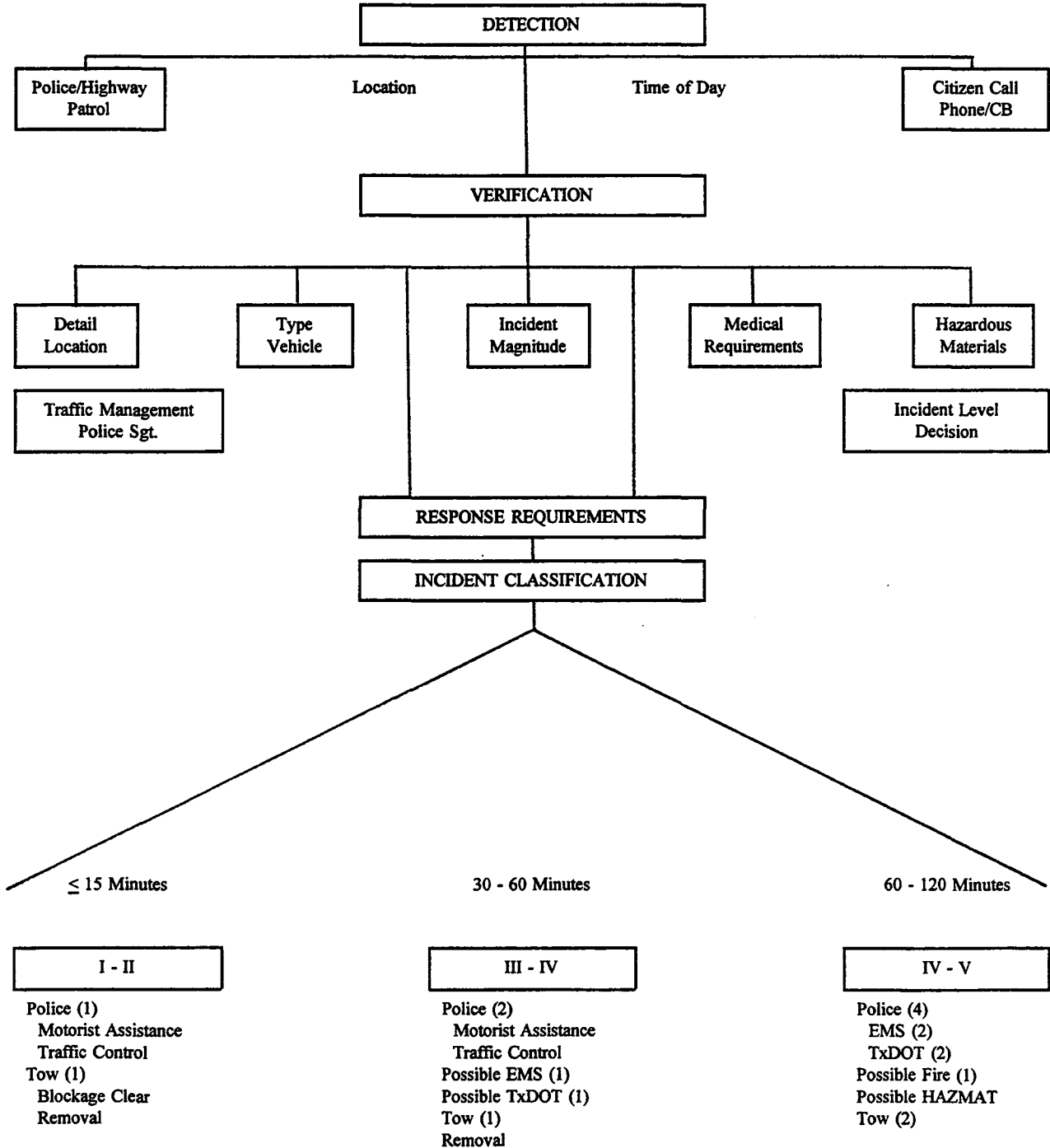
	Incident Classification				
	Level I	Level II	Level III	Level IV	Level V
Types of Incidents (examples)	Vehicle stall on shoulder	Vehicle stall in travel lanes	Minor accident (no injuries) Minor load spill	Serious accident (potential injuries) Spilled load (possible hazardous materials) Vehicle fire	Serious accident (with major injuries) Haz. material spill Several vehicles on fire
Anticipated Duration of Lane Blockage	None	0-30 minutes	30-60 minutes	60-120 minutes	> 120 minutes
Types of Response Activities	Motorist assistance	Motorist assistance with minimal on-site traffic control	Police assistance with on-site traffic control Possible implementation of traffic diversion strategies Debris removal	Police assistance with extensive on-site traffic control Fire department response Haz. mat. response Traffic diversion strategies Debris removal Medical assistance	Police assistance with extensive on-site traffic control Fire department response Coroner dispatch Haz. mat. response Traffic diversion strategies Neighborhood evacuation Debris removal Medical assistance

verification. They are designed and operated to monitor traffic conditions, detect the occurrence of incidents, monitor and report on the status of traffic control hardware, provide information for traffic controls, and operate those controls. They are able to reduce response and clearance time by shortening the time it takes to verify that an incident has occurred and to initiate the appropriate response. They also have the potential to reduce the adverse impacts of an incident by providing the ability to discourage the use of the facility upstream of an incident or by directing motorists more efficiently through an incident site.

PEGASUS (PEople, Goods, and Services Urban System) is the acronym for the freeway corridor surveillance and control system being developed by TxDOT. There are many components of this type of system. Elements of the control phase of PEGASUS - ramp meters,

SMALL AREA
 (≤ 100,000)

DETECTION, VERIFICATION, RESPONSE CAPABILITIES
 (Waco, Abilene, Amarillo, Mid-Land, Odessa, Bryan-College Station)



() - # of units required.

Figure 15. Small Area Detection, Verification, Response Capabilities

MEDIUM AREA
(100,000 - 500,000)

DETECTION, VERIFICATION, RESPONSE CAPABILITIES

(Austin, Lubbock, El Paso, Corpus Christi, Brownsville)

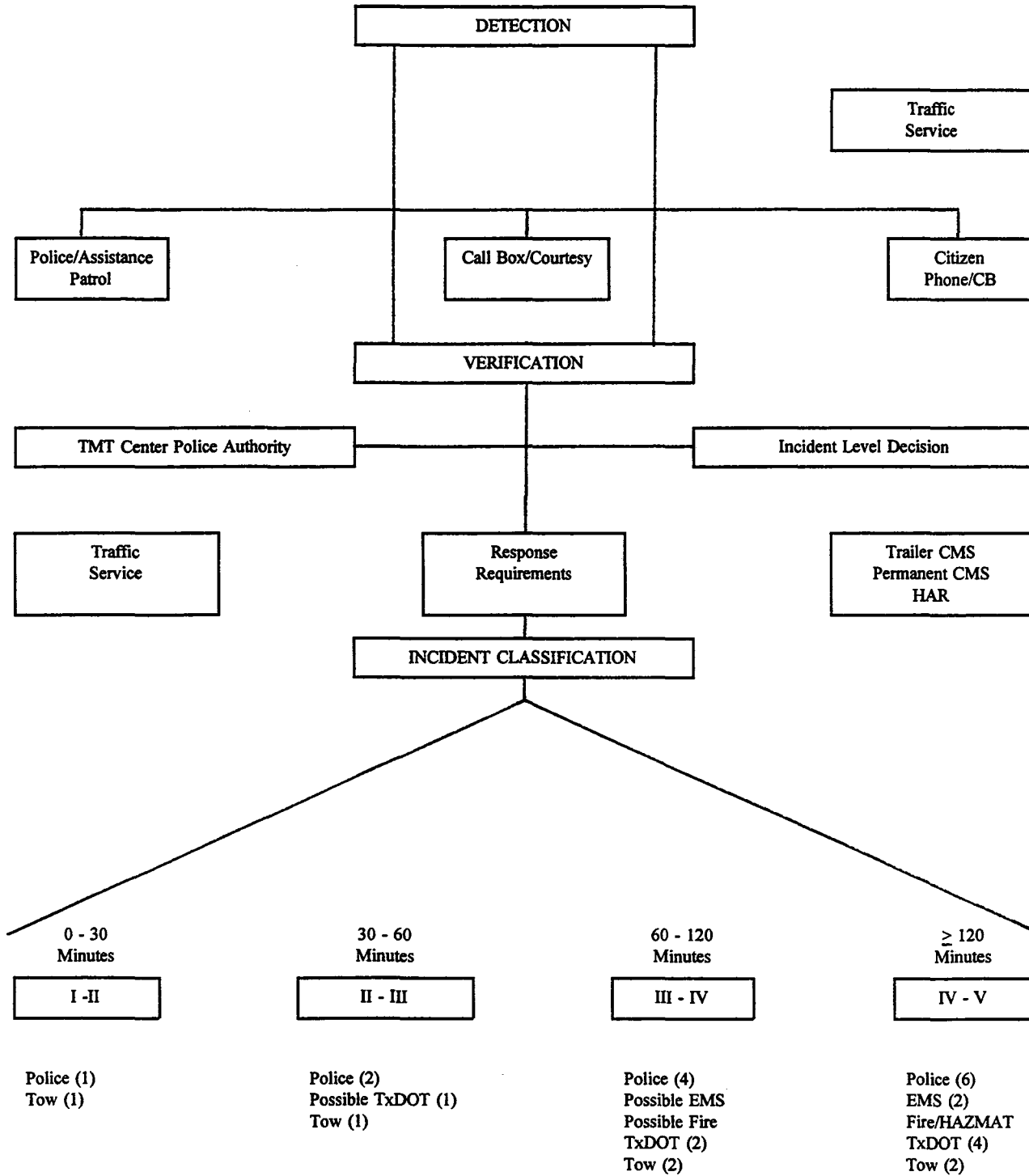


Figure 16. Medium Area Detection, Verification, Response Capabilities

LARGE AREA
 (≥ 500,000)

DETECTION, VERIFICATION, RESPONSE CAPABILITIES

(Ft. Worth, Dallas, San Antonio, Houston)

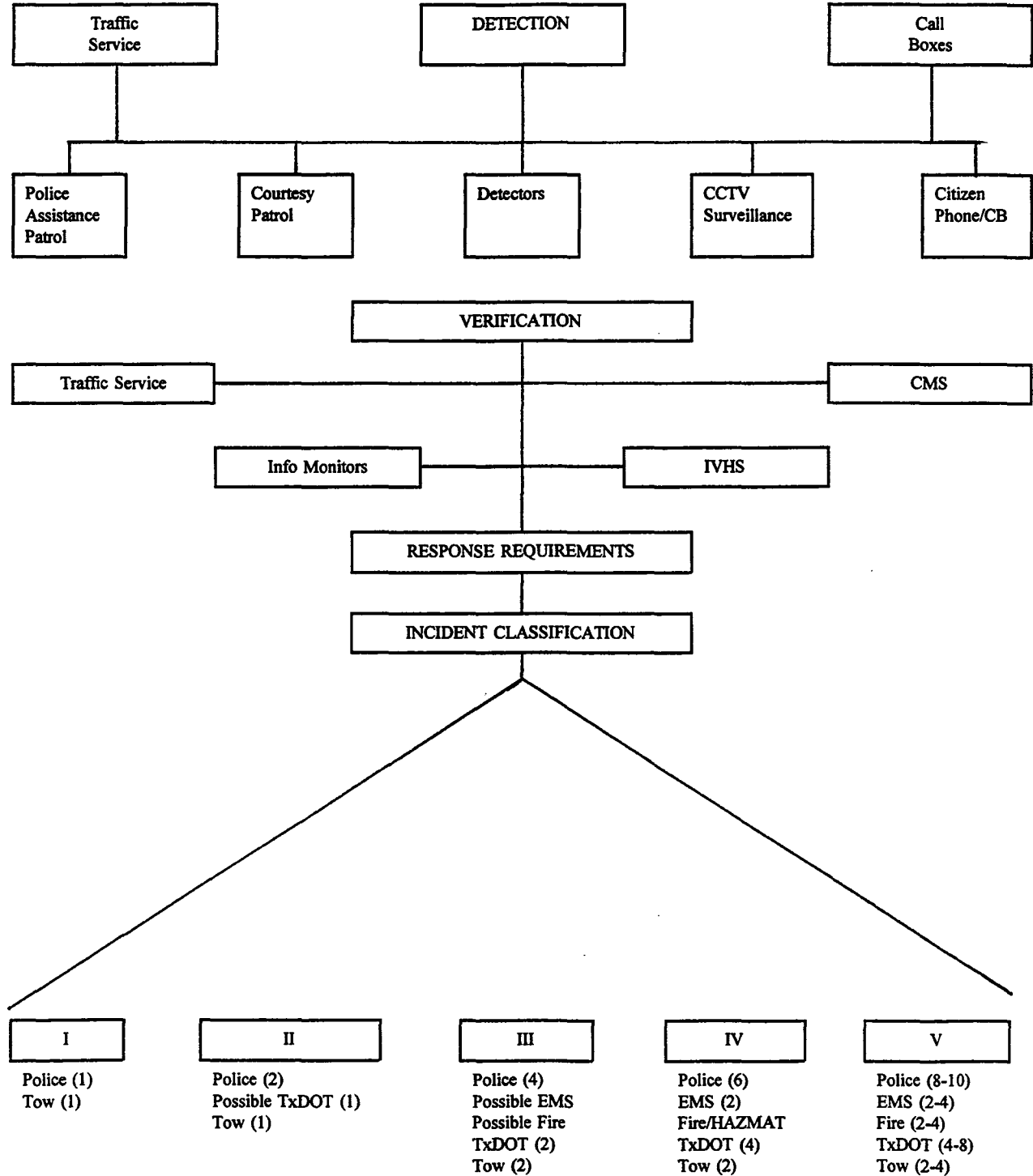


Figure 17. Large Area Detection, Verification, Response Capabilities

changeable message signs (CMS), and lane control signals are most pertinent to the response and clearance stages of an incident and are used in conjunction with the surveillance systems to expedite incident response and clearance. Ramp meters can be used to restrict the influx of traffic upstream of an incident. The CMS's could be used to provide advanced notice of an incident and to inform motorists of an alternative route around the incident location. Lane control signals can be used to indicate which lanes are blocked by an incident. This allows motorists to move into an unimpeded lane upstream of an incident, reducing the potential for erratic maneuvers (i.e, hard braking, last minute lane changes, swerving, etc.) and increasing the efficiency of traffic flow past the incident site.

INTERAGENCY COORDINATION

Coordination and cooperation among various state and local agencies are the keys to successful incident response and clearance. Both traffic management teams (TMT) and incident management teams (IMT) are excellent methods to facilitate communication between the various agencies involved in incident response and clearance. Table 23 indicates the multi-jurisdictions and agencies represented on major metropolitan traffic management teams in Texas.

Table 23. Agencies Represented on Teams in Texas

Jurisdiction	Agency	Beaumont	Corpus Christi	Fort Worth	San Antonio	Houston
State	Traffic Design	.	.	.	.	.
	Maintenance Highway Patrol	.	.	.		.
County	Engineer		.		.	.
	Sheriff				.	.
City	Traffic	.	.	.	.	.
	Police	.	.	.	.	.
	Fire	.				.
	Transit				.	.
Other	Naval Air Station		.			
	Traffic Safety Assoc.				.	
	Railroad				.	

The TMT and IMT bring together professionals from the various transportation related agencies in an area and help them work together to solve the area's traffic and incident problems. They aid in the development of mutual respect among members, help members to view problems from another agency's point of view, and, more importantly, they help to promote effective communication.

VEHICLE REMOVAL LEGISLATION

There are two variations of fast vehicle removal policies. The first places emphasis on educating the public on the need for them to remove their vehicles from the roadway as soon as possible after they are involved in an accident (22). The "MOVE IT" public awareness campaign initiated by TxDOT is an example of this type of fast removal policy.

The "MOVE IT" campaign, which originated in Dallas, is an effort by TxDOT to inform motorists of Article IV, Section 39 of the Texas Motor Vehicles Laws Uniform Act 1981-82. The "MOVE IT" law requires motorists involved in non-injury accidents to move their vehicles off the roadway provided the vehicle can be driven. Simple observance of the law by motorists will lessen the impacts of many incidents on the freeway system. This will result in safer more efficient roadways for everyone.

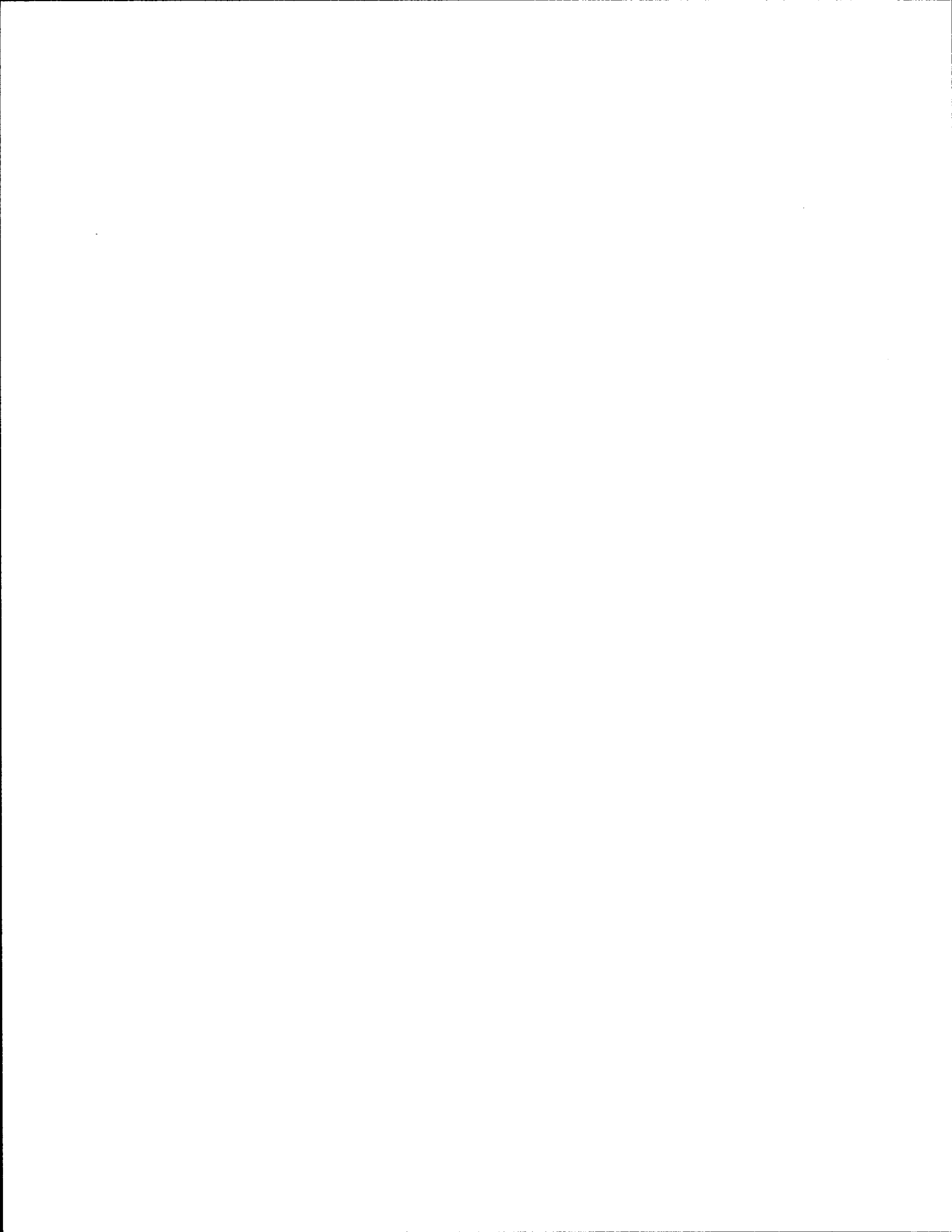
In the second variation of fast vehicle removal policy, the public agency takes the initiative in removing disabled, abandoned, or damaged vehicles. The position of TxDOT was strengthened in this area when the Texas Legislature passed Senate Bill 312. This bill gives TxDOT the authority to remove cargo or personal property from the roadway without owner consent and without the threat of liability for damages or claims of damages, given that the removal or disposal was not carried out in a reckless or grossly negligent manner. This can be done anytime cargo or property is blocking the roadway or otherwise considered to endanger public safety. Unfortunately, there is still some hesitation on the part of some highway officials to move cargo from the roadway for fear of tort liability. Furthermore, concern over what constitutes "reckless or grossly negligent" removal policies has reduced the effectiveness of this legislation somewhat.

ASSISTANCE PATROLS

Motorist assistance patrols are particularly well suited for incident response and clearance. Their primary advantage is that they are active in nature, that is, they directly affect the impact of an incident at the incident site. Eighty-six percent of the incidents responded to by the Houston motorist assistance patrol (MAP) were detected by the sheriff's deputies which man the vehicles. Not only do they help identify incidents, MAP officers also stop and offer assistance and provide directions to lost motorists. Motorist assistance patrols are able to reduce the time of all four stages of an incident and, thereby, have the potential to dramatically decrease total incident duration.

INCIDENT MANAGEMENT SUMMARY

All four of the incident response and clearance procedures identified can provide positive benefits to the motoring public as well as to the transportation agency. Motorist assistance patrols, freeway corridor surveillance and control systems, TMT's and IMT's offer the most favorable atmospheres for TxDOT influence and oversight. Of the three, freeway corridor surveillance and control systems are by far the most expensive. Fast vehicle removal policies require, and have gained, the support of the state legislature. To be effective though, they also require a concerted effort on behalf of the transportation agencies to educate both motorists and their own employees of the existing legislation. The incident response and clearance strategy pursued depends greatly upon the existing problem. For example, if stranded motorists cause an excessive amount of congestion on the roadway network, development of a motorist assistance patrol should be considered. TMTs and MAPs are low-cost, highly effective means of combating the adverse impacts of freeway incidents and should be considered for implementation by any medium to large urban area.



APPLICATION OF ADVANCED TECHNOLOGIES

Many advanced technologies currently exist which hold the potential to improve incident management. Two such strategies of special significance to TxDOT were investigated and are presented as follows.

GEOGRAPHIC INFORMATION SYSTEMS

An important function of traffic management centers is to provide timely response to incident situations. When incidents occur, the operator of a traffic management system must make decisions on what controls to employ, what to display on changeable message signs, who to notify, and how to reduce the effect of the incident on traffic operations.

Geographic Information Systems (GIS) are a powerful technology to perform spatial analysis. It is an organized collection of computing hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (30).

GIS provides a mechanism to relate digital maps to associated databases. The data model consists of topological data structures which are together capable of recording data information associated with points, lines, and polygons. This data model allows the development of applications which perform graphical analysis on geographic databases.

For street networks, GIS provides an arc-node topology where arcs correspond to street segments and nodes provide connectivity between the arcs, thus, modelling street intersections and enabling development of transportation application with GIS. GIS applications in transportation vary considerably in the kinds of analysis and data (31).

ARC/INFO, a widely used commercial GIS development environment which is available on a number of different computer operating systems, has been used as the platform for incident management GIS. A GIS application in ARC/INFO consists of coverage and a set of programs

to manipulate those coverages. A coverage in turn consists of a map layer associated with a set of databases. ARC/INFO is a comprehensive GIS tool which supports the following:

- creation and editing of maps and related databases;
- display of and query on the coverage;
- analysis of network coverage, such as streets;
- conversion between a variety of GIS/database formats and ARC/INFO;
- a programming language for developing custom GIS applications.

A prototype automated incident management plan has been developed using PC-ARC/INFO, the PC version of ARC/INFO for the City of Houston. Figure 18 illustrates the system architecture of the automated incident management plan. Several demonstration/prototype applications have been developed (32). Applications in the areas of incident management operations address the needs of traffic management centers. A major element of the plan is the fleet management of service patrols. In addition, applications in the area of planning and analysis for incident management address the needs of engineers and designers.

INCIDENT MANAGEMENT OPERATIONS

Efficient incident management operations are essential for real-time traffic management. Potential applications can be used in traffic management centers by operators to disseminate the real-time information that is available. The applications broadly support the following:

- 1) Incident Response; through fleet management of service patrols and through closure of areas surrounding incidents;
- 2) Dynamic Route Guidance; through alternate routing and changeable message sign control; and

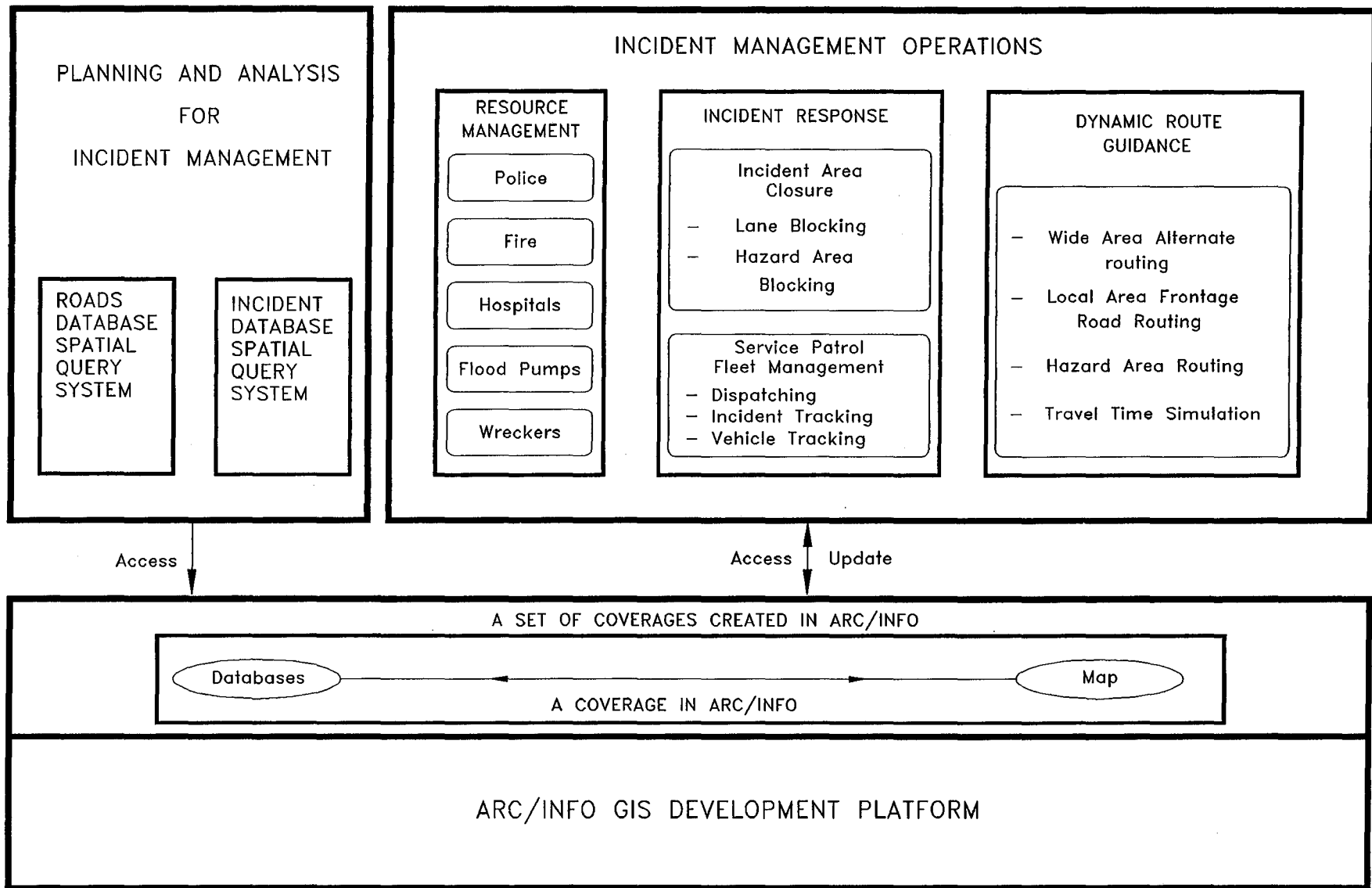


Figure 18. System Architecture of an Automated Incident Management Plan Using ARC/INFO GIS Platform

- 3) Resource Management; through the following:
 - a) contact incident management resources, such as police, fire and EMS; and
 - b) graphical query on incident management resources, such as police, fire, and EMS.

Incident Response

The prototype Automated Incident Management (AIM) plans support for two incident response operations. These are fleet management of service patrols and closure of areas surrounding incidents.

Fleet Management for Service Patrols

Fleet management of service patrols is an important element of the automated incident management plan. Freeway service patrols are typically on call 24 hours per day to provide assistance during incidents. A prototype application for the Motorists Assistance Program (MAP) in Harris County, Texas, has been designed to provide improved response times through fleet management of the MAP vehicles. In general, the prototype application provides the following to the control center for service patrols:

- vehicle tracking with or without Automatic Vehicle Location (AVL);
- incident monitoring;
- vehicle dispatch guidance and directions; and
- query on the underlying roads database.

The application provides a graphical display of all incident locations as well as color-coded locations of all service patrol vehicles, showing for each patrol vehicle whether it is patrolling the freeways or providing assistance at an incident location. Location and incident information can also be displayed in text form. The operator in the control center can perform one or more of the following functions:

- Enter and retract incident information, as well as assess the impact of incidents;
- Enter and update location and status of service patrol vehicles;
- Locate and dispatch the closest service patrol vehicle available to an incident site;
- Update changeable message signs in conjunction with dynamic route guidance, as well as incident area closure applications;
- When the service patrols are equipped with AVL transponders, the operator can track service patrol vehicles automatically, without need for manual entry.

An illustration of the locations of the Houston Area Motorist Assistance Program (MAP) vans on the screen, as well as their location in text form, is shown in Figure 19.

The underlying data manipulation model for fleet management is similar to dynamic route guidance for dispatching purposes. For incident monitoring, fleet management also shares its data model with the application for closure of incident areas.

Incident Area Closure

The purpose of the incident area closure is to assess the impact of incidents before closing the area surrounding an incident and to perform necessary actions based on this assessment. Depending on the kind of incident, there are two applications:

- Block one or more lanes to simulate an incident and assess the impact of the incident in terms of delay caused by the incident. Assess the need for alternate routing and communicate selected alternate routes to field personnel, if required.
- Block a hazard area, such as one where there is a potential of explosion from a chemical spill, using the center and estimated radius of the area affected. The operator may obtain the list of intersections that need to be physically closed and the list of street segments to be evacuated. The incident area will be considered closed and any further alternate routing will be around the area.

Operational MAP Vans

*** Assisting Vans ***

- UNIT: 4051 @ 2000 NORTH FWY
- UNIT: 4052 @ 5000 GULF FWY
- UNIT: 4058 @ KATY FWY / GESSNER S.

*** Patrolling Vans ***

- UNIT: 4053 @ NORTHWEST FWY / LITTLE YORK W.
- UNIT: 4054 @ EASTEX FWY / BELTWAY 8 N.
- UNIT: 4055 @ 11000 SOUTHWEST FWY
- UNIT: 4056 @ SOUTH FWY / ALMEDA Rd.
- UNIT: 4057 @ HARDY TOLL Rd. / FM 1960
- UNIT: 4059 @ 7000 EAST FWY

PgDn.

- ⊛ - Assisting Vans
- ★ - Patrolling Vans

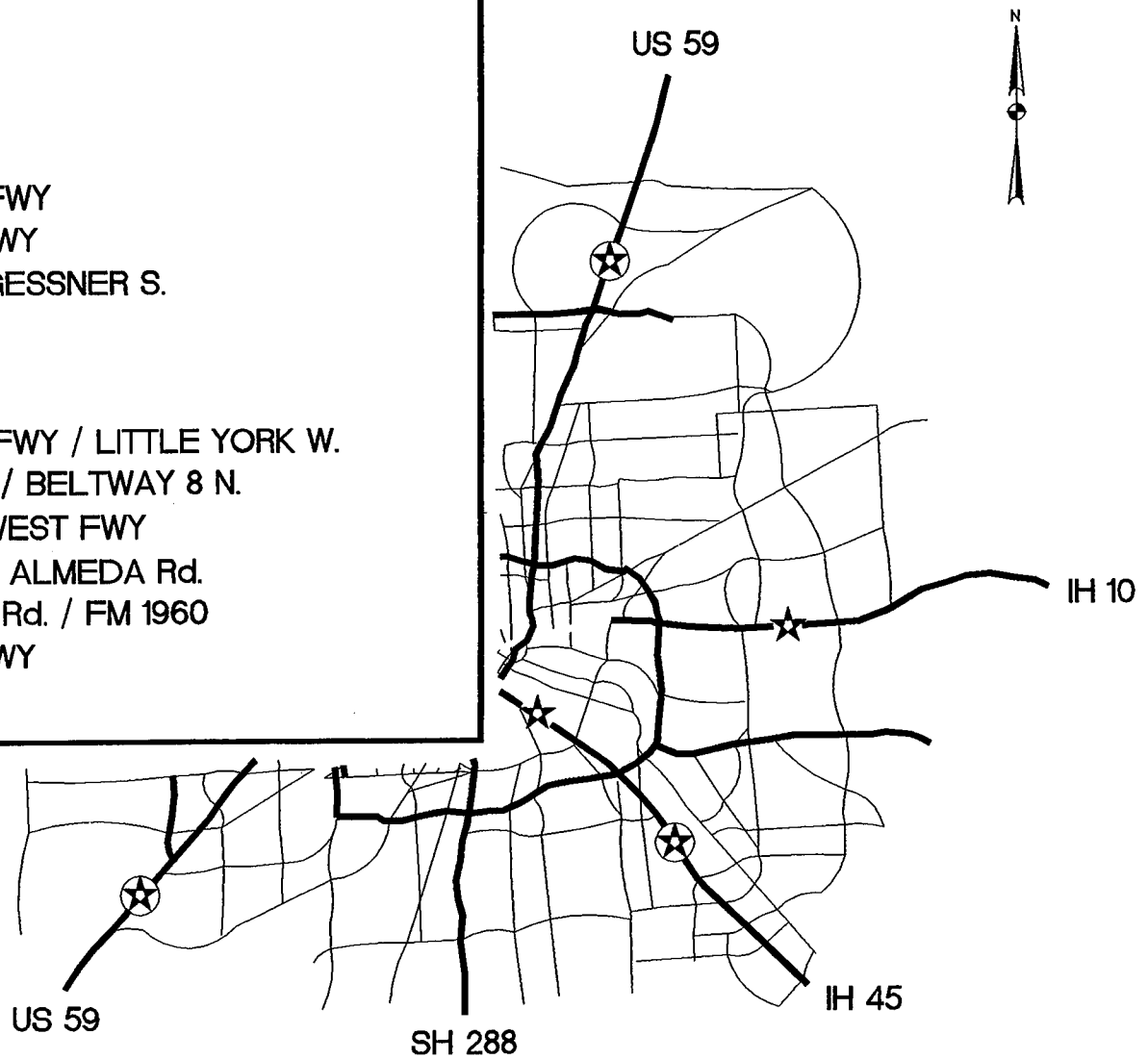


Figure 19. List of MAP Van Locations

Dynamic Route Guidance

Applications for dynamic route guidance may be classified into the following four categories:

- 1) Wide area alternate routing for routing over a general area covering several miles;
- 2) Local area alternate routing, over a limited and specific area, to include use of frontage roads and interchange ramps;
- 3) Routing around a hazard area; and
- 4) Travel time simulation for estimating expected travel times on streets affected by incidents.

All of the above dynamic route guidance applications share the following underlying models:

- 1) Dijkstra's shortest path algorithm which has been implemented in PC-ARC/INFO to accept arc length or travel time for the purpose of finding the shortest path.
- 2) A data model where:
 - a) volume-to-capacity-ratios are related to speeds (33); and
 - b) the volume-to-capacity-ratios change for each street segment depending on either of the following:
 - (i) Time of the day, using historical hourly volume data; or
 - (ii) Blockage of one or more lanes caused by incidents.

An example of the directions generated for a wide area alternate route is shown in Figure 20.

DIRECTIONS FOR ROUTE

Start at origin on SOUTHWEST FWY

Travel	2.54 miles	Turn right to Loop 610 W.
Travel	5.11 miles	Go left to Northwest Fwy
Travel	3.43 miles	Turn right to Bingle
Travel	0.86 miles	To destination
Travel	11.95 miles	

Travel time is
13.67
minutes

Click anywhere to exit

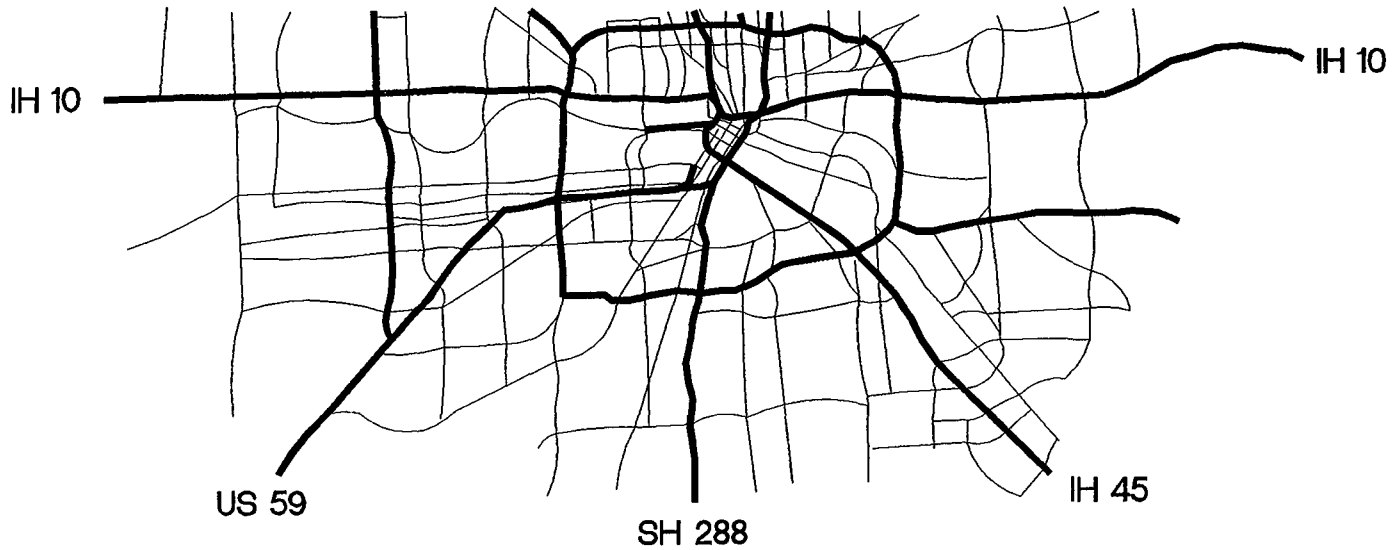


Figure 20. Directions Generated for a Wide Area Route

Resource Management

Resource management is intended to provide the operator with a graphical director of emergency resources and the features of those resources.

Two kinds of applications have been developed using a common base map:

- 1) Associated with each arc is data on the resources for that arc. For example, the names and phone numbers of police, fire, hospital, flood pump managers, and wrecker resources are associated with each arc, which can be queried when needed for incident conditions.
- 2) On this map are superimposed locations of various incident management resources. The user is allowed to conduct queries on these resources. For example, the primary service area of a fire station can be queried. Alternatively, resources meeting user-specified criteria can be listed and displayed. Graphical queries on the resources are also supported.

The following major resources are available in the GIS database:

- Hospitals,
- Police,
- Fire Stations,
- Flood Pump Operators, and
- Wreckers.

Figure 22 illustrates an example showing the address of a fire station that services a user-specified street.

Several other resources, such as Park & Rides and HOV lanes, could also be included as resources for incident management applications.

FIRE RESOURCE

STATION # 3 333-3473 308 MAIN

CONTINUE



86

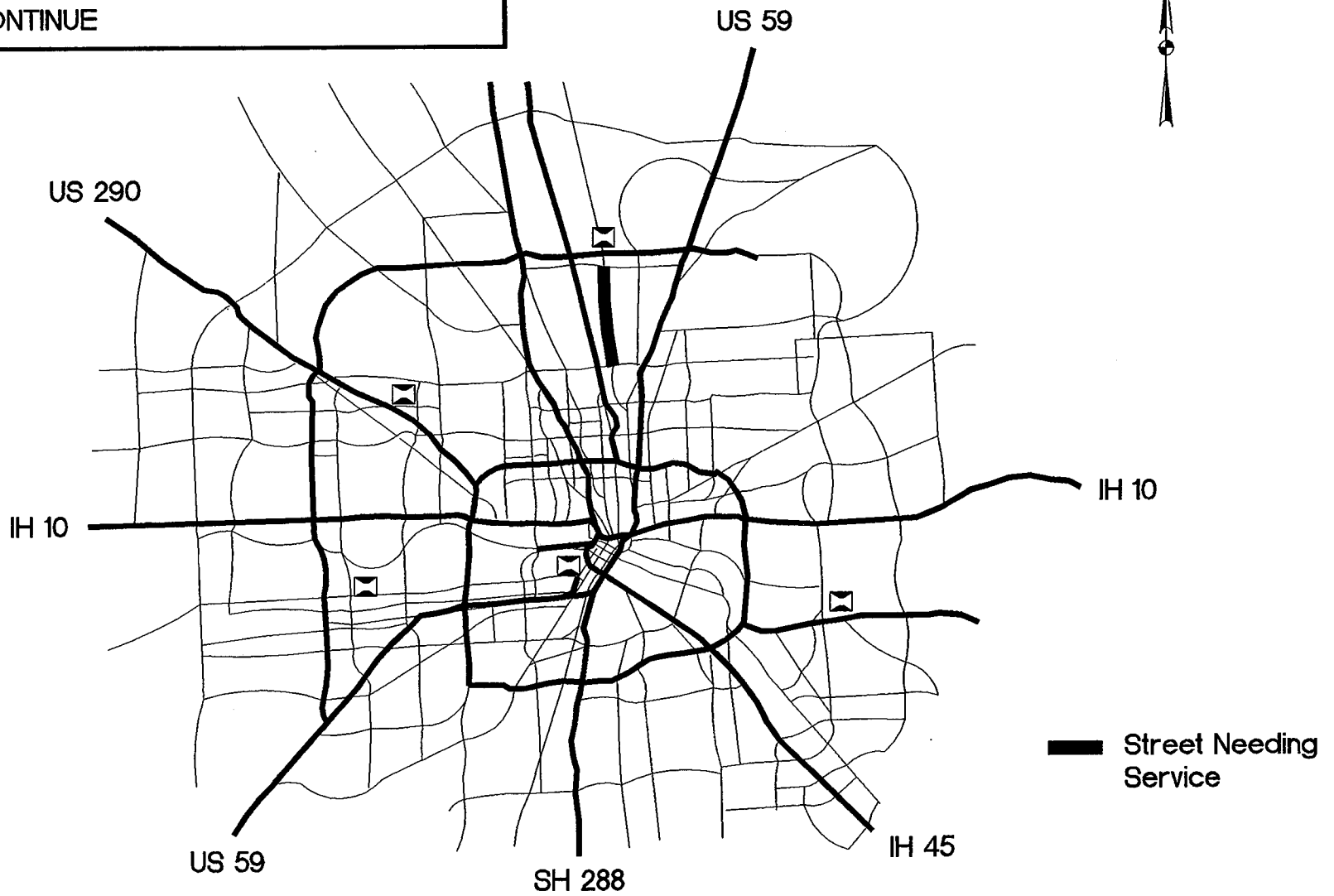


Figure 21. Address of Fire Station Serving Specific Locations

Planning and Analysis for Incident Management

The prototype system provides two kinds of geographic queries for off-line analysis by engineers and designers. Queries are possible on an incident's database as well as on a roadway inventory database.

Incident Database Geographic Query System

An incident database query system is required to ascertain the time, location, type, and cause of incidents. A geographic query on the incident database allows graphical determination of locations which are more prone to incidents and the relationship of incidents to such factors as time of day, visibility, and rain. This application is designed to provide the ability to analyze incidents.

This incident analysis system uses the incident data collected for the Houston Motorist Assistance Program (MAP). For demonstration, the area of operation is currently limited to the Southwest Freeway (US 59) in Houston.

The system allows the operator to conduct queries to perform the following:

- 1) Graphically display, month by month, incidents at each location;
- 2) Graphically display cumulative incident data for each location; and,
- 3) List the incidents reported for each month on the screen.

Such analysis helps the operator identify sections of freeway with historically large number of incidents. This system could be extended to employ traditional accident analysis techniques, such as correlation of accident frequency/severity to operational and physical roadway characteristics.

An example of the results of a query on the incidents frequency in the incidents database is shown in Figure 22.

SOUTHWEST FREEWAY INCIDENT SYSTEM

DECEMBER 1992

INCIDENT: 240

(Bi-directional)

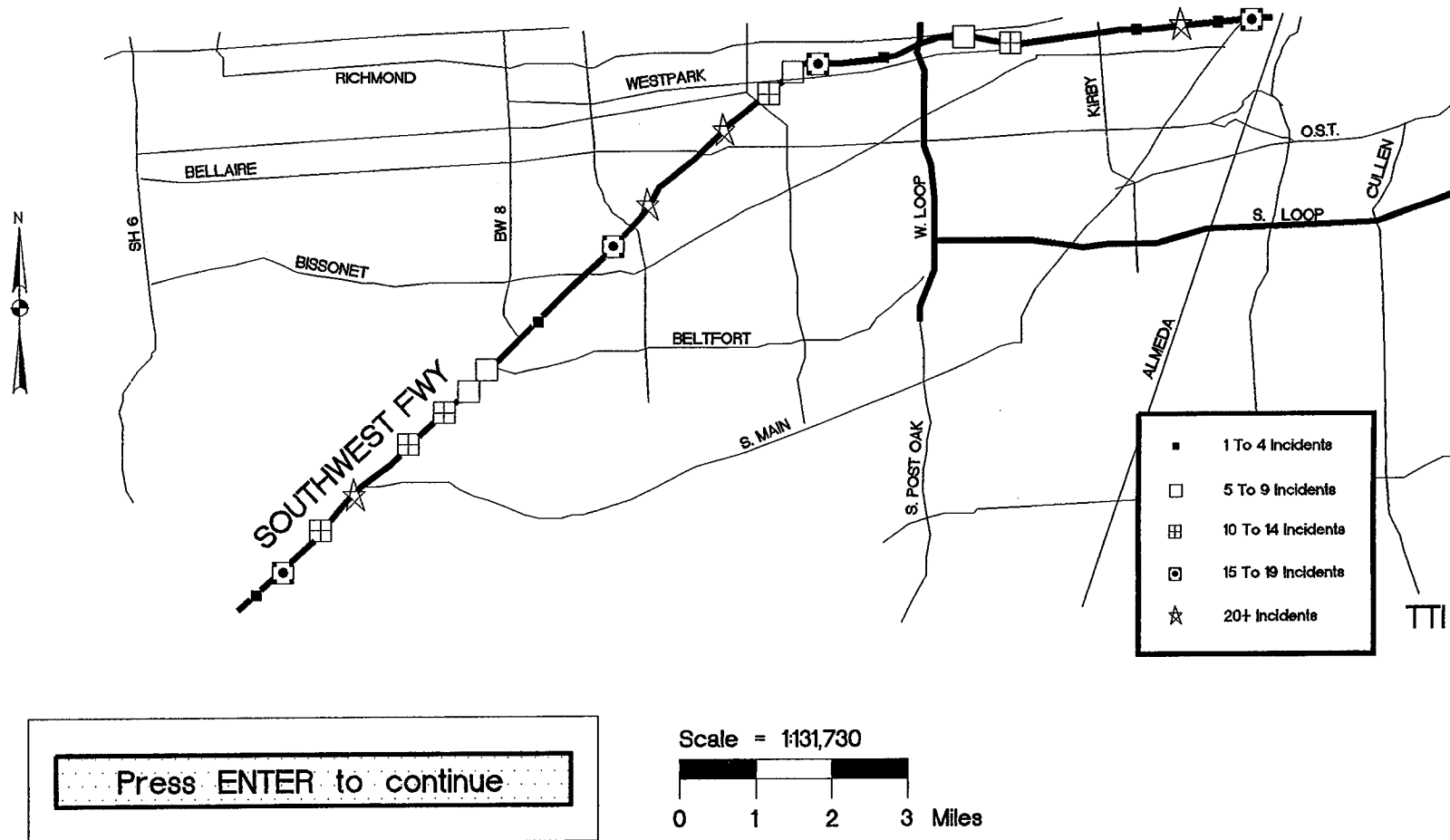


Figure 22. Results of a Query on Incident Frequency

Roadway Database Geographic Matching System

The roadway database matching system has been designed for analysts and planners to be used in conjunction with the incident database query system. Using these two systems, incidents can be related to various conditions on the roadways such as the number of lanes, shoulders, pavement conditions, daily volume, and other characteristics.

Analysts can perform a variety of queries to analyze the road network and identify potentially hazardous road segments. The road segments which satisfy the criteria are graphically displayed and are also listed on a screen. The results of the queries are shown graphically on the screen if the query is text based. On the other hand, a freeway segment may be selected graphically and its database may be viewed by the user.

Examples of the spatial or graphical queries that can be performed are as follows:

- Number of lanes on roads;
- Daily volume of traffic;
- Number of annual accidents;
- Surface conditions;
- Road width; and
- Date last resurfaced.

USE OF TOTAL STATIONS

A novel approach to improving incident clearance when accidents require detailed investigation involves the use of computerized surveying equipment, called Total Stations (34).

Even though police or state patrol are most likely to use this technology, other incident management agencies, notably state highway agencies, may be most interested in its use because it reduces the time to clear an incident and measure damages to highway appurtenances, reducing

delays to motorists and minimizing the time that incident respondents are exposed to danger during an incident.

The electronic total station is a combination of an electronic distance meter which uses an infra-red light to measure distance, and a theodolite, or electronic transit. Several manufacturers offer this equipment. The cost for the field equipment is in the \$15,000 range, bought in any quantity. Surveyors have used this equipment for about 15 years, but it has only recently been adopted for measuring accident scenes.

The electronic distance meter calculates distance by sending an infra-red light to a prism on a rod which is held on the object to be measured and averaging the time the light takes to move to the prism and return. The infra-red light replaces the measuring tape used in the coordinate method. The theodolite measures the horizontal angle from the 0 point at the baseline. Because the station has an internal level, it can also measure vertical angles.

To take measurements, an investigator places the total station at a site from which he or she can view all the objects to be measured. Because the prism is tall, the total station can measure over the tops of objects, including moving traffic. Most of the time, one placement is all that is necessary. One person holds the rod with the prism on a point or object to be measured. Another person sites the total station on the prism. This simple procedure causes the station to simultaneously measure distance, horizontal angle, and vertical angle. A small window shows the measurement information while it is being collected and calculated.

The total station also includes a computer that stores the data as they are electronically collected, replacing the traditional field book. The investigator keys in a code or label for each measured point. The code is a drafting or plotting command for use with an office plotter or computer system.

In the office, the total station connects directly to a plotter to download the information for a quick plot. It can also be connected to a microcomputer so the investigator can manipulate the data within a database or drafting program. The drafting program interprets the assigned

codes and plots a diagram. It can add details of cars, trees, and other objects that have been predrawn and stored in the computer. With special software installed in the office computer, the investigator can even produce an animated recreation of the incident.

Advantages of Total Station Investigation

The most dramatic advantage of using total stations for accident investigation is the reduced delay to the traveling public. The data from urban freeway accidents investigated with total stations and the coordinate method indicate an average clearance time savings of 51 minutes per investigated accident (34). Regardless of any assumptions concerning the cost of fuel and value of time, the equipment cost is offset on the first peak period accident.

Because the equipment can measure over the tops of cars, respondents rarely have to close the roadway completely, if at all. If the road is closed, the closure is shorter because the total station measurement is much faster than previous methods. These differences affect the occurrence and severity of congestion and subsequent secondary accidents, user costs, excess fuel consumption, and driver frustration.

The use of total stations also has some advantage to respondents. First, it increases safety for the investigators. Because scene details can usually be measured from one site and the total stations can measure over the tops of vehicles, investigators need to be on the roadway much less. Measuring is also faster. On-scene investigation with total stations takes less than half the time to investigate than the coordinate method requires. Therefore, investigators are on or near the roadway, exposed to traffic, for much less time. The equipment is also small and portable. It easily fits into a car trunk already filled with police and investigative equipment.

Also beneficial are the computerized drawings which can be produced faster and also convey more information than the hand drawings. The Washington State Patrol estimates that its investigators need about two hours to complete a drawing that used to take eight hours by hand (34). The system also creates a computerized database of site drawings that are reusable

when an accident occurs at a previously measured site. Washington State Patrol has found this feature especially useful for complex intersections.

In addition to the operational benefits described above, the total station method is important in tort liability cases. The equipment produces a more detailed accident description and a more professional drawing of the scene. The system's ability to work with a microcomputer to animate the accident scene provides a jury with a better understanding of the events, causes, and effects of an accident. Better records are also retained in the files. Overall, total station accident investigation removes much of the ambiguity of accident recreation that is common when a trial does not take place until several years after an accident has occurred.

In Washington state, this benefit is important enough that a Major Accident Investigation Team (MAIT) has been formed. The MAIT comprises two commissioned Washington State Patrol officers (one responsible for collision investigation and one for interviewing witnesses); one Washington State Police commercial vehicle enforcement officer to assess vehicle condition; and one Washington State Department of Transportation engineer to record and document the location and condition of the roadway, traffic control devices, and roadway safety appurtenances. The total station is the central piece of equipment the MAIT uses in its investigations.

Perhaps the best indication of the benefits of the total station method for accident investigation is that the Washington State Patrol has purchased three additional systems and anticipates the purchase of two more. With this additional equipment, every investigation team within the Patrol will be equipped with a total station system.

Potential Disadvantages of Total Station Investigation

Like any technology, the total stations do have a few disadvantages. The first is the cost. Costs vary somewhat by manufacturer, but the price is in the \$15,000 to \$20,000 range, depending on the office equipment needed. However, as is shown in the benefit cost analysis, the equipment cost can be recouped in the first peak period accident investigation.

The system also has some minor physical limitations. It is hard to use in dense fog because it is difficult for the investigators to site the prism. Heat waves on extremely hot days can affect measurement.

Finally, although the systems are fairly easy to use, training is necessary, and investigators would need to use them fairly often to remain proficient.

AUTOMATIC VEHICLE IDENTIFICATION/AUTOMATIC VEHICLE LOCATOR

Automatic Vehicle Identification (AVI)/Automatic Vehicle Locator (AVL) are vital (IVHS) Intelligent Vehicle Highway Systems technologies that can be used to enhance an area's overall traffic management and advanced systems. Specifically, these technologies can be used to monitor freeway operations and offer a fast indication of incident occurrence. The AVI systems encompass a more broad monitoring of operations, while the AVL systems can be used to selectively evaluate individual vehicle activities. There are several demonstration tests of these technologies that are on-going throughout the country. Most notable is the Houston volunteer AVI program and utilization of AVL with the Motorist Assistance (MAP) program. In addition, the Metropolitan Transit Authority of Harris County is implementing an AVL system into their bus operations.

HIGHWAY ADVISORY RADIO

Highway Advisory Radio (HAR) offers a vital communication link between traffic/transportation agencies and the motoring public. HAR is used to broadcast incident information including incident severity, anticipated duration, and route diversion. Systems are usually set up with pre-planned messages to correspond to incidents occurring at critical locations. However, HAR offers a dynamic medium in which information can reach each vehicle through its automobile radio. Tests for HAR have been accomplished and proposed for use in truck mounted units to allow portable access to the system. Beaumont is also utilizing a HAR to relay their traffic and transportation information (this is presented in a later section of this report).

CLOSED CIRCUIT TELEVISION

Closed Circuit Television (CCTV) systems are also a viable technology that are becoming more commonplace in larger urban areas. CCTV allows for constant remote monitoring of travel corridors as well as immediate detection and verification of an incident. Most importantly, CCTV facilitates a more accurate response of incident response agencies given the continuous monitoring capabilities. CCTV also offers a medium in which remote monitoring of all surrounding travel corridors can be evaluated to optimize diversion strategies. These systems are being utilized throughout the country. Within Texas, CCTV is being utilized and/or proposed in Austin, Dallas, Ft. Worth, San Antonio, Houston, and El Paso.

CHANGEABLE MESSAGE SIGNS

Changeable Message Signs (CMS) are also a critical link in the dissemination of incident information to the motoring public. Strategically placed CMS can be used to relay the incident location, expected delays, and diversion strategies to the motorist. Most importantly, this technology allows immediate transmission to the public requiring no action from the motorist as they are already receiving visual cues and information from traffic control devices in place. CMS can be a permanent or portable type of device. The permanent CMS seem to be more prevalent in larger urban areas.

GUIDELINES FOR AGENCY RESPONSE

Urban transportation agencies must respond to disruptive incidents within their respective roadway jurisdictions and relieve traffic congestion brought on by the incident as quickly and safely as possible. These guidelines present specific procedures to follow when an incident occurs. Appropriate steps are outlined for effective interagency communication and cooperation in incident response. Since incident consequences and response procedures vary by time of day, the guidelines are categorized by day versus night and by peak period versus off-peak period.

The guidelines focus on responses to major freeway incidents in urban areas of Texas; but, the information can be adapted to small municipalities and rural areas. The guidelines are to be a working document for transportation and enforcement agencies in Texas responsible for responding to and managing the safe and timely clearance of major incidents on freeway systems. While the guidelines incorporate many concepts and experiences developed by other state agencies in incident response, this information has been adapted for specific application to governmental and physical infrastructure conditions existing in Texas. Wherever possible, actual Texas experience and data have been relied upon and given priority in the formulation of these guidelines.

PLANNING FOR MAJOR FREEWAY INCIDENT RESPONSE

Response needs for most major freeway incidents extend beyond the capabilities of a single agency. In Houston, for example, 75% of the lane-blocking freeway incidents require two or more agencies to respond. Different agencies have different responsibilities and objectives when responding to major incidents. These responsibilities have different priorities in the overall incident response framework; but, decisions and actions by any one agency must be compatible with those of the other agencies involved. Incident response planning is a means of establishing the chain-of-command, flow of incident information to aid in response, specific response procedures of each agency, and resources which will be provided by those agencies.

Incident response planning consists of the following steps:

- Establishing multi-agency consensus for incident response planning,
- Identifying common incident classification,
- Establishing interagency cooperation agreements, and
- Developing interagency communication protocols.

Each of these steps is discussed in detail below.

Establishing Multi-Agency Consensus for Major Incident Planning

A consensus of the need for planning should be established among the various agencies involved in incident response. Traffic management teams, now in place in most TxDOT Districts, can serve as the focal point for establishing this consensus; but, other officials that are not a part of the management team will need to be contacted as well. These officials include fire department representatives, medical examiners, and environmental specialists who may be called upon to deal with an incident situation. All agencies that play a role in major incident response must be advised of efforts to establish specific response procedures and why these efforts are needed. Common goals and objectives for improved incident response can be formulated through these consensus-building efforts.

The Texas Department of Transportation is the logical choice to lead in consensus-building for urban freeway incident response because of its broad jurisdictional responsibilities, and because one of the most important benefits is the reduction in incident duration on highways and freeways. Although TxDOT may lead in the consensus-building effort (and perhaps throughout the entire incident response planning process), a law enforcement agency will usually be designated as the agency-in-charge during actual incident response and on scene activities. Later sections discuss the designation of lead agencies and development of the chain-of-command.

Identifying Common Incident Classifications

Agencies are charged with different tasks in incident response; therefore, each one sees a given incident from a slightly different perspective. For example, consider a hypothetical multi-vehicle accident involving two automobiles and a gasoline tanker truck. Medical response units will view the incident in terms of the number and severity of injuries sustained by vehicle occupants. The fire department will analyze the incident for the potential of fire and explosion. The state water control agency will view the incident in terms of the type and amount of hazardous materials that may be released into the environment.

To improve coordination and cooperation among agencies in multi-agency incident responses, a common measure for indicating the severity of a given incident is proposed. The most obvious measure is the expected duration of each agency's involvement in the incident. Earlier, Table 22 presented an example of an incident classification system used by transportation agencies. The duration of an incident decides the level, which is further described by the types of incidents that correspond to that classification, and the response activities that may be required.

Table 22 also indicates that all agencies do not become involved in all incident classifications. Incident types may "shift" to the next higher classification under certain conditions. For example, when an incident occurs late at night, the response times of some agencies may increase. If an incident occurs during peak commute periods, the response time may increase due to difficulty in reaching the incident. Agencies may adjust these classifications to reflect specific differences in their response levels because of resources available in an area. Regardless of the specifics of the classification table, the key is to establish a consistent basis so that all agencies make the same interpretation of an incident classification.

To establish a consistent basis, agencies classifying incident severity must understand how the actions of each agency in incident response fit together. Certain activities by different agencies can occur simultaneously, such as medical assistance to injured occupants at an accident by paramedics at the same time that diversion strategies by police and transportation agency personnel are implemented. Other activities must occur in sequence, such as medical assistance

followed by the removal of incident debris from the roadway. Those activities which must be sequenced extend the total duration of an incident and may cause a shift to a more severe incident classification level.

Establishing Interagency Cooperation Agreements

It is often useful to establish interagency cooperation agreements as part of major incident response planning. These agreements verify each agency's commitment to work cooperatively during incidents and specify the types and amount of resources each agency will commit to incident response. These agreements should include statements concerning:

- Which agency (and officials in that agency) will be in charge during incident response (i.e., the lines of authority/chain-of-command),
- How each agency's need to assist will be determined,
- How agencies will be notified if their assistance is needed, and
- How assistance and coordination of agencies or private sector parties not specified in the agreement will be accomplished.

Developing Interagency Communication Protocols

A coordinated multi-agency approach to incident response requires that officials from each agency be able to pass along and receive important information about the incident as it becomes available. The planning process must determine the information flow process for incident response. This information flow process should include specific criteria concerning when each agency will be contacted, who the contact person (or persons) will be, and the appropriate method for communication.

Effective communication and coordination of TxDOT and other agency contacts must be affected long before the occurrence of a roadway incident. It is a function of detailed pre-planning with the key being a central incident communication control point. This focal point may reside with either TxDOT, police, or other transportation agencies within a given jurisdiction.

Figure 23 shows an example flow chart for incident response proceeding from detection, confirmation, coordination, and communication.

Various documents assist in effective communication of incident information and minimize response time. The first is a descriptive flow chart of communication lines and contacts associated with different levels of a roadway incident. These lines of communication include incident detection through the final clearance report. Each flow chart should include a position with names, locations, and phone numbers which may be different for day or night incident occurrence.

The second document required for effective incident communication and response is a common geographical and roadway location map of the specified jurisdiction. This common map should be available to all potential responding agencies. This map will allow a detailed incident location and should indicate all origin-destination options for agency response with personnel and equipment. The map should also allow extensive formulation of detour, diversion, or alternate routes if needed. This map can be static, or can be part of a sophisticated computerized graphics package (see the earlier discussion of GIS, as an example). An example of this type of map is shown in Figure 24.

Other documents required for effective incident communication and response are complete, updated contact lists of TxDOT maintenance and traffic control personnel. This should be designated by day or night with responsible supervisors highlighted. Likewise, TxDOT dispatch should have contact lists of all other potential responding agencies. A secondary contact list for all agencies should also be available to mobilize additional personnel and equipment, if needed.

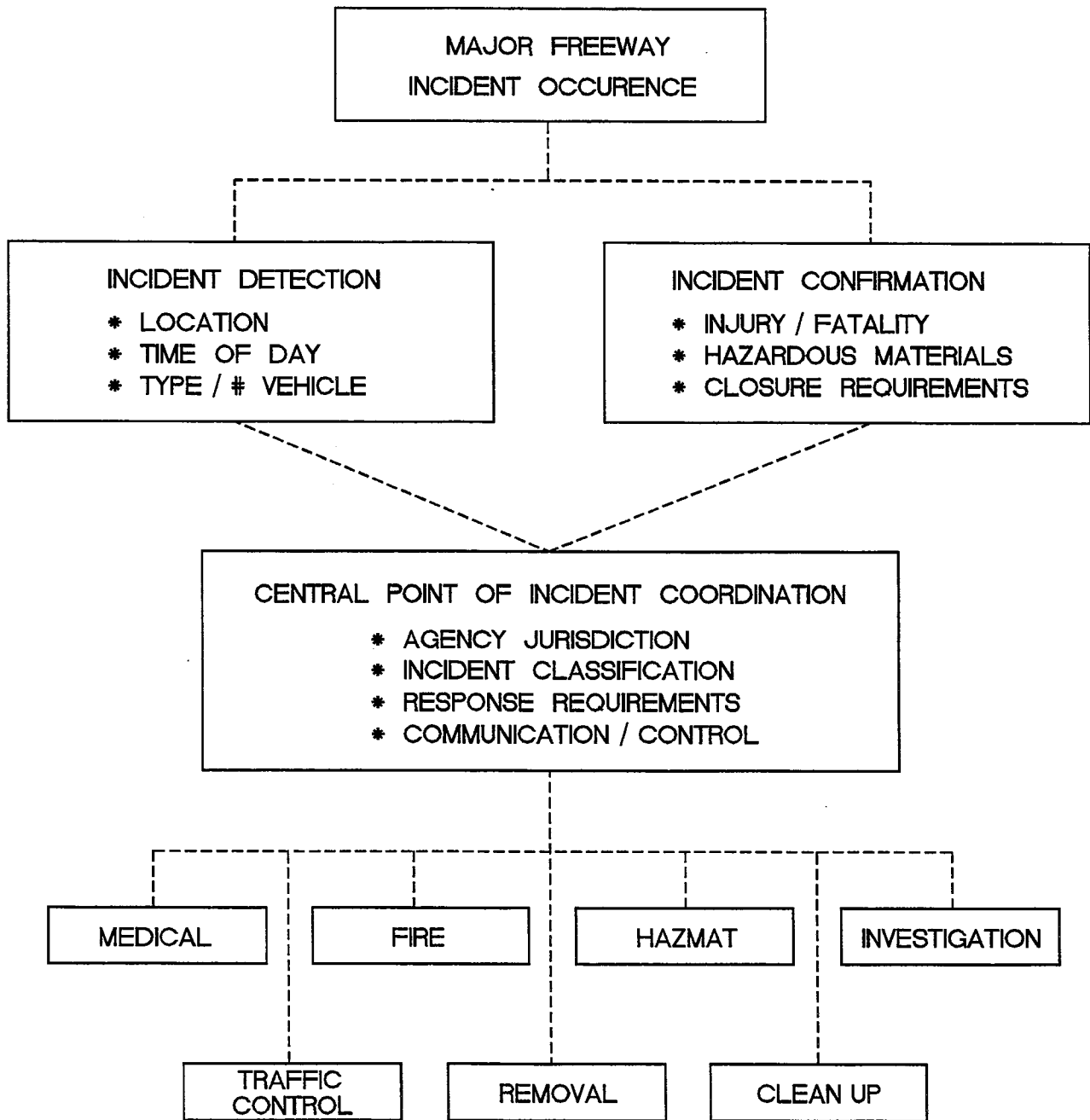


Figure 23. Example of an Incident Response Flow Chart

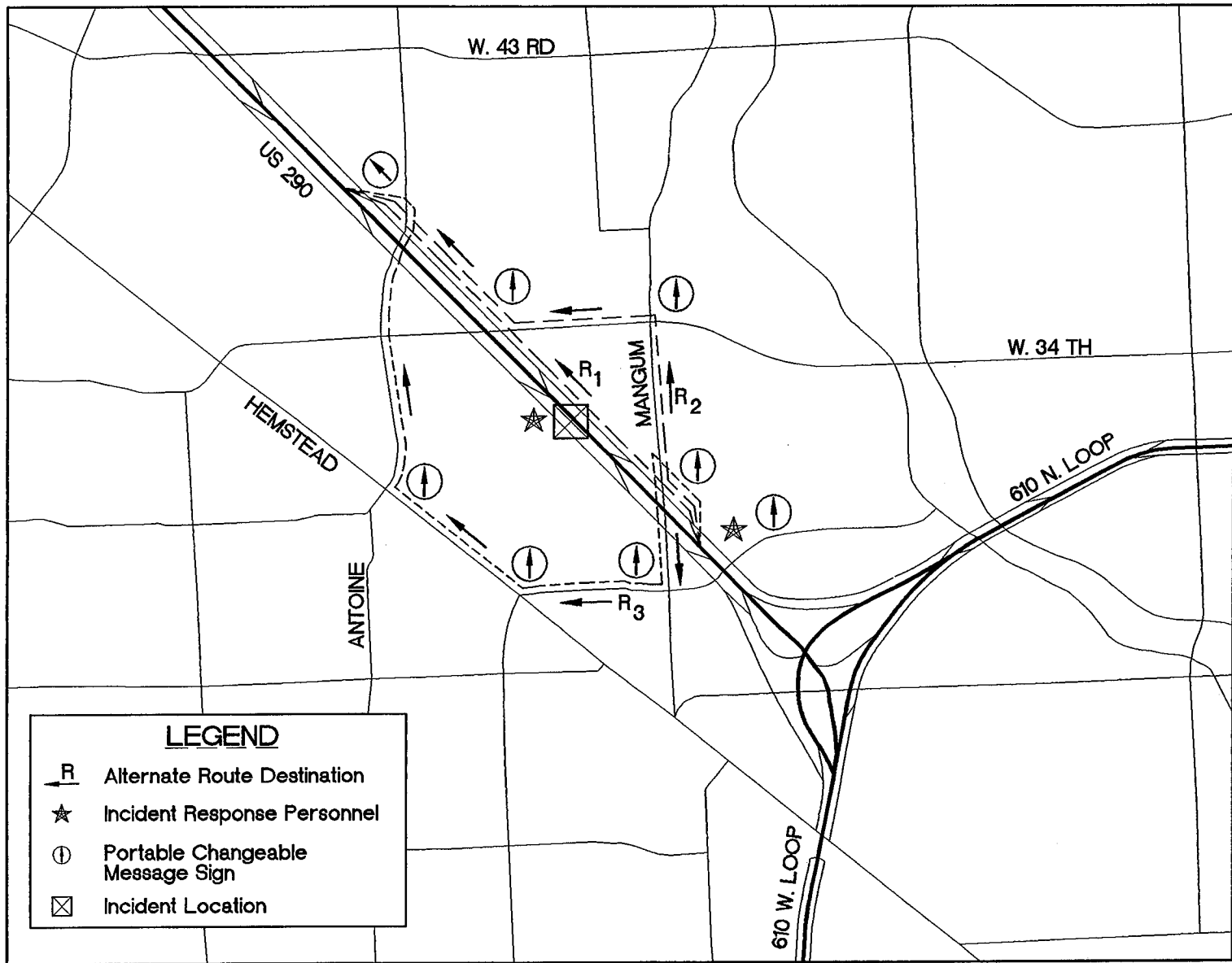


Figure 24. Example of an Incident Diversion Strategy

Usually, the telephone is the designated communication mechanism for exchanging incident information among agencies. Cellular telephones are becoming more common in the work vehicles of many transportation agencies, allowing direct contact with personnel of different agencies in the field. In major urban areas where centralized freeway surveillance and control centers are established, members of key response agencies may be located in the same traffic management center to allow direct communication and interactive decision-making during incidents.

Finally, the public needs to be informed about the incident (i.e., the location, expected duration, diversion locations, etc.). In addition to official communication systems, commercial radio and television stations should be included when disseminating information to the public. The plan should include names and phone numbers of appropriate media personnel.

Transportation Agency Preparations

After the basic structure for interagency cooperation and coordination is established, the transportation agency can improve its response preparedness for major incidents. Transportation agencies are usually called upon to assist in debris removal after a major incident because of the type of equipment they have available (i.e., dump trucks, sweepers, graders, front-end loaders, sanders, boom trucks, etc.). However, requests for other types of assistance for which the agency could serve a useful role are often less frequent because the necessary preparations have not been made beforehand.

Areas in which transportation agencies can provide assistance are on-site response and alternate routing. This section discusses how an agency can improve its capability for response in these functions.

Improved Readiness for On-Site Incident Response

Transportation agencies can enhance their ability to assist in incident clean-up operations on-site by establishing response vehicles which can be dispatched without delay. The vehicles should be provided with equipment and materials as summarized in Table 24. To facilitate access to these materials at the incident site, each response vehicle should be loaded in a uniform manner, with a copy of this loading plan and materials log sheet on board the vehicle for use by operating response personnel. All storage compartments and containers should have a label detailing their contents. In lieu of keeping a specific vehicle loaded, a storage area with these materials should be established which can be quickly loaded onto an incident response vehicle when needed.

Table 24. Equipment and Materials for Transportation Agency Incident Response

Type of Equipment/Materials	Items
Containment Materials	<ul style="list-style-type: none"> • Trash can full of absorbent • Trash can full of sand • Trash can full of diapers (or white foam pads to absorb diesel or oil) • Shovel • Broom • Coveralls
Traffic Control Devices	<ul style="list-style-type: none"> • Traffic cones w/white reflective sleeves • Pylons • Traffic vests • Flashlight w/fluorescent cones for flagging • Flags • Safety vests • Flares and ignitor
Communication Devices	<ul style="list-style-type: none"> • Cellular telephone • Radio (low and high band), 3 or 4 extras
Other Equipment	<ul style="list-style-type: none"> • Spotting scopes to read hazardous material placards from a distance • Hard hats • Marking paint • Spotlight • Fire extinguishers (20 BC or larger) • First-aid kit • Backpack air blower • Electrical generator • High volume pump to remove fuel from overturned tanker trucks • Fuel tank sealant mastic • Vehicle mounted flood lights • Push bumper on incident response vehicles

The number of response vehicles needed is dependent upon the size of the area and traffic under jurisdiction of the transportation agency. Large TxDOT Districts have several maintenance yards with each having assigned responsibility over a portion of the roadway network. Each yard having freeway responsibilities should have one or more specially-equipped response vehicles. These vehicles may or may not be exclusively dedicated to incident response. If not, the vehicle(s) should be easily accessible for this task. Experience dictates whether more vehicles are needed at a specific yard.

For incidents involving overturned combination trucks, special needs may include air bags or air cushions (to return the vehicle to an upright position), as well as mobile construction cranes to expedite incident clean-up. These items are probably beyond the capabilities of a DOT and should be provided by a private source.

Different methods exist to get heavy-duty tow trucks to the scene of an overturned heavy commercial vehicle (Figure 25). If there is only one provider in town, the process of selection is simplified. However, in large urban areas there will typically be several operators, so a method of selection is usually needed which is fair to all who qualify. The most common method used in large urban areas utilizes a rotation list maintained by law enforcement agencies which respond to incidents. In some cases, the tow company must qualify for the list by meeting preestablished requirements of equipment size, lift capacity, and a good service record. Less common is the use of a few heavy duty tow companies that are contracted to provide the service. Some jurisdictions are considering penalties in contracts when tow vehicles take excessive time in responding.

Site Specific Planning for Incident Response

The Incident Inventory and Classification chapter indicates that large urban areas can expect a major freeway incident (blocking one or more travel lanes for more than 30 minutes) once every 137 million-vehicle-kilometers (85 million-vehicle-miles) driven (Figure 26). For areas with high traffic demands and a significant number of freeway lane miles, this incident rate translates into one to two major incidents per week. In some metropolitan areas, a specific multi-agency incident response team (IRT), consisting of state and local police and transportation



Figure 25. Use of a Heavy Duty Tow Truck



Figure 26. Example of a Major Freeway Incident

officials, has been established. The IRT is called to each major incident scene where they establish a command post near the incident and make decisions regarding on-site response and traffic management procedures to implement.

Data is not available to indicate the size of an urban area that can support a formal IRT. Even if a decision is made not to establish an IRT, the transportation agency (TxDOT) should establish an incident response contact person (IRP) who is available to travel to major incidents. The IRP would be in addition to the specific response personnel assigned to assist in debris clean-up, on-site traffic control, etc. The IRP should have a working knowledge of traffic operations and management procedures, and be trained to identify traffic problems which could be reduced at the incident site.

A major task for the IRT or IRP is to implement specific traffic management plans when a major incident occurs. These traffic management plans should be developed prior to the incident and in such detail as to show where and what types of signing and traffic control will be implemented and which agencies will implement them. The magnitude of traffic management actions specified in the plans may vary by the time of day the incident occurs due to the differences in traffic volume expected, as well as the severity of the incident.

Incident Traffic Management Plans

A general process for developing site-specific traffic management plans for incident response is as follows:

- Prioritize freeway sections 1.6 to 3.2 kilometers (1 to 2 miles) in length to be considered for site-specific traffic management planning. This priority can be based on the severity of potential traffic problems caused by a major incident in that section, or on the actual frequency of major incidents that occur. Typically, sections will begin and end with major interchanges or major arterials that can be used to access alternate routes.
- Beginning with the highest priority sections, estimate the expected severity of traffic impacts caused by various lane blockages (i.e., one lane, two lanes, etc.) at various times of day. Typically, three time periods are considered: 7 P.M. to midnight, midnight to 5 A.M., and 5 A.M. to 7 P.M. In some jurisdictions, only

peak and off-peak conditions may need to be considered. Traffic impact severity can be estimated in terms of the difference between the reduced roadway capacity past the incident site and average traffic volume during that time of day. The maximum number of vehicles which may travel through a given roadway section is established as 2000 vehicles per hour per lane on multi-lane highways (Figure 5). The reduction in capacity caused by incidents is not proportional to the physical reduction of the total roadway width due to lane closure. The loss of one lane of a three lane roadway reduced total capacity by 50%; loss of one lane of four reduces total capacity by 33%; two lanes of three reduces total capacity by 80%; and a shoulder blockage or closure due to an incident (no lanes blocked) reduces total roadway capacity by 20%. This loss of capacity, depending on facility and traffic demands by time of day, may translate into significant congestion and delay (Figure 27).

- Determine appropriate traffic management techniques to be employed for each lane blockage/time of day scenario. Scenarios where traffic demands are less than capacity or exceed capacity by only a small amount may require that officials simply monitor activities at the site. Conversely, if traffic demands far exceed the reduced capacity (or if the roadway will be closed entirely), more elaborate actions will be necessary (Figure 28).
- For scenarios where demands far exceed capacity, diversion from the freeway will be necessary. Diversion can either be advisory (if some flow can pass by the incident) or mandatory (if the freeway is closed completely). The parallel frontage road adjacent to most urban freeways in Texas is the most likely primary alternative. However, if the amount of traffic that needs to divert far exceeds the capacity of the frontage road, additional arterial routes farther away from the freeway may need to be utilized. For each section, primary and secondary diversion routes need to be identified and inventoried to make sure they are suitable. Generally, routes that pass schools, hospitals, playgrounds, etc. are not politically acceptable alternatives. For each alternative route, the need for trailblazing signs, police officer control at critical locations (high-volume intersections, ramp closures), etc. is then determined (Figure 29).
- The possibility of establishing special diversion route traffic signal timings on primary and secondary alternative routes should be examined (involving cooperation between TxDOT and local transportation agencies). At a diamond interchange, a three phase operation is often preferable to a four phase operation during diversion. This technique has significant potential for implementation where the signal system is under a computerized system control (either centralized or decentralized).
- Permanent changeable message signs (CMS) are being installed in several urban freeway corridors statewide. The CMS is a very useful tool during diversion operations. If permanent CMS are not available, portable CMS owned by TxDOT for work zone traffic control may be useful. If used, they should be placed on the freeway shoulder, upstream of the exit ramp where traffic is being diverted. This

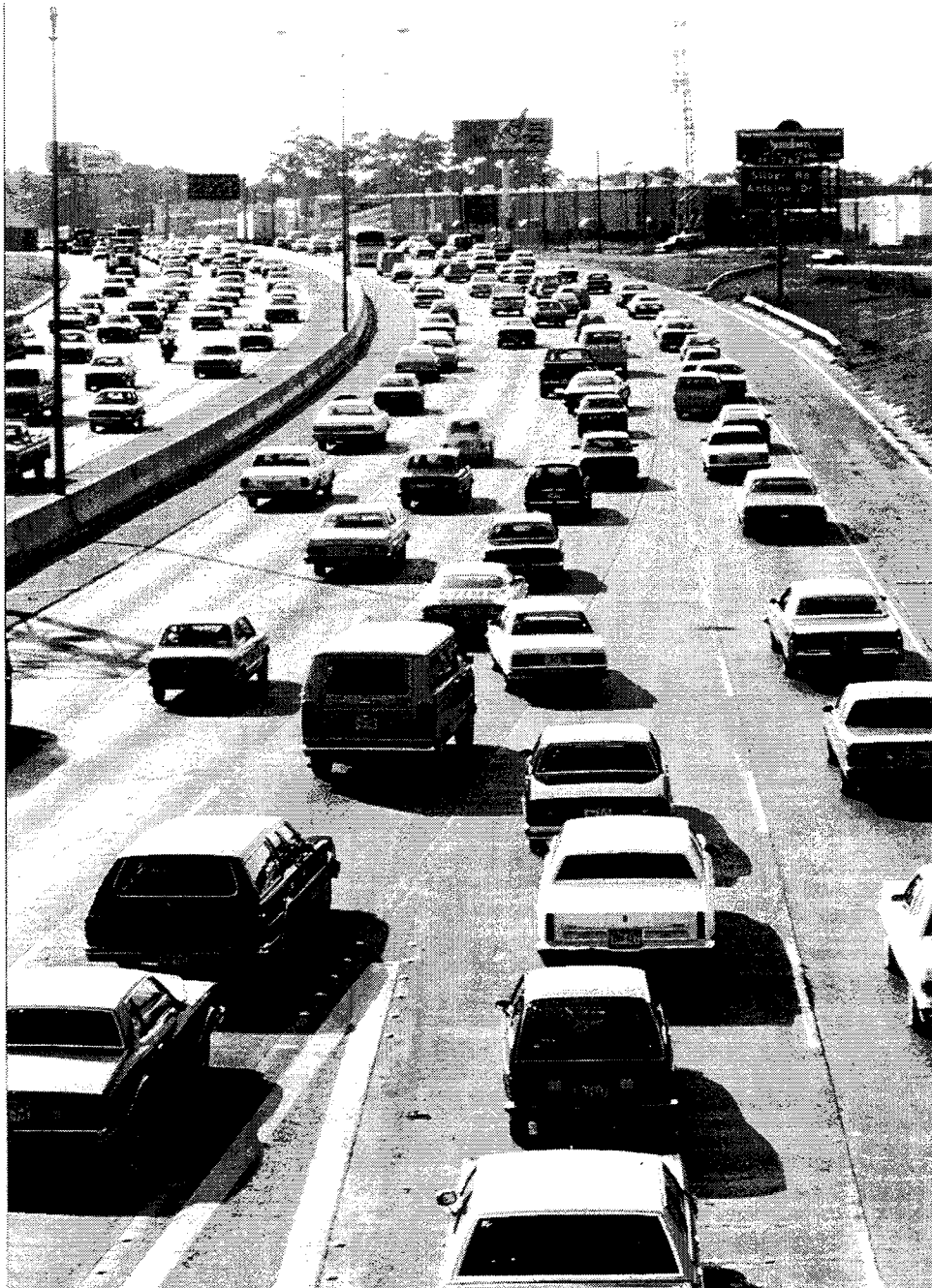


Figure 27. Example of Freeway Congestion



Figure 28. Lane Closure Traffic Control



Figure 29. Law Enforcement Traffic Control

location should be specified for each site-specific plan, along with the message(s) to be displayed.

- Consideration should also be given to potential locations for large equipment staging areas. Many types of incidents require large, specialized equipment to rescue vehicle occupants and clear the roadway. A nearby location should be identified and established for these vehicles to be managed and stored during incident response operations.
- Once the specific traffic management techniques for a given potential incident site are determined, manpower and equipment resources required to implement those techniques are determined. The locations where signs (advance warning, changeable message sign, etc.) will be stored is determined, and individuals responsible for installing them identified. All pertinent information is transferred to a detailed map of the area, marking traffic control and officer locations, primary and secondary routes, and times and conditions when the various levels of traffic management are to be implemented.

It is recommended that the IRT, IRP, or agency responsible for developing the site-specific traffic management plans for an urban area limit the size and scope of the plans initially to evaluate their effectiveness in incident response. Adjustments in the amount and type of information needed on each site plan can then be customized to the needs of the agencies. When site-specific plans are finished, they must be distributed to the agencies involved for their approval.

Levels of Incident Response

Knowing historical information on the types of incidents, where they typically occur, and their rate of occurrence should be helpful in response activities. Using a large database from Houston and smaller databases from Austin and Beaumont, several informative results become apparent. First, major freeway incidents usually involve trucks; and, truck incidents usually occur between 9 A.M. and 4 P.M. Also, clearance time for an overturned truck or spilled load typically increases from 2.5 hours (passenger cars and non-overturned truck) to over 3 hours (Figure 30). Location was also a significant factor with major freeway incidents of all vehicle types, occurring 3.5 times more often at freeway-to-freeway interchanges than between them.

Realistically, an agency incident response level can be dictated given specific parameters of an incident. Criteria such as location, time of day, and severity can assist each agency in pre-

planning for an incident. Specifically, assessment and classification designation of a freeway incident is dependent upon time of occurrence. In general, transportation agency response may be described as indicated in Table 25. Depending on time of incident occurrence (peak versus off-peak, day versus night) and roadway closure (lane capacity versus traffic demand), response level designation may change as shown in Tables 26 and 27. Other factors, such as availability of alternate detour routes, may also be of influence.



Figure 30. Example of an Overturned Truck Incident

Table 25. Response Level Description

Response Level	Departmental Action
1	On site traffic control provided by local law enforcement agencies. Activation of lane control signals and overhead message signs from control center, if available.
2	Level 1 supplemented with special traffic control devices (arrowboards, trailer mounted changeable message signs) provided and operated by department staff and some off freeway traffic management activities (most probably limited to frontage road).
3	Level 2 plus necessary departmental personnel and equipment to deploy traffic control devices for modified version of MUTCD traffic control plan.
4	Level 3 plus necessary departmental personnel and equipment to deploy traffic control devices for closure of lane(s).
5	Level 4 and necessary departmental personnel and equipment for the following activities: <ol style="list-style-type: none"> <li data-bbox="444 1791 1427 1833">1) Deployment of traffic control devices for closure of lane(s). <li data-bbox="444 1843 1427 1902">2) Off freeway traffic management activities (frontage road and primary alternative route(s) including signing and traffic signal handling).

Table 26. Response Level for Peak Period Incidents (Day)

Number of Lanes Closed	Total Number of Freeway Lanes			
	2	3	4	5(+)
	Response Level			
1	3	2	1	1
2	5	4	3	2
3		5	4	3
4			5	4
5(+)				5

Table 27. Response Level for Peak Period Incidents (Night)

Number of Lanes Closed	Total Number of Freeway Lanes			
	2	3	4	5(+)
	Response Level			
1	1	1	1	1
2	3	2	1	1
3		4	3	2
4			4	3
5(+)				4

Training

The proper training of incident response personnel is essential to successful incident response. Table 28 lists some of the areas to include in the training program for incident response.

Table 28. Training for Incident Response Personnel

Area	Training
CPR	Initial training course, with periodic refreshers or updates.
Basic first aid	Initial training course, with periodic refreshers or updates.
Radio communication, with emphasis on reporting	Each agency trains its employees in its own communication procedures and terminology.
Traffic control strategies	TxDOT Traffic Control Course Traffic control section in this manual.
Public relations	Briefing by TxDOT District Public Affairs
Incident command system training	On-the-job training.
Basic hazardous materials identification training	Hazardous Materials Incidents section in this manual.
Removal of disabled vehicles	Disabled Vehicle Removal section in this manual.
Working knowledge of how to use the equipment in the response vehicle	On-the-job training.
General knowledge of departmental procedures and policies of each of the responding agencies	On-the job training.
Fatal or felony accident	Briefing from the DPS accident investigation officer.



RESPONSE GUIDELINES

Incident response techniques can sometimes be identified as "practical" recommendations. Specific guidelines are listed below that follow this type of pre-planning activity. In addition, a step-by-step process is presented for incident response in TxDOT or similar type of transportation agency of jurisdiction. These guidelines are as follows:

- Incident Communication Control or any other emergency agency dispatch calls the TxDOT dispatch requesting incident response.
- TxDOT dispatch informs the Incident Response Team, Maintenance Supervisor, and Public Information that an incident has occurred.
- Members of the Incident Response Team respond to the incident in their trucks.
- While en route, members of the Incident Response Team communicate with on-site personnel by radio to obtain pertinent details about the incident.
- Members of the Incident Response Team, including the Maintenance Supervisor (or a representative), develop a plan of action on the way to the incident scene.
- The Maintenance Supervisor (or a representative) calls in additional maintenance technicians and equipment to the scene, if necessary.
- TxDOT personnel set up traffic control.
- The Incident Response Team calls the TxDOT dispatch with traffic control information.
- TxDOT dispatch notifies selected personnel that specific traffic control has been established.
- For incidents whose anticipated duration is four or more hours, selected personnel are informed by TxDOT dispatch that an incident has occurred and the types of traffic control in effect.
- TxDOT contacts the media regarding traffic control and traffic conditions.
- TxDOT personnel clear the roadway as required.
- The Incident Response Team informs TxDOT Dispatch that the incident has been cleared.

- The Highway Radio Operator notifies selected personnel that the incident has been cleared.
- TxDOT contacts the media regarding traffic control and traffic conditions.
- Required incident response reports are completed and filed.

In general, these guidelines should be followed for both day and night incidents. However, specific personnel contact locations will be different at night, along with associated staging response times. Also, the maintenance supervisor or incident response team leader will act as spokesperson representing TxDOT for any media communication.

MAXIMIZING TRAFFIC FLOW PAST THE INCIDENT

Maintaining traffic flow is an important part of dealing with an incident. With the exception of vehicles parked to secure the incident scene, emergency vehicles should be parked on the shoulder to keep from blocking any additional lanes of traffic. The main goal is to keep as many lanes of traffic open as possible.

MINIMIZE USE OF FLASHING LIGHTS DURING PEAK PERIODS

The use of emergency flashing lights to alert oncoming motorists that an incident has occurred can be positive or negative, depending on the time of day. Flashing lights are a must when vehicles will be travelling on the shoulder or next to it at high speeds, especially at night. Flashing lights are also important aids to personnel travelling to the incident scene. However, flashing lights can distract motorists if they are used unnecessarily. These distractions cause increased congestion at the scene of the incident. Arrow panels should be set up once the incident response vehicle has arrived at the incident scene.

REMOVAL OF VEHICLES

Removing vehicles that block the roadway can be a major step in opening lanes of traffic and relieving congestion. Push bumpers provide incident response vehicles and patrol cars with the capability to push vehicles with various bumper designs off the roadway quickly and safely. The longer congestion exists, the higher the probability that a secondary accident will occur. Therefore, it is important to clear the vehicle out of the roadway as soon as possible.

The authority exists to clear obstructions to open the roadway as soon as possible. Section 103 of Article XIII of the Texas Motor Vehicle Code establishes legal authority for vehicle removal from roadways. This may increase the state's exposure for potential tort action. However, the main concern is to work for the greater good of the motoring public; this goal outweighs any damages to private property that could be incurred.

The recommended procedures for pushing vehicles off the roadway are as follows:

- Always obtain driver permission before pushing the vehicle off to the shoulder (except if the vehicle is a hazard or interrupting the flow of traffic on a bridge facility).
- Make sure the driver knows where the vehicle is being relocated. The driver must understand the direction to steer. Also, remind the driver that the power steering or brakes may not be functioning.
- Guide the driver by giving instructions through the loudspeaker.
- Push the vehicle to the nearest shoulder. Do not cross traffic to clear a vehicle, unless it is absolutely necessary.
- Ensure the bumper connection is well fit.
- Do not push the vehicle too quickly.

Push a vehicle when:

- the vehicle is stalled or disabled, but its wheels are free to roll,
- the incident response vehicle has compatible bumpers or push bumpers,
- the vehicle is no larger than a pickup, and
- the driver is capable of steering the vehicle to the side of the roadway.

Do not push vehicles when:

- the vehicle is too large to move,
- the wheels are locked (air-brake systems on many heavy trucks can be unlocked so as to move the vehicle out of a traffic lane if damage is not too extensive),
- the driver is not capable of steering the vehicle to the shoulder,
- there are injuries or fatalities. In cases of incident fatalities, a coroner must examine any bodies before they can be removed from the incident scene,
- the driver is suspected of being impaired by a substance such as alcohol.

USE EXTREME CAUTION AROUND HAZARDOUS MATERIALS INCIDENTS

The safety consequences of a hazardous material incident cannot be overstated. It is essential to communicate immediately to local, state, and (if necessary) national officials information concerning incident details associated with hazardous cargos spills.

When encountering an incident suspected of involving hazardous materials, approach the incident scene upwind. Stay clear of all spills, fumes, vapors, and smoke. Do not assume that odorless vapors or fumes are harmless. Do not attempt to enter the incident scene until potential hazardous material exposure is cleared. Use spotting scopes to determine the type of material spill from a distance. Help cannot be provided to others until the hazards have been completely identified.

Placards, container labels, shipping papers, and/or knowledgeable people on the incident scene can be valuable sources of information. Evaluate and consult them all. Use the *1990 Emergency Response Guidebook* for the following procedures. This is done by observing the following information from a distance using binoculars or similar spotting scope.

Obtain the Material Identification Number

- Find the four-digit ID number on the placard or orange panel; or
- Find the four-digit ID number on the shipping papers or package. Shipping papers should be located in a pouch on the driver's door, in clear view of the truck driver's seat, or on the seat itself; or
- Find the name of the substance on the shipping papers, placard, or package.

Find the Guidance Number

- Find the procedures that correspond with the appropriate guide number (white pages with the orange rim)

If unsure of hazardous materials, contact the Chemical Transportation Emergency Center (Chemtrec) at (800) 424-9300 for hazard information warnings and guidance by providing only the product name and nature of problem.

PRESERVE THE INCIDENT SCENE AT FATAL OR FELONY ACCIDENTS

In the event of fatalities or suspected felonies (i.e., hit and runs), extreme care must be taken to preserve evidence at the scene. Traffic should be routed around all physical evidence (i.e., skid marks, broken glass, automobile parts), if possible. All response team members should be aware of this and take necessary precautions. Care should be taken not to disturb anything on-site.

INCIDENT REPORTING (ON-SITE)

A designated individual within TxDOT or the responding transportation agency should complete and file a report regarding activity associated with a roadway incident necessitating closure of a travel lane(s). This report can be accomplished at or through agencies represented at a control center, if applicable. Note the following information in that report:

- Indicate the location of the incident.
- Check off the appropriate weather and road conditions.
- Specify the time TxDOT arrived and the time the road was closed.
- Estimate the duration of the closure.
- Provide a brief description and possible cause(s) of the incident.
- If this is a HAZMAT spill, identify the material spilled and its approximate quantity.
- If clean-up is required, fill out all necessary details regarding the equipment used.
- Identify who has taken responsibility for the clean-up.
- List TxDOT's traffic control activities.
- State whether detours or route diversion were needed.
- List all agencies involved.
- Note how TxDOT was notified (by radio or phone).
- List the names of all TxDOT employees on the scene.
- Obtain pertinent information about the vehicles involved.
- List the time the roadway was opened.
- Note the time that traffic control started and ended.
- Check off all equipment used at the incident scene.

- Describe how the clean-up was conducted, noting the equipment, the time clean-up started, and the time it ended.
- Check which traffic investigation method was used, if applicable.
- Make pictorial documentation of the incident and actions.
- Note any damage to any TxDOT highway appurtenances as a result of the incident.
- Indicate presence of medical examiner, if required.
- Note any other pertinent comments about the incident.

An example of an on-site report form is provided in Figure 12.

INCIDENT REPORTING (AFTER INCIDENT)

In addition, an individual within TxDOT or the responding transportation agency responsible for incident dispatch communication should complete and file a written report to corroborate with the on-site report and provide identification/notification information not known by representatives/agencies on-site. This report may be combined with the on-site report if both are done at a control center. The report should include:

- The roadway designation, mile post, county, and nearest major landmark of the incident scene.
- A description of the incident.
- Any hazardous materials present.
- Time when a HAZMAT response team was notified.
- Each maintenance person on the scene and the time he or she was requested. In addition, note the time that he or she arrived on the scene.
- Any additional maintenance crews that were required, the time of contact, and response.
- Any additional TxDOT equipment required.

- Who requested the road closure and when.
- Whether the road closure was total.
- Which lanes were closed and when they were reopened.
- Any on- or off-ramps that were closed and the time they were reopened.
- Any detour information, if necessary.
- Any additional comments that pertain to the incident.

EVALUATION OF GUIDELINES BY CASE STUDIES

A major goal of this research study was to establish realistic and useful incident response implementation guidelines for urban areas in Texas. As a means of investigating their practicality and usefulness, the guidelines documented in the previous chapter were applied to three urban areas (Houston, Austin, and Beaumont) assumed to represent typical conditions in large, medium, and small urban areas, respectively. Table 29 documents the salient features of each case study location. As was desired, significant differences are evident between the case study locations with respect to population, freeway lineage, number of transportation-related agencies having jurisdiction within the region, and expected frequency of major freeway incidents. Whereas, Houston can expect to endure a major freeway incident almost twice weekly, Beaumont must deal with a major incident only once every two months or so. Consequently, transportation agency focus, available resources, and operating protocols were quite different for each case study location.

RESPONSE PLAN DEVELOPMENT PROCESS

The major freeway incident response plans were initiated in a fairly uniform fashion for all three case study locations. TTI researchers began the process by attending the Traffic Management (TMT) meetings of each region to solicit input and support for the idea of a multi-agency incident response plan. Given the limited study duration and extensive pressures and commitments already existing for the major TMT members in each area, TTI researchers opted to serve as the actual coordinators and developers of each plan. Three different staff members took the lead role in plan development for each case study and proceeded to initiate follow-up contacts with TMT members in the region as necessary, conduct needed traffic and roadway analyses, and develop a draft product for subsequent review by the TMT. The following paragraphs summarize the key characteristics of the developmental effort for each case study location.

Table 29. Characteristics of Case Study Locations

Characteristic	Location		
	Houston	Austin	Beaumont
Population	2,000,000	500,000	125,000
Freeway Lineage	240 kilometers (150 miles)	112 kilometers (70 miles)	55 kilometers (35 miles)
Traffic Management Team Membership	Texas Department of Transportation City of Houston Metropolitan Transit Authority of Harris County Houston Police Department Houston Fire Department Harris County Sheriff Office Harris County Constable Office Harris County Engineering Department Harris County Toll Road Authority Texas Department of Public Safety Houston-Galveston Area Council Houston Traffic Management Center Metro Traffic Shadow Traffic City of Pasadena	Texas Department of Transportation Austin Police Department Austin Fire Department Emergency Medical Service Austin Department of Public Works and Transportation Texas Department of Public Safety Travis County Sheriff Department Capital Metro	Texas Department of Transportation Beaumont Police Department Beaumont Fire Department Beaumont Department of Public Works/Transportation Texas Department of Public Safety
Expected Frequency of Major Freeway Incidents	87 per year	21 per year	6 per year

Houston

The Houston region represented, by far, the most complex and time-consuming effort for implementation of incident response guidelines. For several years now, transportation officials in the region have duly noted the significance and importance of the freeway incident problem and have been taking steps on several fronts to help deal with such incidents. For instance, a joint venture was undertaken a few years back by the regional transit agency (METRO), the Texas Department of Transportation (TxDOT), the Harris County Sheriff office, Houston Automobile Dealers Association, and Houston Cellular to initiate motorist assistance patrols on selected freeways. These vans, equipped with push bumpers, gasoline, water, and basic automobile repair tools travel the area freeways to help stranded motorists get their vehicles from the freeway as quickly as possible.

A major computerized traffic surveillance and control system is presently being installed to assist TxDOT, METRO, and the Houston Police Department identify freeway incident

characteristics and response needs more quickly. Changeable message signs (CMSs) and lane control signals (LCSs) have been installed to provide motorists with freeway incident information while they are en route. In addition, the transportation officials have established close working relationships with the area traffic information reporting services (Metro and Shadow Traffic) to ensure that incident information is quickly made available to all motorists via their automobile radios.

The TTI office in Houston currently has research underway to explore the potential use of Geographic Information Systems (GIS) for managing roadway and traffic data in real-time for incident conditions. One of the concepts being explored in that research is the ability to utilize GIS algorithms to identify appropriate alternative routes around incident locations. Other potential uses include the ability to consolidate and manage information concerning roadway construction and maintenance activities on alternative routes, and the management of equipment and supplies (barricades, cones, etc.) stored at remote locations for traffic control purposes in the event of an incident. Houston has been designated as a Priority Corridor location by the federal government and earmarked to receive additional monies for advanced technology implementation to assist with traffic management activities (including incident response and management).

As discussed, several components to assist in major incident response are already in place or under development as part of other efforts within the region. Therefore, the TTI plan development leader for this study focused on documenting these and other various traffic management and incident response components in Houston and discussing how they will be integrated into an overall incident response package in the future. A proposed incident response flow chart and incident classification (five level) were proposed as part of that package. Appendix C presents the draft incident response plan that was developed for Houston as part of this study effort.

Austin

The major incident plan development in Austin also focused primarily on identifying the existing incident response procedures, noting areas of potential improvement, and investigating

the potential of the various agencies to implement the proposed improvements. Efforts to improve major freeway incident response in Austin are currently not as extensive as they are for Houston, although several members of the Austin TMT acknowledged the need for improvements in one or more aspects of existing incident response procedures. Adoption of a four-level incident classification scheme was recommended, as was improved interagency communication capabilities. Also, the need for a consistent map positioning protocol was cited in the plan (the city police use block numbers as opposed to a mile point reference system utilized by TxDOT and the Department of Public Safety). Appendix D presents the draft incident response plan for Austin.

Beaumont

Beaumont has a smaller, but highly-effective TMT that has an established record of working together and resolving transportation-related issues in a timely manner. Because of both the history of cooperation and smaller organizational structure of the TMT, it was possible to explore the development of a detailed incident response plan more reflective of an end product than was possible in either Houston or Austin at the present time.

The incident response plan for Beaumont utilized a simple three-level incident classification scheme. Beaumont does not experience the extremely high volumes that plague both Houston and Austin area freeways. For most lane-blocking incidents, traffic management activities that emphasize effective on-site traffic management were judged to provide suitable mobility as long as one lane was available for travel past the incident site. Consequently, all incidents that allowed for traffic flow past the incident were designated as Level 1. The next level of severity, Level 2, included those incidents that involved the closure of all freeway travel lanes in one or both directions of travel. In most cases, the frontage road adjacent to the freeway can serve as the diversion route. Traffic control at this level focuses on effectively moving traffic to the frontage road, processing them through any capacity restrictions such as signalized intersections, and returning them back to the freeway as quickly as feasible. The most severe category was identified as Level 3 which are any incidents expected to exist for more than 2 hours at a location where the frontage road is discontinuous and, therefore, cannot serve as the

diversion route. Traffic management actions for this incident level require coordination of state and city police and transportation agencies, as drivers must be diverted from the freeway (a state-maintained facility) onto local arterial streets and then back onto the freeway. These were the incidents that the plan was designed to address in a detailed manner.

Based on the comments of several members of the TMT, no efforts were made to establish special incident response vehicles or supply/equipment stockpiles. As noted in Table 29, the Beaumont area only experiences a few major incidents per year. The emphasis of the plan is on the specification of selected alternative routes for incidents at critical locations along the freeway system. Also, the Beaumont District of TxDOT recently upgraded the highway advisory radio system they have had installed for several years (now termed the Traveler Information System). As part of the response plan, specific radio messages were developed for implementation with the various alternative route plans to assist motorists in finding their way around the incident location via the arterial street system. Trailblazing sign arrays were proposed on these plans as well. Appendix E presents the major freeway incident response plan developed for Beaumont.

Evaluation by TMT Members

It was not possible to implement improved incident response procedures and utilize them during an actual incident at any of the sites within the time constraints of the research study. As an alternative, TTI researchers distributed draft copies of an initial incident response plan to members of the various TMTs. The TMT members were then contacted by telephone to obtain their opinions regarding the usefulness of the document, potential areas of improvement, and how the existence of such a document would improve their response preparedness.

The plans presented to the Houston and Austin TMTs were fairly general in nature and could not address most of the major freeway incident response issues to any great detail. Comments by TMT members in those areas generally noted the need for additional information of one sort or another. As an example, officials in Austin asked for additional discussion concerning the role of video detection on US 183 and about incident severity from the perspective of different agencies. They also noted the importance of establishing a database to record impacts

and actions taken at past incidents for reexamination at a future date. In Houston, one TMT member indicated that specific alternative route plans were especially needed. These route plans would designate which arterial streets would serve as alternatives in the event of an incident at any point along the freeway, and when such alternative routes would be needed dependent on traffic volume/time-of-day characteristics at that location.

Most of the interest from TMT members in Beaumont were also on the specific alternative route plans that were presented. For example, a few TMT members suggested different alternative routes at some of the locations based on their knowledge of local roadway conditions. They also noted that it may be necessary to identify several alternatives at some of the locations because a single arterial route would not be able to handle the additional freeway traffic during certain times of the day. The Beaumont Public Works/Transportation representative noted that his agency would need to look more closely at the recommended routes and develop "incident" traffic signal timing plans for those arterials identified as alternatives. Finally, another member indicated that the permanent placement of Interstate route shields (with "Incident Detour" placards mounted beneath each shield) should be explored at strategic locations on the arterial streets to be in place to guide motorists in the event that traffic needed to be diverted off of the freeway.

Beaumont TMT members also noted that most of the other information contained in the plan would probably not be needed at a major incident site. The Beaumont Police Department officers who respond to the various incidents that arise know what to look for when they first arrive at a scene and do not need the basic information contained in the beginning of the plan. It was suggested that only the actual alternative route plans that were finally accepted by the TMT be copied and laminated along with the list of telephone numbers so that just those pages could be distributed to the BPD officers to keep with them in the glove box or trunk of their police vehicle.

DISCUSSION

The objective of SPR Study 1345 was to develop guidelines that can be applied statewide in large, mid-size, and small cities for the preparation of an incident management plan or the improvement of an existing incident management plan.

The literature review provided valuable insight into the documentation of various topics on major incident response and incident management procedures. There are some historical studies that quantify impacts of major incidents and plenty of studies that recommend concepts to formulate incident management parameters. However, there was limited documentation and/or evaluation on the development and potential implementation of incident management plans.

The state-of-practice in Texas and incident response questionnaire identified specific assets and liabilities of each agency contacted. Specific criteria in interagency communication, coordination, and control were also documented. The incident inventory and classification section provides some of the most interesting results of this study. Based on the limited data received through the state-of-practice, some general criteria were established to identify incident parameters and trends in Texas. These include incident rates as a function of traffic and geometric variables as well as characteristics of incidents in terms of their frequency, time of day, severity, type, and duration. A summary of this inventory data was presented earlier in this report on page 74.

Incident management and response requirements were identified to address incident detection, response, clearance, and recovery parameters. A specific framework of incident management for central control activities was developed to encompass these parameters for small, medium, and large urban area categories.

The application of advanced technologies for incident response offers significant improvement to the existing system used to detect, verify, respond, and clear major freeway incidents. Inclusion of these technologies is vital to transportation agencies in dealing with these incidents in the future.

The guidelines for agency response and response guidelines sections presented earlier in this report outline the criteria necessary for incident management within Texas. These guidelines are sometimes practical recommendations (i.e., maximizing traffic flow past the incident, use of emergency vehicle flashing lights, removal of vehicles, dealing with hazardous materials, etc.). However, specific criteria dealing with incident planning, classification structure, cooperative agreements, and communication protocols were also identified. Two of the most important results identified in this study were the agency reporting and documentation of incident data, as well as the pre-planning incident activities, especially that of diversion strategies.

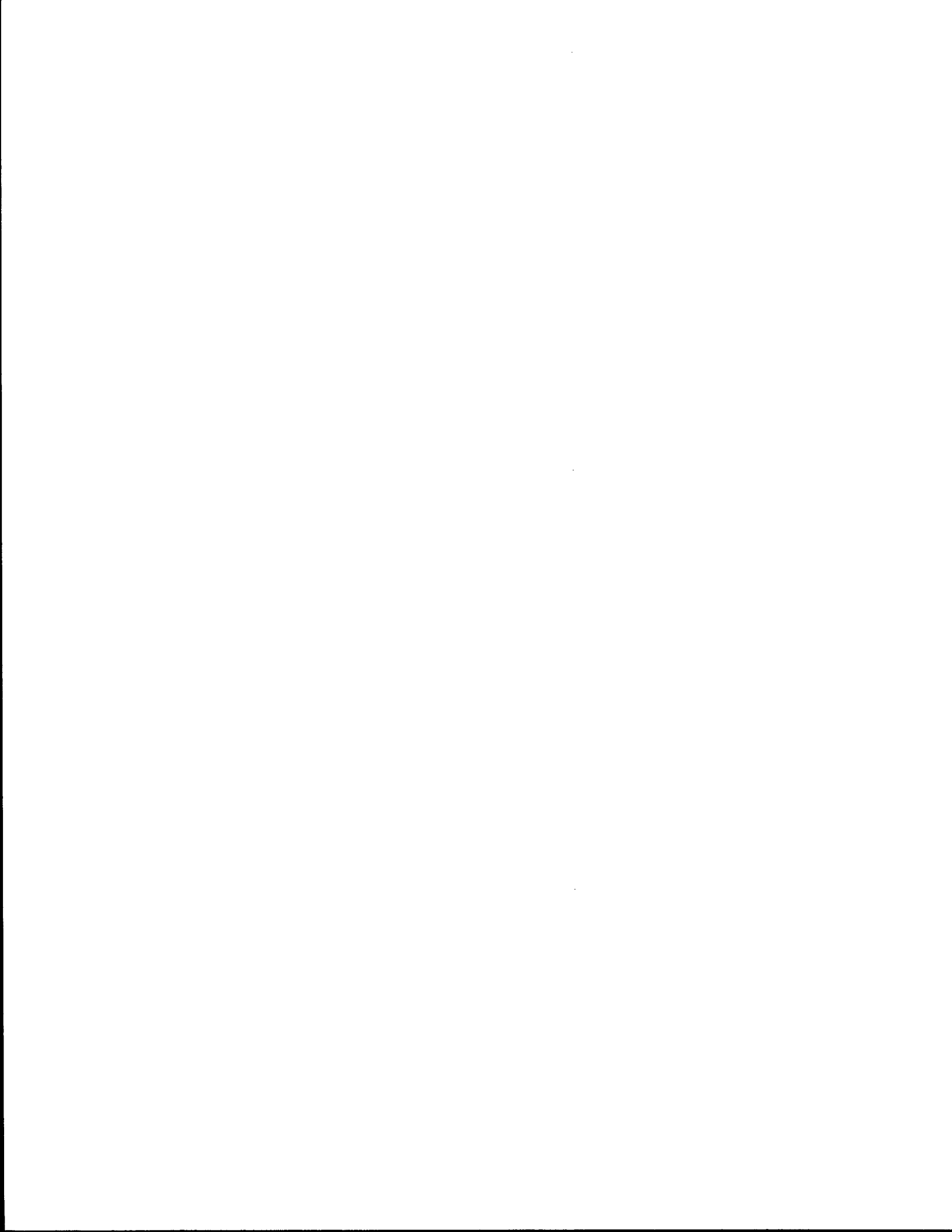
The development of the incident response guidelines culminated in the establishment of Incident Management Plan Guideline Case Studies. The case study implementation process and subsequent evaluation illustrated a number of other important issues that pertain to the development of an effective response plan for major freeway incidents. Some of these issues are cited below.

- One of the major issues left unresolved was how to further reduce the time lag in getting TxDOT clean-up equipment to incident sites. In general, the TxDOT perspective was that the law enforcement personnel in charge at an incident did not always notify TxDOT of their equipment needs in a timely manner. In contrast, the law enforcement perspective was that TxDOT officials do not trust the initial assessment of equipment and clean-up needs by police officers and so send their own officials out to the incident site first to verify these needs before authorizing clean-up equipment to be dispatched. In all likelihood, the typical incident scenario is probably a combination of both of these behaviors. As more urban areas in Texas receive video surveillance systems as part of computerized traffic management systems, the ability to determine and verify equipment needs by TxDOT personnel at the control center will be enhanced accordingly. However, for those jurisdictions without video surveillance, a more detailed equipment assessment process will need to be worked out. Unfortunately, it does not seem likely that a third party (such as TTI) could establish such a process. Rather, it will take officials from both sides sitting down together and working out a description and equipment request protocol that is amenable to both agencies.
- Another major cause of incident response and clean-up delays is the time required to get a medical coroner to the scene of a traffic fatality. Congestion caused by the incident hampers the ability of the coroner to reach the incident site. Presently, there seems to be very little that can be done to alleviate this particular problem. The person-in-charge at the incident can only make sure that the coroner is called as soon the need for one is known. It is important that clean-up

equipment and any other assistance needed be requested as soon as it is known, however, so that the clean-up activities can be initiated as quickly as possible after the coroner is finished.

- Evidence from the three case study locations suggests that the development of alternative route plans is the incident response planning activity of greatest interest to transportation-related agencies. Agencies should prioritize potential incident locations based on likelihood and severity of occurrence, and initiate efforts to establish feasible alternative route plans early on in the incident response planning process. In some instances, more than one alternative route may need to be identified to accommodate the volume of freeway traffic that would need to divert.
- As a result of the case study analyses, it appears that two types of manuals may be needed to completely document incident response activities in a region: (1) a field manual to be carried by law enforcement officers that identifies specific actions (telephone numbers, ramp closures, alternative routes, etc.) to be enacted based on the location and severity of the incident, and (2) an office manual that documents the interaction between various agencies, the various traffic management components involved, and how they should be used, etc.

Future research from this study could include a more in-depth evaluation of the case studies, development of alternate routes, and diversion strategies for the Houston and Austin case study areas, as well as the development of the field and office manuals suggested above.



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