Traffic Incident Management Handbook

Prepared for:

Federal Highway Administration

Office of Travel Management

Prepared by:

PB Farradyne

November 2000

Table of Contents

List of Figures

List of Tables

1 Introduction to Incident Management

1.1 PURPOSE

Incident management is defined as the systematic, planned, and coordinated use of human, institutional, mechanical, and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims, and incident responders. These resources are also used to increase the operating efficiency, safety, and mobility of the highway by systematically reducing the time to detect and verify an incident occurrence; implementing the appropriate response; and safely clearing the incident, while managing the affected flow until full capacity is restored.

This handbook will assist agencies responsible for incident management activities on public roadways to improve their programs and operations. Agencies typically responding to highway incidents include:

- Police
- Fire
- 911 dispatch
- Towing and recovery
- Emergency medical service (EMS)
- Hazardous material
- Transportation agencies
- Media

The intended audience for this Traffic Incident Management Handbook is primarily (1) managers who are responsible for incident management program development; and (2) field practitioners who are responsible for providing program services on a day-to-day basis. As such, this Handbook provides guidance from two perspectives: First, as a process to follow in establishing a new incident management program or in improving an existing one, and second, through the identification of tools and strategies that can enhance field operations.

This document is an update to the Freeway Incident Management Handbook, published in 1991 by the FHWA. It provides detail on important elements of successful incident management programs, as well as field operations. It includes new and advanced incident management topics. This update assumes that the traffic congestion issues posed by incidents are already well understood by most agency personnel. As such, the focus in this update is on the safety benefits achievable through effective incident management, as experienced by crash victims, the motoring public, and response agency field personnel. As implied in this handbook's title, this update promotes the notion that incident management is needed on all types of highways, not just freeways.

1.2 ORGANIZATION

This handbook is organized into three major sections:

- Introduction to incident management
- Organizing, planning, designing and implementing an incident management program
- Operational and technical approaches to improving the incident management process

1.3 THE PROBLEM

An "incident" is defined as any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand. Such events include traffic crashes, disabled vehicles, spilled cargo, highway maintenance and reconstruction projects, and special non-emergency events (e.g., ball games, concerts, or any other event that significantly affects roadway operations).

Although the problems most often associated with highway incidents is traveler delay, by far the most serious problem is the risk of secondary crashes. Another related issue is

Figure 1-1: Fixed tow-trucks using multiple lanes to upright tractor-trailer

the danger posed by incidents to response personnel serving the public at the scene. Other secondary effects of incidents include:

- Increased response time by police, fire, and emergency medical services
- Lost time and a reduction in productivity
- Increased cost of goods and services

- Increased fuel consumption
- Reduced air quality and other adverse environmental impacts
- Increased vehicle maintenance costs
- Reduced quality of life
- Negative public image of public agencies involved in incident management activities.

The magnitude of these problems is severe. Incidents critically limit the operational efficiency of the transportation network and put all users of the network at risk. However, the impacts can be mitigated.

1.3.1 Safety Implications of Incidents

A Minnesota study found that 13 percent of all peak period crashes were the direct result of a previous incident (1). A study by the Washington State Department of Transportation further emphasizes this point. The study found that, over a seven-year period, 3,165 shoulder collisions had occurred on interstate, limited access, or other state highways. These collisions caused 40 deaths and 1,774 injuries. Injury rates for shoulder collisions were substantially higher than the rates for all other accident categories. The study noted that 41 percent of all shoulder collisions involved injuries (2).

In addition, the severity of secondary crashes is often greater than that of the original incident. The longer an incident is in place, the greater the exposure to additional crashes. A 1995 analysis of collision statistics on several arterials and expressways in California showed that secondary crashes represent an increase in collision risk of over 600 percent (3).

Incident responders are at risk of being struck by passing vehicles as they are performing their duties. In 1997, nearly 40 percent of all law enforcement officers who died in the line of duty died in traffic (4). The longer an incident is in place, the longer incident responders are vulnerable and exposed to injury.

In addition to the hazards of the incident scene, emergency responders traveling to other emergencies or emergency medical vehicles transporting sick or injured to medical facilities are also at risk because of incidents. In 1998, there were 143 fatalities in the United States involving emergency vehicles, 77 of which occurred when the vehicle was responding to an emergency. Reducing the traffic impacts of incidents can improve the health and safety of those who are not even involved in the incident (5).

1.3.2 Congestion

In most metropolitan areas, incident-related delay accounts for between 50 and 60 percent of total congestion delay. In smaller urban areas, it can account for an even larger proportion, according to studies conducted by the American Trucking Association in cooperation with Cambridge Systematics, Inc (6).

The magnitude of incident-related congestion can be quantified by considering the total amount of non-recurring congestion estimated in major US cities. The Texas Transportation Institute reports on urban roadway congestion each year (7). For the top ten most congested urban areas in 1998, the amount of incident-related congestion delay ranged from 218,000 to 1,295,000 person-hours.

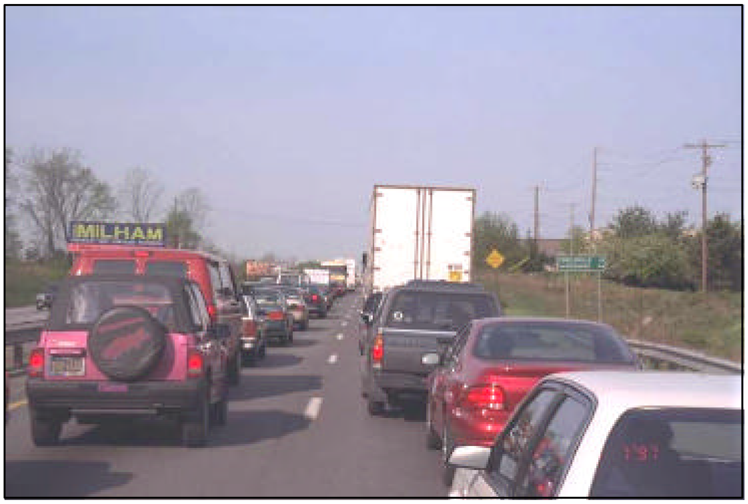

Figure 1-2: Congestion from even minor incidents can be significant

The additional fuel consumed annually in the ten most congested urban areas, because of incidents alone ranges from 214 to 1447 million liters. This translates into an annual cost to each eligible driver of $140 to $291.

Updated information on the impacts of freeway incidents on roadway capacity is reported in the 1996 Traffic Control Systems Handbook. Table 1-1: illustrates that an incident or unplanned work zone activity reduces freeway capacity by an amount far greater than the physical reduction in roadway space caused by the incident. As such, an incident blocking one lane of a three-lane freeway reduces capacity by almost 50 percent, although only a third of the lanes are blocked.

Table 1-1: Percentage of freeway capacity available under incident conditions

Number of Freeway Lanes in Each Direction	Shoulder Disablement	Shoulder Accident	Lanes Blocked		
			One	Two	Three
2	0.95	0.81	0.35	0.00	N/A
3	0.99	0.83	0.49	0.17	0.00
4	0.99	0.85	0.58	0.25	0.13
5	0.99	0.87	0.65	0.40	0.20
6	0.99	0.89	0.71	0.50	0.25
7	0.99	0.91	0.75	0.57	0.36
8	0.99	0.93	0.78	0.63	0.41

1.4 INCIDENT TYPES

It is clear that mitigating incident impacts is critical in improving traveler and responder safety, transportation system efficiency, and the nation's economic competitiveness. In order to understand how to minimize incident impacts, an understanding of incident types is also helpful.

In 1997, Cambridge Systematics combined the results of previous research efforts to develop a similar classification profile of highway incidents (6). Figure 1-4, excerpted from the Cambridge Systematics report, illustrates the distribution of freeway incidents by incident type, severity, and duration. The majority of incidents were found to involve

Figure 1-3: Disabled vehicle being attended to by DOT service patrol

disabled vehicles on the shoulder and other incidents that have little impact on freeway capacity. The table from the Cambridge report lists the effect that various types of freeway incidents can have on mobility.

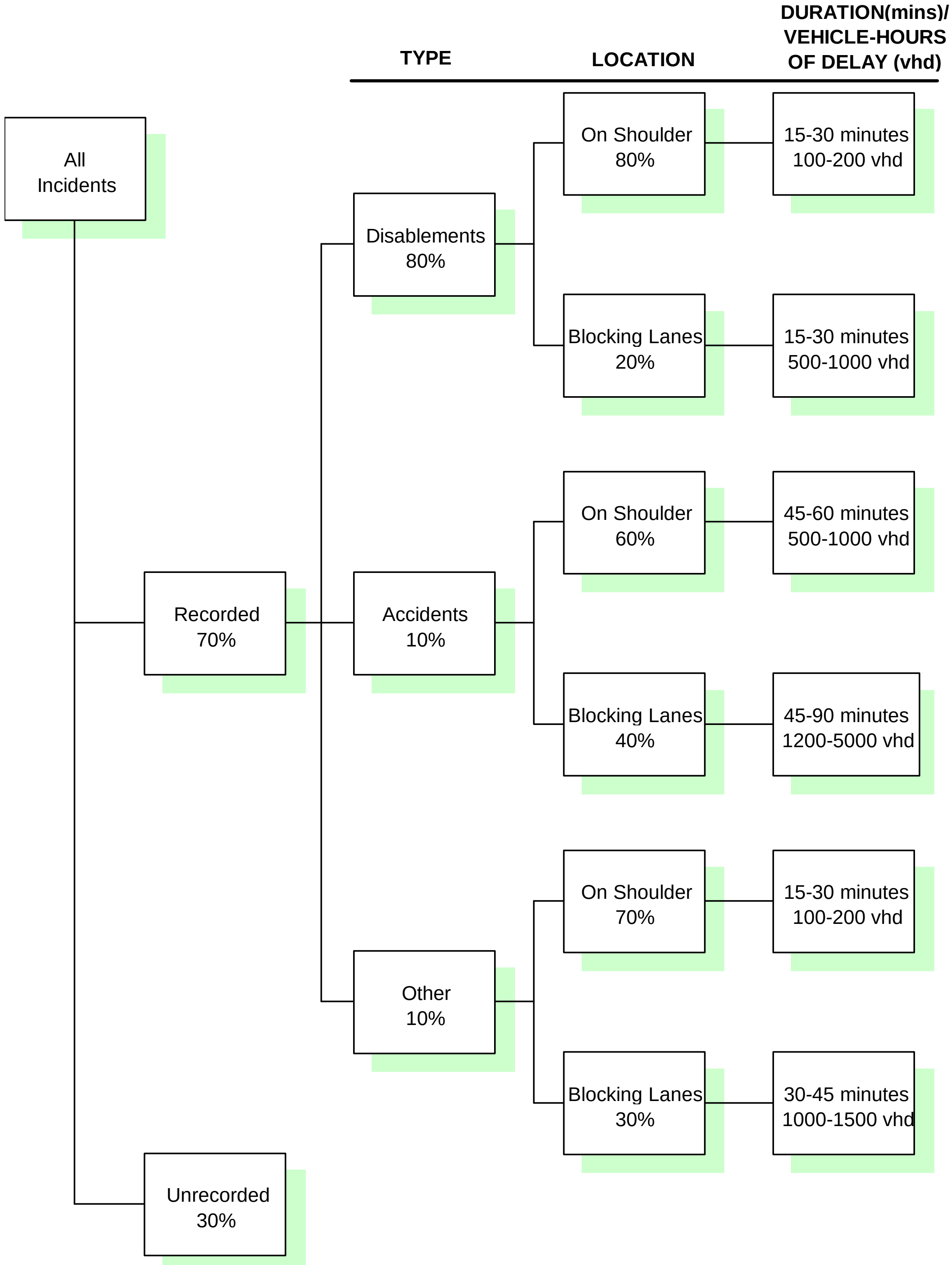

Figure 1-4: Composite Profile of Reported Incidents by Type (Source: Cambridge Systematics)

1.5 INCIDENT MANAGEMENT ACTIVITIES

Before discussing specific field operations that have been found effective in improving incident management, a discussion of the distinct functions that together comprise the process of incident management is helpful. Incident management entails an identifiable series of activities, which may be carried out by personnel from a variety of response agencies and organizations. These activities are not necessarily performed sequentially. For instance, motorist information is continually updated and typically disseminated throughout the duration of the incident while other incident management functions, such as clearance take place. In any case, the incident management process can be characterized as a set of activities that fall into the following seven categories.

1.5.1 Detection

Incident detection is the process by which an incident is brought to the attention of the agency or agencies responsible for maintaining traffic flow and safe operations on the facility. Methods commonly used to detect and verify incidents include:

- Mobile telephone calls from motorists
- Closed circuit TV cameras viewed by operators
- Automatic vehicle identification (AVI) combined with detection software
- Electronic traffic measuring devices (e.g., video imaging, loop or radar detectors) and algorithms that detect traffic abnormalities
- Motorist aid telephones or call boxes
- Police patrols
- Aerial surveillance
- Department of transportation or public works crews reporting via two-way radio
- Traffic reporting services
- Fleet vehicles (transit and trucking)
- Roaming service patrols

1.5.2 Verification

Incident verification entails confirming that an incident has occurred, determining its exact location, and obtaining as many relevant details about the incident as possible. Verification includes gathering enough information to dispatch the proper initial response. Incident verification is usually completed with the arrival of the first responders on the scene. However, when hazardous materials are involved, the verification process may be quite lengthy. Methods of incident verification include the following:

- Closed circuit TV cameras viewed by operators
- Dispatch field units (e.g., police or service patrols) to the incident site
- Communications with aircraft operated by the police, the media, or an information service provider
- Combining information from multiple cellular phone calls

1.5.3 Motorist Information

Motorist information involves activating various means of disseminating incident-related information to affected motorists. Media used to disseminate motorist information include the following:

- Commercial radio broadcasts
- Highway advisory radio (HAR)
- Variable message signs (VMS)
- Telephone information systems
- In-vehicle or personal data assistant information or route guidance systems
- Commercial and public television traffic reports
- Internet/on-line services
- A variety of dissemination mechanisms provided by information service providers

Motorist information needs to be disseminated as soon as possible, and beyond the time it takes clear an incident. In fact, it should be disseminated until traffic flow is returned to normal conditions. This may take hours if an incident occurs during a peak period, and has regional impacts.

1.5.4 Response

Incident response includes dispatching the appropriate personnel and equipment, and activating the appropriate communication links and motorist information media as soon as there is reasonable certainty that an incident is present. Response requires preparedness by each responding agency or service provider. This is fostered through training and planning, both as individual, and collectively with other response agencies. Effective response mainly involves preparedness by a number of agencies (i.e., planned cooperatively) for a variety of incident types, so that response to individual incidents is coordinated, efficient, and effective.

Figure 1-5: Infrastructure damage can occur that requires a timely response.

1.5.5 Site Management

Site management is the process of effectively coordinating and managing on-scene resources. Ensuring the safety of response personnel, incident victims, and other motorists is the foremost objective of incident site management. Site management encompasses the following activities:

- Accurately assessing incidents
- Properly establishing priorities
- Notifying and coordinating with the appropriate agencies and organizations
- Using effective liaisons with other responders
- Maintaining clear communications

Effective incident site management can be facilitated by an incident command system (ICS). An ICS is a formalized system that fosters consistency in the way agencies and service providers function cooperatively at an incident scene. ICS fosters efficiency by eliminating the need to develop separate response plans at each incident. An ICS provides a planned and organized approach to incident and emergency management. ICS should be viewed as a set of guidelines within which each responder understands his or her role and responsibility. Components of an ICS include:

- Common terminology
- Modular organization
- Integrated communications
- Agreed upon command structure
- Consolidated action plans
- Manageable span of control
- Designation of incident facilities
- Comprehensive resource management

1.5.6 Traffic Management

Traffic management involves the application of traffic control measures in areas affected by an incident. Traffic management in the context of an incident may include:

- Establishing point traffic control on-scene,
- Managing the roadway space (opening and closing lanes, blocking only the portion of the incident scene that is needed for safety, staging and parking emergency vehicles and equipment to minimize impact on traffic flow)
- Deploying appropriate personnel to assist in traffic management (e.g., state police, local police, and service patrols).
- Actively managing traffic control devices (including ramp meters, lane control signs, and traffic signals) in affected areas, and
- Designating, developing, and operating alternate routes.

As with each function of effective incident management, traffic control in the incident management context is rooted in planning. This includes ensuring the availability of traffic control equipment and materials; knowledge of available fixed traffic control resources; and alternate route planning.

1.5.7 Clearance

Incident clearance is the process of removing wreckage, debris, or any other element that disrupts the normal flow of traffic, or forces lane closures, and restoring the roadway capacity to its pre-incident condition. At times, this may also include temporary or permanent repair to the infrastructure.

1.6 ROLES AND RESPONSIBILITIES

The incident management activities described in Section 1.5 require the skills and expertise of a diverse disciplines and agencies. To develop an effective incident management program or to improve an existing one, it is important to understand the roles that various agencies play in incident management.

The roles and responsibilities described below are not assumed to be representative of all regions around the country. Nor are they intended to be recommendations. It is understood that roles and responsibilities of those involved with incident management activities will vary from region to region. Those described below merely illustrate how these agencies and service providers are typically involved in the incident management process.

1.6.1 Law Enforcement

Although it varies from region-to region, law enforcement agencies from the state, county, and local levels are involved in incident management activities. In large part, participation is dictated by the jurisdiction in which the incident occurs. Typical incident management roles and responsibilities assumed by law enforcement include:

- Assist in incident detection
- Secure the incident scene
- Assist disabled motorists
- Provide emergency medical aid until help arrives
- Direct traffic
- Conduct accident investigations
- Serve as incident commander
- Safeguard personal property
- Supervise scene clearance

1.6.2 Fire and Rescue

Fire and rescue services are provided by local fire departments, and by surrounding fire departments through mutual aid agreements. Incident management roles and responsibilities typically assumed by fire departments include:

- Protect the incident scene
- Provide traffic control until police or DOT arrival
- Provide emergency medical care
- Provide initial HAZMAT response and containment
- Fire suppression
- Crash victim rescue from wrecked vehicles
- Rescue crash victims from contaminated environments
- Arrange transportation for the injured
- Serve as incident commander
- Assist in incident clearance

In most jurisdictions, the fire department is the primary emergency response agency for hazardous materials spills. Unlike police, who operate individually for most duties, fire departments operate under a highly organized team structure with the close supervision of a commanding officer. Fire departments and emergency medical service providers (EMS) also act at the direction of one decision maker, and may not respond individually to requests from other response agencies unless their command officer so directs them.

Police and fire departments occasionally have conflicts about who has lead responsibility, what actions have priority, where emergency vehicles should be situated, and who has priority for collecting driver and/or patient information. These types of disagreements can become distractions at incidents and impair coordination. It is therefore important to understand the needed interaction among responding agencies and to develop agreements regarding lead and support responsibilities, prior to encountering conflicts in the field.

1.6.3 Emergency Medical Services (EMS)

The primary responsibilities of EMS are the triage, treatment, and transport of crash victims. In many areas, private companies provide these services to local jurisdictions under contract. Typical incident management roles and responsibilities assumed by EMS include:

- Provide advanced emergency medical care
- Determine of destination and transportation requirements for the injured
- Coordinate evacuation with fire, police and ambulance or airlift
- Serve as incident commander for medical emergencies
- Determine approximate cause of injuries for the trauma center
- Remove medical waste from incident scene

Figure 1-6: Crash victim being airlifted from incident

Emergency Medical Services have evolved as primary care givers to individuals needing medical care in emergencies. As with police, EMS has a defined set of priorities. They focus on providing patient care, crash victim rescue, and ensuring the safety of their personnel.

A primary concern of EMS operators is liability. Even if a vehicle has little or no damage, when an occupant complains of possible injury, EMS policy may dictate that emergency medical responders stabilize or immobilize the patient and carefully remove the crash victim from the vehicle. Consequently, this can take a significant amount of time. Clarifying the exact circumstances under which this policy is in force may lead to reduction in clearance times, which will lead to increased impacts on traffic. As such, these more comprehensive measures are only used when absolutely necessary.

1.6.4 Transportation Agencies

Transportation agencies are typically responsible for the overall planning and implementation of incident management programs. Typically, these agencies are also involved in the development, implementation, and operation of the traffic operations center (TOC), as well as the management of service patrols. Typical operational responsibilities assumed by transportation agencies and their service patrols include:

- Assist in incident detection and verification
- Initiate traffic management strategies on incident impacted facilities
- Protect the incident scene
- Initiate emergency medical assistance until help arrives
- Provide traffic control
- Assist motorists with disabled vehicles
- Provide motorist information
- Determine incident clearance and roadway repair needs
- Establish and operate alternate routes
- Coordinate clearance and repair resources
- Serve as incident commander for clearance and repair functions
- Repair transportation infrastructure

To foster improved incident management some DOTs have forged active partnerships with traditional response agencies, such as police and fire. DOT's can provide considerable technological resources and innovative approaches to incident management. However, it is noted that traditional response agencies in some areas have been less supportive of DOT led efforts. Resistance is generally more formidable where traditional responders are not included in the early stages of incident management program planning and development. In fact, institutional and jurisdictional issues are among the most significant barriers to effective incident management. Consequently, DOTs need to be aware of possible sensitivities of regional partners.

Figure 1-7: DOT operated air-bag being used to up-right tractor-trailer

Generally speaking, successful incident management programs result from proactive leadership that foster cooperation and coordination from the executive level on down to field operations. Establishing trust and open communications among the many and varied responders is the only way to resolve potential and real issues before they get in the way of effective field operations. Effective DOT led programs provide an open forum for program development without directly challenging traditional agency roles and responsibilities. Many DOT programs have dealt with these issues successfully. Examples of their accomplishments are provided throughout this Handbook.

1.6.5 Towing and Recovery Service Providers

Towing and recovery service providers are responsible for the safe and efficient removal of wrecked or disabled vehicles, and debris from the incident scene. Their typical responsibilities include:

- Remove vehicles from incident scene
- Protect victims' property and vehicles
- Remove debris from the roadway
- Provide transportation for uninjured vehicle occupants
- Serve as incident commander for recovery operations

Towing and recovery companies that respond to highway incidents are indispensable components of all incident management programs. Even programs that include service patrols with relocation capability depend on towing and recovery service providers. Challenges facing this industry are unique because they are not public agencies. As such, they must remain profitable to retain a skilled work force and to stay in business.

Figure 1-8: Crashes involving tractor-trailers can cause significant infrastructure damage

1.6.6 Media

The typical roles and responsibilities of the media as they relate to incident management activities include:

- Report traffic incidents
- Broadcast information on delays
- Provide alternate route information
- Update incident status frequently
- Provide video or photography services

1.6.7 Information Service Providers (ISPs)

Information service providers are usually commercial entities that provide traffic information updates to both motorists and the media. These service providers operate in many metropolitan areas nationally. Information is typically disseminated by ISPs via:

- Broadcast radio
- Broadcast television
- Telephone systems
- Cable television traffic alerts

- E-mail services
- Pager services, or
- Internet web-sites

1.6.8 Coroners and Medical Examiners

By law coroners or medical examiners are responsible for investigating deaths that result from anything other than natural causes. As such, they play an important role in investigating fatal accidents that occur on roadways.

1.6.9 Hazardous Materials

Hazardous materials contractors operate in a number of regions in the United States. They are hired by emergency or transportation authorities to clean up and dispose of toxic or hazardous materials.

1.7 IDENTIFYING OPPORTUNITIES FOR IMPROVEMENT

Neither quantitative or quantitative performance standards are generally applied to incident management programs. Moreover, it is rare that programs are compared to similar programs around the country to determine their relative performance. And, while response times are measurable and considered critical they may never be evaluated. The same holds true investigative and clearance times, which may take hours rather than minutes.

Obviously incident procedures cannot be measured in the same way as auto repairs or other time-sensitive activities. However, some baselines can be established so that agencies can determine whether they are prioritizing tasks properly, and whether they are restoring roadway operations within a reasonable period. Agencies involved in incident management can use the following procedure to evaluate their level of success.

1.7.1 Review Goals and Objectives

The review of goals and objectives should be taken at the executive level of the organization. Current goals and objectives should be reviewed to ensure they include proper response and timely completion of incident management tasks. Further, these goals and objectives should be reviewed periodically to ensure that they are current.

1.7.2 Evaluate Current Efforts

The next step is to evaluate current incident management efforts objectively. Interviewing local response agencies and getting comparative information from programs in other areas can accomplish this. An internal working group should be developed and tasked with determining what can be improved when sufficient resources are provided. When the recommendations are complete, a review of training programs should be conducted to see what improvements could be accomplished internally before or while increased resources are being requested.

1.7.3 Establish Standards

Once the evaluation process is complete, working groups should be established to determine achievable standards for incident management activities. As part of this process, other similar programs can be reviewed to determine acceptable thresholds. For example, in the Tacoma, Washington area, the average response time for blocking incidents by the state patrol is four minutes. In another urban area, the average response time for the same type of incident is 23 minutes. By any objective measure, 23 minutes is unacceptable. As such, immediate steps should be taken to shorten this response time.

1.7.4 Assess Training Programs

Assessing training programs is also advised to identify opportunities for improvement. Responders cannot be expected to operate as efficiently as possible without proper training. Incident management training programs for police and other responders are many times outdated. Many training programs, for example, only cover incident management on two-lane roadways.

2 Organizing, Planning, and Designing an Incident Management Program

Section 1 provided several compelling reasons to plan, develop and implement an incident management program to improve roadway safety, for the motoring public and emergency responders alike.

Building on the information provided in Section 1, this section focuses on issues and approaches to creating, expanding, or refining an incident management program. Understanding the institutional, organizational, and policy implications of program development is important for any leader who is committed to providing quality incident management services. As such, program development, and the "administrative" elements of incident management, merits special attention.

The second part of this section describes key elements of effective incident management programs. These elements fall into three primary categories: people, infrastructure, and practices. The first category, people, encompasses Incident Response Teams (IRTs); training; and the resources, or guidelines that IRTs rely on in the field. The second category, practices, covers major incident debriefings; program documentation and evaluation; and freeway service patrols. The third category, infrastructure, describes the physical elements of the surface transportation network and their relationship to incident management. This discussion focuses on the role of Intelligent Transportation Systems (ITS) and the National ITS Architecture in incident management. Recent advances in ITS provide significant opportunities to support and enhance incident management operations, many of which have been deployed around the country with impressive results. A discussion of incident management programs' documented benefits concludes Section 2.

2.1 STEPS IN DEVELOPING AN INCIDENT MANAGEMENT PROGRAM

Even in areas without formal incident management programs, agencies perform some type of incident response. That is, someone responds to incidents that occur. Thus, the goal of an incident management system is not to create a response, but rather to create a more effective response for all responding agencies.

This is an important distinction. Incident response, which is carried out in every area covered by any form of emergency management, does not entail the same degree of coordination, planning, and conscious effort implied by effective incident management. As stressed throughout this handbook, planning for, and formalizing incident response among multiple agencies, departments, and jurisdictions can provide many benefits, including saved lives, resources, and time. The following defines a structured approach to creating or refining an effective incident management program. This section draws heavily upon an earlier FHWA publication, "Framework for Developing Incident Management Systems," written by Jodi Koehne, Fred Mannering, and Mark E. Hallenbeck (8). This seminal work provides an effective approach to developing an incident management program. With the most salient points of the document are summarized herein, the interested reader should consult the document for more detailed guidance.

2.1.1 Prologue to the Process: Getting the Players to the Table

Stakeholder Identification

A critical step in developing a successful incident management program is to identify the relevant stakeholders and to build from this group's critical coalitions and institutional frameworks that will support, protect, and fund the program. This groundwork should be laid at the beginning of the planning. Identification of stakeholders should be inclusive of:

- Each agency that are responsible for incident management functions (e.g., department of transportation, fire, state and local police, department of natural resources);
- Other departments or individuals within the typical response agencies (e.g., within a department of transportation, it is usually important to involve both maintenance and traffic operations, at a minimum);
- Other stakeholders who are affected by, or contribute to, traffic operations (e.g., media, towing and recovery, major employers, user groups, interested elected officials and other policy makers).

In addition, it is critical to involve stakeholders from each jurisdiction within the planned program area. Incident impacts are not constrained by the jurisdictional boundaries that delineate agency service areas or operational responsibilities. When one part of the freeway or arterial network is not functioning properly, it affects the safety and efficiency of the transportation system for other jurisdictions and departments, as well as the motoring public. Stakeholder involvement is among the most important aspect of program development insofar as incident management programs are crafted jointly around the stakeholders' unique needs. The success of the incident management program is a direct function of the extent of cooperation and coordination that is achieved.

The Kick-Off Meeting

Identifying as many agencies, officials, and representatives as possible and arranging for them to attend a kick-off meeting to introduce the concept and benefits of incident management is a vital first step in incident management program development. The list of attendees to a kick-off meeting may include, but are not limited to, representatives from the following types of organizations:

- State Department of Transportation
- Elected and appointed officials
- Metropolitan Planning Organizations (MPOs)
- County and city departments of transportation and public works, including transportation planning staff;
- Major emergency preparedness organizations
- Police agencies
- Fire agencies
- Transit operators

- Commercial transportation firms
- User groups (e.g., AAA)
- Emergency medical services
- Towing and recovery services
- Environmental protection agencies
- Media

Each potential participant should be contacted well in advance with a request for their support in a cooperative effort to improve incident response. The request may take the form of a memorandum stating the perceived problem and indicating the need for each agency's participation. In recruiting stakeholders, keep in mind their level of authority within the organization, more specifically, their ability to commit and secure budget or expenditures. "Since traffic management systems often compete with other 'traditional' agency activities and expenditures (e.g., pot-hole patching, construction, etc.), the support of top management is essential if agency resources are to be allocated to the operation and maintenance of the system" (8).

In addition to securing broad stakeholder participation from the relevant agencies and jurisdictions, it is also important to ensure that an adequate amount and the appropriate type of public outreach are pursued. Public outreach serves two primary functions:

(1) To make the public aware of the value of incident management, leading to generalized public support; and

(2) To help the public better understand how their actions, such as moving drivable vehicles out of traffic, and providing good information in reporting incidents, can support effective incident management.

Public outreach can be fostered through:

- Radio and television advertising,
- Through the Internet, and via
- Specialized mailings sent as part of utility bills, or
- Driver's licensing and registration correspondence

Once stakeholders have reached consensus that incident management is a goal worthy of investment of time and resources, an Incident Management Task Force should be formally established. An incident management Task Force constitutes a logical framework in which participating agencies can cooperate in incident management program development. The local division office of the Federal Highway Administration (FHWA) can assist in the effort to establish an Incident Management Task Force by providing technical support, which may include sponsoring an incident management workshop, providing videos and written information about successful programs in other areas, and identifying experienced incident management practitioners from other

areas. Such practitioners may be able to support efforts by providing technical information and sharing "lessons learned."

A kick-off meeting agenda for a newly formed Incident Management Task Force might include the following items:

- Self-introduction of each participant

- A summary of the incident management problem in general, and within the specific local or regional context
- Detailed examples of existing incident management programs
- Identification of local or regional incident management issues, including
  - Agency perspectives
  - Coordination issues
  - Responsibilities
  - Existing resources
  - Potential solutions
  - Potential resources

In turn, action items resulting from initial Task Force meetings may include the following:

- Seek resources with which to initiate research and planning
- Develop tentative timelines for each phase of the program development process
- Recruit or assign a Task Force secretary, who will be responsible for minutes, setting up meetings and other activities, information dissemination, and other duties, as required
- Set the next meeting date and establish initial agenda items

As noted in the Freeway Management Handbook, “Consensus building does not just “happen.” It must be fostered and developed over time” (9). This useful source offers several practical tips for promoting cooperation among diverse agencies and organizations:

- Hold regular meetings (monthly or bimonthly)
- Strive for continuity in the personnel who attend each meeting
- Work to establish a frank, but cooperative, non-confrontational atmosphere
- Be sure to have, and adhere to, an agenda for each meeting
- Focus on reaching verbal consensus on the issues being discussed, with the awareness that this may take time.

2.2 THE BASIC 8-STEP INCIDENT MANAGEMENT PROGRAM DEVELOPMENT PROCESS

Once the Incident Management Task Force has been established, the group can address program development in earnest. Systems development theory provides a logical framework around which to organize this complex process. The logical steps suggested follow the same process that is used in many types of transportation planning exercises, from simple intersections to complex multi-modal regional and national transportation plans. The steps are listed below; each is explained in detail in the text that follows.

- Define the problem
- Set goals and objectives
- Develop alternatives
- Evaluate alternatives
- Select alternatives
- Implement alternatives
- Reevaluate alternatives
- Refine the system

2.2.1 Define the Problem

Before identifying, much less selecting a solution, a clear understanding of the severity, impacts, and locations of incident-related problems is required.

"It is important not only to attempt to quantify the overall magnitude of the incident problems that must be addressed, but also to identify in as much detail as possible the types of incidents that are a problem and the magnitude of their impacts. The degree to which specific problem areas can be identified in this step of the process determines how effectively possible mitigation alternatives are identified and implemented" (10).

Figure 2-1: Tractor-trailer accidents can significantly impact the flow of traffic

Problem definition can be accomplished through a combination of data collection, data compilation, brainstorming, and constructive critiques of existing practices. In addition, findings from particular areas may be compared to baselines that are based on other incident management programs elsewhere in the country.

Three issues are especially important in identifying problems to be solved with respect to incident management: (1) the frequency of incidents by location, time weather, and special circumstance; (2) the duration of incidents; and (3) the traffic impacts of incidents. Table 2.1 identifies data that may be useful in identifying incident management issues and problems.

Data to explore issues related to incident frequency and duration are often available from accident and police dispatch reports, as well as state accident reporting systems. Assessing traffic impacts, however, may be more difficult. Simulation modeling is carried out in some areas to determine incidents' typical traffic impacts in terms of lane blockages, queue lengths, and cumulative delays.

Table 2-1: Data useful in identifying incident management issues and problems

INCIDENT FREQUENCY	INCIDENT DURATION	TRAFFIC IMPACTS
• Incident frequency by location • Incident frequency by month • Incident frequency by season	• Time required to detect incident • Time from incident report to on-scene response • Time required to clear	• Video monitoring • Traffic simulation modeling • Traffic Impacts

• Incident frequency by weather • Incident frequency by day of the week • Incident frequency by hour of the day • Incident frequency by special events (e.g., sports event)	incident • Traffic flow at time of incident • Number of injuries • Number of fatalities • Number of lanes blocked • Number of vehicles involved • Types of vehicles involved • Incident severity • Presence of hazardous materials	

In assessing current incident response practices, the following questions may be helpful in pinpointing areas for program development:

- What incident management tasks does each agency currently perform?
- What are each agency's responsibilities and priorities?
- Are each agency's tasks, responsibilities, and priorities well understood among the other responders and stakeholders?
- Do any of these responsibilities or priorities conflict? What is the nature and cause of the conflict? How can Incident Management Task Force members cooperate to resolve it?
- Are agencies' tasks ever redundant? Under what circumstances?
- Are there gaps in the delivery of incident management services as agency responsibilities are now configured?

In addition to considering responder activities, responsibilities, and roles in assessing the current practices, it is also important that the Incident Management Task Force consider the legal and policy environment in which incident management is carried out. Questions that may be helpful in determining this environment include:

- What are the legal limits to the incident response roles that an agency's personnel can perform? (e.g., Which agency has the authority to close the roadway? Does any agency have the authority to move a disabled vehicle out of the traffic flow?)
- To what extent do real or perceived legal constraints pose an obstacle to effective incident management?
- What is the financial liability of agencies, agency personnel, and the public with respect to incidents and specific incident management tools, such as quick vehicle clearance? How well is this liability understood among responders? Do they overestimate the constraints posed under statutes?
- Does the state have the authority under current laws to charge at-fault motorists for the time and materials required to clear an incident and repair any damage to the roadway? Statutes provide this authority in many states. If not, should such legislation be considered as part of an overall incident management program?

It is important to consider the issue of incident management not only within the current operational environment, but also in light of specific future challenges, such as demographic growth, planned changes in the infrastructure (e.g., major capital improvements), and air quality forecasts. For this reason, it is advisable that the Incident Management Task Force utilize existing local, regional, and state transportation and land use planning plans, which will indicate relevant forecasts and major anticipated changes in the transportation and land use environment.

2.2.2 Set Goals and Objectives

Once current and future challenges in incident management have been thoroughly explored, the Incident Management Task Force should establish guiding principles for program development. These “guiding principles” most often take the form of a mission statement, backed up by goals and objectives and based on the identified problems. Simply stated, goals and objectives describe what the program is designed to accomplish. While goals reflect an agency’s long-term, systems-level aspirations, objectives typically define the specific, often measurable, level of performance that would be required to progress toward a given goal. More than one objective may be required for a given goal.

Figure 2-2: Goals and objectives may be developed for each function of incident management

It is important that at least some of the objectives set to support system goals be measurable. “Developing objectives that can be measured provides impetus to collect data on the delay caused by incidents before the incident management process has started. This data becomes baseline traffic performance indicators for comparison with similar information after the system has been implemented. Often, funding for baseline data is not considered until after implementation has begun, and little “proof” is available to show the impacts of the new program. This lack of validation information decreases an agency’s ability to demonstrate the success of a project and may hamper that agency’s ability to add new management measures or to further increase the management system’s capabilities”(8).

The Freeway Management Handbook provides a useful example of a problem, a system goal, and three system objectives designed to support the goal in Table 2-2.

Table 2-2: Identifying goals and objectives

PROBLEM	SYSTEM GOAL	SYSTEM OBJECTIVES
• Incidents are a primary	• Reduce the impact of	• Detect all major

source of freeway congestion	incidents	incidents within two minutes of their occurrence • Reduce the average time to clear an incident from the freeway by five minutes • Improve motorist information (9)

Other common goals and objectives for incident management programs are listed in Table 2-3.

Table 2-3: Common incident management program goals and objectives

GOALS	OBJECTIVES
• Reduce secondary incidents • Increase safety for responders • Increase and improve use of alternate routes • Reduce liability for response agencies	• Decrease detection times • Improve response times • Increase motorist information • Improve clearance procedures • Decrease number of lanes closed • Decrease road and lane closure times

In formulating its goals and objectives, the Incident Management Task Force should consider the following:

- What are the factors driving the initiative to promote incident management? How can they best be reflected in the program's goals and objectives?
- What are the area's greatest unmet needs with respect to incident management?
- How can the program's goals and objectives be framed such that they reflect the missions, roles, and priorities of all of the Incident Management Task Force members?
- Are there political stimuli (e.g., traffic congestion at a specific location or bridge that is deemed "unsafe") that need to be addressed by the incident management program?
- How can the program's goals and objectives be framed so that they respond to any pressing public demand for incident management?

Prioritizing the goals and objectives is important because it provides a criterion to use when selecting among alternatives, as agencies seek to balance demands with limited resources.

2.2.3 Develop Alternatives

Once stakeholders have been convened, problems have been identified, and goals and objectives have been established, the group can then begin to consider ways to combine the many available incident management tools and techniques into program packages for evaluation. These alternatives may also specify a logical sequence for implementation.

At this point in the process, site visits to incident management programs in other regions around the country may be helpful in gathering additional information on how other areas have approached their challenges, how system components function in practice, and "lessons learned" by other professionals.

The principal functions of effective incident management programs are summarized later in this section, and Section 3 contains a more comprehensive catalog of operational strategies. These discussions cover the wide range of incident management techniques currently in use. The Incident Management Task Force's choice of strategies and techniques will depend on the nature, causes, and scale of the problems identified in Step 1. The goals and objectives established in Step 2 will provide objective criteria with which to choose among alternative packages.

Where a new program is being established, leaders should keep in mind the importance of considering each incident management function: detection, response, site management, clearance, and motorist information. Each incident management function can be thought of as links in a chain. Failure to consider any one of them can result in delays that are costly in terms of safety impacts, responder resources, and time. Like any other chain, an incident management program is only as strong as its weakest link.

In addition to ensuring that the techniques developed are appropriate in terms of covering each of the functional areas of incident management, it is also important that they be suited to the level of interagency coordination that has been established, or that is feasible. "Particularly when the management techniques to be evaluated require the cooperation of multiple agencies, the evaluation technique chosen should also consider the impacts of, and likelihood of, getting that cooperation and coordination" (8).

Finally, the interests and perceptions of the ultimate customer, the motoring public, must be considered. It is easy for agencies, each of which operates according to its own culture, budgets, and incentives, to forget that the motoring public may experience the costs and benefits of incident management quite differently. The increasing willingness and ability of state and local departments of transportation to advocate for the interests of the motoring public has been a major driver in incident management programs nationwide. As such, the Task Force should consider alternatives that address publicly perceived deficiencies in the transportation system. Considering the following questions may be helpful in this regard:

- Does the incident management alternative, as configured, address what the public views as the area's most significant transportation and safety problems?
- Will the program's benefits be visible to the public? If not, how can benefits be communicated? (Recognizing the high visibility of its incident response vehicle on to motorists, Washington State's program allows all Incident Response Team members to offer assistance to disabled motorists blocking one or more travel lanes while traveling to and form work, or whenever traveling in the IRT vehicle.)

2.2.3.1 Funding

A critical step in developing the alternatives is to assess their likely costs, as well as funding sources. Added costs due to the incident management program may include infrastructure improvements (e.g., ITS infrastructure, such as CCTV, dynamic message signs, and computer-aided dispatch); additional labor hours and staff development; and additional materials and equipment, including specially outfitted incident response vehicles. The purpose of this discussion is to provide an understanding of the funding programs that can be tapped for incident management operations, and under what conditions this is feasible.

Funding for incident management activities is usually derived from a combination of local, state, and federal sources. State revenue sources include state gas and fuel taxes, vehicle registration fees, and state general fund disbursements, which may ultimately be drawn from property, income, or sales tax bases. State and local governments contribute the lion's share of funding in successful incident management programs.

Figure 2-3: Agencies have identified several innovative ways to finance service patrols

Funding at the federal level is distributed among states according to a combination of complex formulas and specific earmarks. While federal funding, which draws on federal gas and other fuel taxes, as well as a variety of commercial vehicle fees, funds a substantial portion of state capital budgets, states must nonetheless raise revenues for the matching portion required to secure federal funding, as well as the vast bulk of maintenance and operations. Although federal funding can provide fledgling and existing programs a boost, it would not be advisable to rely primarily on federal funding for operational costs. Not only do federal funding levels vary over time, so do the regulations governing their use.

In terms of incident management, the most notable recent shift in federal transportation funding is the extent to which, increasingly, federal dollars may be used to support operations and management. Until the early 1990s, federal funding was effectively constrained to traditional capital improvements, such as roadway and bridge construction. With the construction of the interstate highway system largely complete, and with major new construction constrained by political and environmental concerns, Congress, and the US Department of Transportation, have come to recognize that in coming decades, maintenance and improvement of levels of service will rely far more on increasing the efficiency of existing capital facilities, than on the construction of new roadways. This recognition has positive implications for incident management, which, aside from the deployment of major new ITS infrastructure, entails primarily operational costs. Explored in the following discussion is the manner in which this shift is reflected in specific federal funding programs.

Transportation funding at the federal level, unlike most other federal programs, is authorized as a massive package every six years. The current "package," which was signed into law in 1998, is called TEA-21, which stands for "Transportation Equity Act for the 21st Century." TEA-21 authorizes $217 billion in transportation funding over six years. Within TEA-21, funding is categorized among major programs, several of which can be tapped for incident management operations.

Programs under TEA-21 that fund the deployment of ITS technologies to support incident management activities include the following:

- National Highway System (NHS)
- Surface Transportation Program (STP)
- Congestion Mitigation Air Quality (CMAQ)

<u>The National Highway System</u>

The National Highway System (NHS) focuses federal resources on those roadways and corridors that are most critical to interstate travel and national defense; roads that connect with other transportation modes; and roads essential for international trade. Collectively, this group of roadway links is designated as the NHS. Until 1991, the NHS funding program limited to two years the period over which funding could be used for traffic management and control, of which incident management is a part. However, TEA-21, as well as its predecessor, ISTEA, eliminated this limitation, much liberalizing the use of this source for incident management. This is inclusive of start-up and operating costs. Also favorable for incident management is the fact that "infrastructure-based intelligent transportation system capital improvements" have been added as eligible projects for NHS funding. Additionally, as defined in 23 U.S.C. 103(b)(6), the term "operating costs for traffic monitoring, management, and control" now includes a much broader range of eligible expenditures, including the following:

- Labor costs
- Administrative costs
- Utilities and rent
- Other costs associated with the continuous operation of traffic control, such as integrated traffic control centers

Operating expenses are now defined to include hardware and software upgrades, as well as major systems maintenance activities (i.e., those undertaken to ensure peak performance). Replacement of defective or damaged computer components and other traffic management system hardware, including street-side hardware, is also eligible. However, restrictions still preclude use of these funds for routine maintenance.

<u>Surface Transportation Program (STP)</u>

The Surface Transportation Program (STP) is a block-grant type program that can be used by state and local governments on any road (including NHS) that is functionally classified as local or rural minor collector or higher. Once funds have been allocated by the states, each state must set aside 10 percent of the total package for safety construction activities and 10% for transportation enhancements. "Infrastructure-based intelligent system capital improvements" are eligible for STP funding. STP funds may be used indefinitely for capital and operating costs for traffic monitoring, management, and control facilities. However, as with NHS funding, STP funds may not be used for maintenance.

Congestion Mitigation and Air Quality Program (CMAQ)

Congestion Mitigation and Air Quality Program (CMAQ) channels resources for air quality improvement to non-attainment areas for ozone and carbon monoxide under the federal Clear Air Act. Both traffic and congestion management strategies, including incident management, are eligible for CMAQ funding, provided they can demonstrate that they improve air quality.

Operating expenses for traffic monitoring, management, or controls are eligible for CMAQ funding under the following conditions:

- The project produces demonstrable air quality benefits
- Project expenses are incurred as the result of new or additional service levels
- Previous funding mechanisms, such as fees for services, are not replaced

Although CMAQ funding can only be used to support operating expenses for up to three years following initial implementation, TEA-21 permits the transfer of CMAQ funding to other categories, such as NHS and STP, which do not limit funding of operating expenses as tightly.

ITS Program

Because ITS and incident management are so closely related, program deployment in most metropolitan areas will not only require an increase in funding for equipment and infrastructure but also for ITS training and operation and maintenance. In addition to funding from NHS, STP, and CMAQ, there is another category of federal funding that can be used for the advanced technology elements of incident management that is the dedicated ITS program administered by the Federal Highway Administration.

<u>Public-Private Partnerships</u>

Private sponsors, including insurance companies, cellular phone companies, and radio stations have also contributed to incident management programs around the country. Primarily their involvement has been part of a corporate marketing strategy.

2.2.4 Evaluate Alternatives

The structure and formality of the evaluation process used to assess the costs and benefits of the alternatives will depend on the complexity and coordination needs of each agency or Incident Management Task Force. They will also reflect the evaluation and selection process already in use by agencies for other types of program development. In any case, the evaluation process and criteria should be rooted in the goals and objectives established in an earlier step in the program development process.

It is important to bear in mind that when, "the management techniques to be evaluated require the cooperation and support of multiple agencies, the evaluation technique chosen should also consider the impacts of, and the likelihood of, getting that cooperation and coordination" (8).

Figure 2-4: Procuring equipment for incident clearance may be one alternative that may be evaluated to improve the incident management process

2.2.5 Select Alternatives

Incident management programs consist of many individual practices, tools, and infrastructure elements. To achieve the most synergy, and benefits, effective incident management requires that these pieces be selected and implemented in concert. For instance, two small pieces may have a significant impact if implemented together, but less than half the impact if only one of the two is carried through.

It is also important to remember that no incident management program has ever been conceived and brought to life in a single stroke. Rather, programs are typically patched together piecemeal, evolving with the area's needs and resources, and the ability to coordinate among agencies and jurisdictions. In fact, there are definite advantages to developing an incident management program gradually, as pointed out in the Freeway Management Handbook, "Experiences from several past incident management implementation efforts indicate that partners should utilize a building-block approach, initiating low-cost components first to demonstrate to the public and to elected officials the benefits of incident management activities. It is then easier to 'sell' other components…that are more capital-intensive" (9). Accordingly, agencies and task forces with long-range vision will want to consider and select both short- and long-term strategies.

2.2.6 Implement Alternatives

As difficult as it may be to establish, even in theory, a shared understanding of the value of incident management among multiple agencies and jurisdictions, program implementation is usually far more challenging. It is at the point of implementation that mechanisms for resolving many of the "nuts and bolts" of incident management must be developed.

Among the most sensitive alternatives that may be implemented are alternate routes. Ideally, alternate route planning is a systematic process that involves determining where and how much traffic should be diverted whenever an incident occurs, on any section of transportation network, at any time of the day. In most areas, alternative route contingency plans are developed for various severity levels, for various times of day, for points throughout the system. Determining how long a freeway is to remain closed before an alternate route plan is implemented is a regional policy decision. Some areas only divert traffic when an incident is expected to take an hour or longer to clear. Alternative route plans frequently specify the equipment and personnel required to implement a given level of a given plan. It is usually undesirable to reroute traffic along arterials containing schools, hospitals, or low bridges (9).

One tool that has fostered more efficient planning and implementation of alternate routes is Geographic Information Systems (GIS). Prior to the advent of GIS, alternate route plans had to be distributed in hard copy form to responding agencies. However, GIS developments now enable more efficient access to more detailed, dynamic, geographic data.

GIS has also proven very useful in the implementation and operation of alternate routes. When emergency responders' vehicles are equipped with mobile data devices, map images at varying scales, complete with the location of fire hydrants, schools, hospitals, and other features can be transmitted.

Coordination and cooperation with local agencies in planning alternate routes is essential since diversion of freeway traffic to local streets is often politically sensitive. Different jurisdictions within the same metropolitan area may have decidedly different takes on this planning process. In one area, for example, a recent alternate route planning effort included a city whose representatives felt that planning for alternate routes was extremely helpful, insofar as it gives the responsible agencies a chance to shape and control the rerouted traffic. However, a representative from another city in the same metropolitan area expressed reluctance to even share data from that city's arterials, because they did not want to facilitate the diversion of freeway traffic onto his city's streets under any circumstances.

Other important incident management issues that typically require resolution prior to implementation include the following:

- Jurisdictional boundaries - Who responds to incidents in what areas? Under what circumstances might these boundaries be flexed? How can resources and staff from adjacent jurisdictions be leveraged for maximum efficiency? How do agreements reached need to be documented?
- Joint training - How can responding agencies be convened for periodic joint training? Who will fund the training? Who will actually provide it?
- Incident management impacts on other services - How will the incident management program affect field personnel's other, non-incident-related duties? Do these impacts require mitigation?
- Field communications - Are field communications among responders and between responders and their respective agencies, adequate? If not, what measures or equipment will be required to ensure effective field communications?
- On-site command - Who should command on-site incident management, and under what circumstances? How can on-site command structure be established in advance to ensure that site management proceeds smoothly?

This list is merely a sampling of the issues to be worked out as areas implement their own incident management programs. Other unique challenges may be experienced regionally. Effective programs seek to resolve them early, with the input and consensus of all stakeholders. Moreover, operations are monitored to ensure that the solutions arrived at remain appropriate, and that new issues are anticipated and resolved as they emerge.

One mechanism for formalizing understandings among agencies and jurisdictions is an interagency or inter-jurisdictional agreement. The number, formality, and content of these agreements needed are a function of the specific needs and operating environment of a given area.

2.2.7 Reevaluate Alternatives

Incident management program development is an ongoing process, one that must take into account changes in the local operational, technological, political, and funding environment. Effective program evaluation and the subsequent revaluation of alternatives to refocus or refine an exiting system require the routine collection of appropriate data.

Regular data collection, which occurs in the course of regular program operations, allows program managers to assess the effectiveness of their efforts, to identify areas for improvement, to demonstrate the benefits provided by the program, and to support requests for additional resources. A more detailed discussion of incident management documentation, and its role in program reevaluation, is discussed in detail later in this section as an element of successful incident management programs.

Among the types of data that have proven useful in evaluating incident management programs include:

- Time required to detect incidents
- Time required to reach the incident site
- Time required to clear the incident
- Delay caused by the incidents
- Incident management program costs
- Costs recovered from "at-fault" drivers to clear the scene

Making a practice of holding "debriefings" following major incidents, which are attended by all responders, and in which both positive and negative aspects of the response are reviewed, is another key in continuously reevaluating incident management programs. Debriefings are also discussed in this section as an element of successful incident management programs.

2.2.8 Refine the System

To continuously improve and adapt a regions incident management program, effective feedback at two levels must be established and maintained. Each level is equally important, although in quite different ways. First, it is critical that clear lines of communication are maintained with upper management at participating agencies and jurisdictions. Chief among these "policy makers'" functions is gauging the political winds in terms of perceived needs, frustrations, and funding sources. Support at this level can not only buffer a program from competing needs, but can also ensure that the program has the resources to improve and expand, where appropriate.

Second, it is important that field-level personnel and their supervisors provide ongoing feedback regarding the effectiveness of specific techniques, tools, and approaches. It is the field personnel who have most direct information on which aspects of the operational program are or are not functioning well.

If communications and coordination are fostered continuously and genuinely at each of these levels, the end result should be, "a constantly evolving management system that continues to improve the incident management process; continues to adapt to the changing needs of the local area; and continues to meet the needs of the participating agencies, the affected jurisdictions, and the motoring public" (9).

2.3 ELEMENTS OF SUCCESSFUL INCIDENT MANAGEMENT PROGRAMS

The first part of this section focused on the process of incident management program development. This section builds on these concepts and provides detailed descriptions of components of successful incident management programs. While the form and nature of the components will certainly vary around the country, and even within the region, the elements of successful programs have much in common. These components have been organized into three major areas: people, practices, and infrastructure.

2.3.1 Elements of Successful Incident Management Programs: People

2.3.1.1 Incident Response Teams (IRTs)

Incident Response Teams (IRTs) are distinct from the Incident Management Task Forces discussed earlier. Whereas the purpose of the Incident Management Task Forces is to set broad program priorities at the policy or administrative level, IRTs deliver actual incident management services in the field, and in conjunction with their colleagues in traffic operations centers.

The following discussion provides information on several issues related to IRTs. However, it is noted that every IRT is unique in its membership, responsibilities and operations. As such, the information provided herein is in no sense representative of IRTs across the country. Instead, this information is intended to illustrate issues and approaches in establishing and developing IRTs.

<u>Function</u>

IRTs are most often interdisciplinary teams that are specially trained to handle a range of roadway emergencies. In many cases those participating from each responding agency (e.g., fire, police, DOT, EMS), often volunteer for this duty.

IRTs may comprise from one to several members from each agency, depending on the agency's size and structure, its function and typical incident management involvement, and the frequency of major incidents. However, many IRTs are staffed by personnel from a single agency. Staffing configurations vary considerably. Where incidents are relatively infrequent, the DOT, for instance, may have a single IRT member on duty with a backup who responds to major incidents only. In busier metropolitan areas, several DOT team members from traffic engineering and maintenance may be devoted to incident management, on either a routine or an on-call basis. IRT members in other organizations, such as city or county government, may only become involved when incidents directly impact their jurisdictions (as in cases where alternate routes run through their streets and highways). In any case, the following agencies and service providers may be part of the IRT:

- Service patrols
- Ambulance services
- Towing and recovery

- Transit
- Toxic material control
- Emergency services
- Other (Coast Guard, Railroads, etc.)

IRTs are generally authorized to determine a course of action, deploy personnel, and commit their agency's resources. Effective IRTs function as a unified entity. As such, they make decisions in cooperation with other responding agencies. Given the level of professional judgment required in the field, each IRT member participates in incident management, at least until his or her specific responsibilities have been carried through.

Interagency planning, training, and training exercises are all characteristics of successful IRTs. Where representation from various responding agencies is broad, each team member has the opportunity to represent the best interests of their agency and the public interest, as well as functioning as part of a coordinated team. In planning, training, and in the field, they analyze the incident from their unique perspective; help determine the optimal response; and track needed follow-up within their agency to ensure that the program is continuously improved.

Figure 2-5: Service patrol technician assisting motorist

The question of who serves as IRT leader at a given incident should be determined by existing incident management functions, interagency agreements, and applicable laws. Most typically, law enforcement officers serve as large collision scene leaders. However, if the incident involves hazardous materials or a fire, a fire commander usually takes the lead. Good IRTs rely on one other for guidance and support. One member will defer to another team member with the primary responsibility for a particular task if more than one course of action is recommended.

2.3.1.2 Training

Multi-agency training is fundamental in maintaining and improving incident management program quality. Regardless of its particular role, it is extremely important that every responding agency be involved in joint incident management training. Training programs, like other aspects of incident management programs, vary significantly from region to region. In any case, training may include any combination of field drills; traffic operations center training; and classroom lectures, discussion, and exercises.

Typical objectives of multi-agency incident management training include:
- Emphasize the importance of incident response from each responder's perspective
- Foster improved interagency cooperation
- Identify opportunities to improve the efficiency of incident management operations
- Foster a safe environment for each responder, crash victims, and other motorists
- Identify and discuss incident management policies and regulations
- Ensure mutual understanding of the relevant command system
- Review procedural information
- Review equipment use

Based on these objectives, elements that may be included in an incident management training program include:
- CPR
- Basic First Aid
- Radio communication
- Traffic control strategies
- Public relations
- Incident Command System
- Basic HazMat identification training
- Removal of disabled vehicles
- Response vehicle equipment use policies and procedures
- Fatal or felony accident procedures

The importance of proper training cannot be underestimated in light of our society's litigious nature. According to the Freeway Management Handbook, "It appears that the liability an agency bears for failing to properly train its personnel to react to normal day-to-day situations is slowly being extended in the courts to cases involving more dynamic emergency situations. "In the future, if it can be proven that adequate training to handle emergency situations could have prevented injuries or damages, an agency may be forced to assume at least some liability for failing to provide that training" (10).

2.3.1.3 Field Guides

Formal training programs provide the knowledge and skill base that IRT members need to perform their jobs effectively. To supplement this training, most agencies provide their IRT members with written (or electronic) field guides. Resource guides, like other aspects of incident management programs, are tailored to the nature, scope and resources of each area's program. The guide that is used by Washington State's IRT, in any case, provides an excellent example.

It is important to note that field response guides per se are distinct from policy guides, although the two types of documents may be combined. Generally speaking, policy guides focus on the administrative and theoretical aspects of incident management, and are based on laws and statutes. In contrast, field guides provide IRT members with the "nuts and bolts" information they need, including contact lists, to do their job in what are often harsh and demanding conditions.

The Incident Response Guide used by Washington State DOT covers the following topics:

- Introduction to incident management
- The incident response vehicle (including policies governing their use and routine maintenance and restocking procedures)
- Equipment and materials (locations and availability)
- Step-by-Step incident response procedures for all stages of incident response, from detection through motorist information.
- Communications - The field guide explains procedures for use of the communications tools available to IRT members, which include variable message signs and highway advisory radio. In addition, guidelines governing the use of On-Scene Command and Communication Radio Network (OSCCR), a dedicated on-site emergency frequency for use by dissimilar agencies at an incident scene, are also provided. Another element of the communications section provides tips on interacting with the media on-scene.

2.3.2 Elements of Successful Incident Management Programs: Infrastructure and Operational Strategies

Intelligent Transportation Systems (ITS) – the application of advanced sensor, computer, electronics and communication technologies – provide a complementary means to maximize the efficiency and safety of transportation infrastructure. Successful incident management programs do a good job of integrating their human resources with their transportation infrastructure. Infrastructure can be defined as, "the fundamental facilities and systems serving a country, city or area, as transportation and communication systems, power plants, and school" (14). This definition obviously encompasses transportation elements as basic as roads and bridges. Increasingly, however, we use this term as shorthand to cover a myriad of advanced computer and telecommunications technologies that are allowing us to monitor, control, and respond to our transportation system in more sophisticated ways. To our centuries-old roads and bridges we have added Intelligent Transportation Systems (ITS) to our definition of infrastructure.

"ITS is the application of management strategies and technologies to increase the efficiency and safety of the national, regional and local surface transportation systems. Rather than solving transportation challenges solely by building additional roadway capacity, ITS strategies strive to use existing facilities more efficiently, by applying technology and effective management strategies to collect, transfer, process, and share historical and real-time transportation information. This includes the use of computer, communications, sensor, information, and control technologies and a structured approach to manage the planning, development, deployment, operations, and maintenance of ITS systems and projects (15).

ITS is particularly relevant to incident management. Indeed, it is during atypical events, such as incidents and catastrophic weather, that ITS provides the greatest benefit (16). Many ITS technologies offer faster, safer, more efficient tools for incident management—for use by not only transportation agencies, but by other emergency responders, such as police and fire, as well.

2.3.2.1 Detection and Verification

Surveillance technologies serve several traffic management functions, including traffic monitoring and data collection. Typical data collected via these technologies include vehicle volumes, speeds, occupancy, and traffic density. Surveillance technologies have some utility in detecting incidents. In practice, surveillance technologies are most useful for incident verification. Where CCTV is available, it can be used to provide traffic operations centers with valuable information about the specific location, nature and extent of incidents. The various types of automated surveillance are summarized below.

However, it must be stated that many agencies have acknowledged that given the widespread use of wireless telephones, most incidents are readily reported by multiple wireless calls to 911 numbers. Incident management programs are reporting the percentage of incidents detected by cell phone callers to 911 or other numbers as high as 90%. These calls can be from passing travelers or by police and service patrols. In areas with dense traffic the time to detect incidents is nearly instantaneous. While this form of detection is highly certain, the agency receiving the call (public service answering point or PSAP) must then have a means and procedure to relay the information to the TMC.

<u>Inductive Loop Detectors</u>

Magnetic, or inductive loop detectors, which are embedded beneath the roadway pavement, are the most common form of automated vehicle surveillance. In use for decades, they do have several limitations. They are prone to failures, and servicing them, which requires opening up the pavement, can cause serious disruption, particularly in high-traffic areas. These limitations have prompted the development of alternative forms of traffic surveillance.

<u>Magnetometer Detection</u>

Magnetometer detection was initially developed as an alternative to loop detectors for special situations, such as bridge structures. They are similar to loop detectors, in terms of the mechanism via which they detect vehicle presence. Magnetometers contain small probes that are embedded in the pavement that measure the density of vertical flux lines in the earth's magnetic field. When a vehicle passes over the probe, the ferrous material in the vehicle increases the density of the flux lines. Magnetometers sense this increase and interpret it as the presence of a vehicle. The installation and maintenance of magnetometers is not as expensive or disruptive as that associated with embedded loops.

<u>Microwave Radar Detection</u>

Microwave radar is one form of non-intrusive detection. With microwave radar detection, microwave energy is beamed onto the detection area from a radar sensor mounted either above or beside the roadway. Vehicle presence and speeds are detected by frequency changes in the return signal. Unlike inductive loops or magnetometers, both of which require, to differing degrees, dismantling the pavement, non-intrusive traffic surveillance sensors are mounted on a structure above the roadway surface. Microwave radar has the advantage of performing well in all weather conditions. Because detectors are not embedded in the pavement surface, they are not subject to the effects of ice, sand, and salt. Recent research indicates that this form of detection is highly accurate and reliable (9).

Infrared Detection

Infrared detection is another form of non-intrusive detection. There are two primary types of infrared detection, active and passive.

- Active Infrared Detection Sensors - direct a beam of energy toward a background, such as the roadway surface. A portion of that beam is directed back to the sensor, which detects vehicles on the basis of changes in the returning infrared beam. One advantage of active infrared detection is that the beam emitted is very narrow, which allows for quite accurate determination of the vehicle's spatial position on the roadway. A disadvantage is that beam patterns are sensitive to vibrations, clouds, shadows, fog, rain, moisture, dust, and airborne particles.
- Passive Infrared Detection - This type of detection simply measures the energy emitted by objects in their field of view; they do not transmit energy themselves. The amount of energy emitted by a vehicle depends on its surface temperature, size, and structure. Like active infrared detection, passive infrared detection is sensitive to environmental effects.

Ultrasonic Detection

This detection method relies on electronic sound wave signals and a receiving unit to detect vehicles. Like microwave detectors, ultrasonic detectors transmit a beam into their field of view and detect the presence of vehicles on the basis of shifts in the return signal. Until recently these devices were not favorable because of their sensitivity to environmental conditions and the need for highly specialized maintenance capability, recent advances in this technology are promising (17).

Video-Image Processing

Video-Image Processing is another form of non-intrusive vehicle detection. It works by monitoring specific points in the video image of a traffic scene to determine changes in successive frames. Typical video image processing systems include one or more video cameras, a microprocessor system to process the video images, and software that translates the processed images into vehicle detection data. A disadvantage of video imaging is its sensitivity to light and shadows, which can cause the processing systems difficulty in accurately interpreting the images. The performance of video imaging processing systems can be, however, enhanced by improving their detection algorithms. Another disadvantage, compared to other detection systems, is its very high cost. However, the advantages of video-imaging detection over other forms of traffic surveillance are significant:

- The life-cycle cost for video imaging detection is lower than embedded loop technologies in most cases;
- Installation is less expensive in terms of labor, materials, equipment, time, and disruption to the roadway network;
- Maintenance can be done year-round, with minimal traffic disruption;
- Detector regions can be relocated or added with software;
- Resurfacing or construction projects do not affect traffic detection;
- Camera location is flexible, and can be controlled remotely;
- Very little training is required for installation staff.

Closed Circuit Television (CCTV)

Another form of non-intrusive detection, CCTV can be equipped with video image processing capability. This integration allows operators the ability to immediately verify incident warning measures. If an incident has occurred within the coverage area, operators can switch the video image processing equipment from video imagery mode to a standard CCTV mode and monitor nearby incidents with pan, tilt, and zoom controls. CCTV is extremely helpful in verifying the location, nature, and scope of an incident that has already been detected.

Vehicle Probes

Vehicle probes serve as yet another form of non-intrusive traffic surveillance and rely on an entirely different concept. "Vehicles, acting as moving sensors (or probes) can provide information about traffic conditions on each link traversed. This information can be transmitted to a central computer system where it can then be merged with information from other sources to provide an accurate representation of actual travel conditions in the transportation system" (9). In terms of traffic surveillance, vehicle probes are used primarily to provide link speeds and travel times. Several emerging technologies are used to enable vehicles to act as traffic probes: automatic vehicle identification, automatic vehicle location, and cellular telephone probes.

Automatic Vehicle Identification

These systems allow radio communications between transponder-equipped vehicles and roadside transmitters at strategic locations. The data collected at the roadside is then transmitted to a traffic operations center for processing. AVI technology has several applications, including traffic monitoring. In Houston, Texas, for instance, AVI systems monitor traffic on the main lanes and high-occupancy vehicle lanes on three major freeways. Transponder-equipped vehicles are used as probes to collect current travel time information, which is used to alert freeway operators to potential incidents and congestion. AVI can also be used to provide electronic border and weigh station clearance for commercial vehicles.

Automatic Vehicle Location

These systems track vehicle movements through time and space. Emergency vehicle management, transit operations, and delivery companies have applied this technology to manage fleet vehicles. AVL is also very useful in managing incident response vehicles and resources. Mayday systems, which send a signal to a dispatch center indicating the vehicle's location, are another useful application of this technology. AVL can also be used for security purposes, such as locating a stolen vehicle.

AVL systems may be based on one or more of the following technologies:

- Dead reckoning and map-matching systems monitor the vehicle's internal compass and odometer and calculate its position by measuring its distance and direction from a known starting point. The disadvantage of dead-reckoning systems alone is that often get off track. However, their performance can be improved by integrating them with map-matching technologies, which store a map of the vehicle's coverage area in a database. Despite the improvement to dead-reckoning possible through map matching, this combined technology is fairly inaccurate compared to other available AVL technologies.

- Signpost based positioning systems are a relatively accurate, inexpensive AVL technology. These systems can be used where vehicles regularly travel a fixed route, as do transit buses. Antennas placed on signposts at locations along the vehicle's route record the time at which transponder-equipped vehicles pass by.
- Ground-based radio navigation. Ground based radio-navigation systems are based on a series of receiving antennas within in a given metropolitan area, which are installed by the AVL vendor. Participating vehicles are specially equipped to broadcast radio signals to nearby receiving antennas. By measuring the time it takes for the signal to travel to the antenna, the distance from the vehicle to the antennas can be determined. If three or more antennas have received the vehicle's signal, the vehicle's position can be uniquely determined. One advantage of ground-based systems is their low price relative to other forms of AVL. However, since antenna installation represents a large capital investment, these systems are usually only feasible in densely populated metropolitan areas with significant market potential.
- Global Positioning Systems are based on a network of satellites that continuously orbit the earth. These satellites, which can be used free of charge to anyone with a device capable of receiving their signal, can locate an object anywhere on the planet. The position of objects is determined by measuring how long a radio signal takes to reach the object from multiple satellites. GPS is by far the most accurate navigation system ever developed to date. The U.S. Department of Defense (DOD) originally launched the satellites to track objects of strategic and military interest. A disadvantage of GPS is that GPS signals have trouble transmitting through large objects, such as buildings, and through opaque material, such as foliage. In addition, the accuracy of satellite transmissions has been purposely degraded somewhat by the DOD for security reasons. Differential GPS, however, corrects for this error. "A receiver placed at a known location calculates the combined error in the satellite range data. By knowing the error, correction factors can be applied to all other receivers in the same locale, virtually eliminating all errors in measurements" (9).

<u>Incident Detection Algorithms</u>

These are the mechanism by which traffic surveillance methods are translated into incident detection data. An algorithm is set of computational rules for the solution of a mathematical problem within a finite number of steps. An algorithm allows a person or a computer to determine relationships among various sets or pieces of data. For instance, various types of incident detection algorithms have been established to allow computer systems in traffic operations centers to alert operators to the possibility on an incident in any part of the traffic network for which traffic data are available. The operator can then use other equipment, such as CCTV if the incident occurs within proximity to the camera, to verify that an incident has occurred, and to assess its scope.

In order to detect an incident electronically, data regarding vehicle volumes, speeds, and/or occupancy (whether a particular detection area is occupied, not how many people are in the car) are taken in from the devices discussed previously, compared, and analyzed against various scenarios. Incident detection algorithms can be divided into the four major categories including:

- Comparative (or pattern recognition) algorithms compare traffic parameters at a single detector station or between two detector stations against thresholds that define when incident conditions are likely. This category includes ten Modified California Algorithms, as well as the Pattern Recognition (PATREG) Algorithm.

- Statistical algorithms use statistical techniques to determine whether observed detectors data differ statistically from historical or defined conditions.
- Time-Series/Smoothing algorithms compare short-term predictions of traffic conditions to measured traffic conditions. Exponential Smoothing and Low-Pass Filtering are two algorithms in this category.
- Modeling algorithms use standard traffic flow theory to model expected traffic conditions on the basis of current traffic measurements. Dynamic Model and McMaster algorithms fall into this category.

Algorithm performance is typically measured in three ways: (1) the percentage of incidents detected, (2) the time required to detect an incident, and (3) the percentage of "false alarms." It should be noted that there is generally a trade off between two of these measures. The more sensitive an algorithm is to incidents, the more likely it is to produce false alarms. "Agencies must decide for themselves what is an acceptable balance between detection sensitivity and false alarm rates for their detection system. False alarms can be tolerated in order to achieve a higher detection sensitivity, so long as they are not too frequent and liable to be ignored by the system operator." Research indicates that the best performing algorithms detect 70 to 85 percent of all incidents with a false alarm rate of 1 percent or less (9).

2.3.2.2 Motorist Information

Motorist information includes the dissemination of incident-related information to motorists who are (1) at the scene of the incident, (2) approaching the scene of the incident, and (3) not yet departed from work, home, or another location. Motorist information should be provided as early in the incident management process as possible and should continue until the incident has been cleared and the traffic backup has dissipated. Motorist information supports incident response and clearance in the following ways by:

- Reducing traffic demand at and approaching the scene
- Reducing secondary incidents
- Improving responder safety on scene
- Reducing erratic behavior due to motorist frustration

Specific ITS technologies that can be used to disseminate motorist information can be divided into two primary categories, en-route and pre-trip. Motorist receives en-route information while they are traveling. Pre-trip traveler information is received in non-travel settings, such as home, office, or shopping areas and is provided to assist travelers in making travel decisions.

Roadside devices that are commonly deployed to disseminate information to motorists are described below.

<u>Variable Message Signs</u>

VMS are also known as Dynamic Message Signs (DMS) or Changeable Message Signs (CMS). VMSs can be used by operating agencies to disseminate travel information on a near real-time basis. VMSs are among the most flexible and powerful means of communicating with motorists on the road. Both fixed-location and portable VMSs are used to support incident management functions. The messages presented can be operated on a fixed-time basis, via on-site controls (as in an incident), or remotely, via a connection with a traffic control center. VMSs are most often used to:

- Inform motorists of varying traffic, roadway, and environmental conditions (including variable speed limits in adverse conditions);
- Provide specific information regarding the location and expected duration of incident-related delays;
- Suggest alternate routes because of construction or a roadway closure;
- Redirect diverted drivers back onto the freeway;
- Inform drivers when passage along the shoulder is permissible (e.g., in the event of a major incident, where this can help restore the traffic flow safely).

The technology that enables the display of messages per se is not particularly advanced. VMSs fall into two broad categories: light-reflecting and light-emitting. A hybrid category combines these. A more sophisticated aspect of VMS technology is the extent to which field equipment can be controlled remotely from a traffic operations center. A few ITS systems, such as the one in San Antonio, Texas, provide automated VMS activation to remote units from the TOC.

<u>Highway Advisory Radio (HAR)</u>

HAR information is communicated to drivers via their vehicles' AM radio receivers. Drivers receive notification to tune into a specific frequency upstream of the transmitter. Message transmission can be controlled either on-site or from a remote location, such as a TOC.

The functions served by HAR are similar to those served by VMS. An advantage of HAR, according to research, is that since the information is sound, the driver experiences less sensory overload than when having to read and process a written message, which also requires that they take their eyes off the road. Another advantage of HAR over VMS is that longer, more complex messages can be communicated. However, HAR has disadvantages, including the following:

- Drivers who do not have functioning radios cannot access the information
- Drivers who tune in midway through the message have to listen through another cycle
- Many drivers disregard the message to tune in

<u>Automated Highway Advisory Radio (AHAR)</u>

One of HAR's primary disadvantages is that it requires specific action on the part of the driver--that he or she pay attention to the advance signal, and then tune in to the specified station. In practice, many drivers disregard the message to tune in. For this reason, AHAR systems are under study. AHAR systems emit a special electronic signal upstream of a HAR message. This system allows the HAR message to interrupt regular transmission of a specially designed radio/compact disc player within the vehicle. The major impediment to widespread AHAR implementation is that the in-vehicle receivers required are quite expensive; and as such, not yet acceptable to consumers (9). However, with sustained interest and investment in ITS, this technology may become more viable.

Something that both HAR and VMS have in common is that operators need to ensure that they maintain credibility with drivers. In order to do this, they must work to ensure that the motorist information they disseminate via these media is timely, accurate, and relevant to the intended audience.

Wireless Phone "Hotlines"

With the spread of wireless telephone usage, transportation agencies have a new and quite powerful way to communicate with travelers who are already on the road. Wireless phone hotlines can be used by drivers to access construction, congestion, and incident-related travel information on the route or routes they are interested in via touch-tone menus. The following recommendations are offered for the management of wireless hotline systems:

- Calls should be toll-free to users.
- The telephone number should be easy to remember and dial.
- The information should be concise.
- Menu systems should not be long and tedious.
- Enough phone lines should be provided to prevent most drivers from getting a busy signal.
- Human operators should be on duty for systems that collect incident information; their function is to clarify confusing or unclear reports (8).

Commercial Radio

In use for decades, commercial radio has long provided traffic information to commuters and travelers. Its clear advantage is that it is well understood and utilized by millions of drivers. However, there are areas for improvement in commercial radio transmissions. In particular, because they are based on programming and scheduling constraints, the information does not always meet the traveler's needs. With technological advances in ITS, have also come the recognition of the need for better coordination among all the organizations, including commercial radio, that play a part in traffic information dissemination. As such, many transportation agencies recognize the important role commercial radio plays in information dissemination. To that end, transportation agencies are forging closer alliances with the media, with the goal of improving the quality and timeliness of broadcasts. Some agencies, for example, allow commercial radio staff to work in their Traffic Operations Centers.

Methods to provide pre-trip information to travelers are discussed below.

Kiosks

Kiosks are travel and traffic information stations that may take the form of video monitors mounted on a stand-alone cabinet, in a wall, or on a countertop. They may have input devices, such as keyboards or touch screen displays. Kiosks can be utilized to provide incident related information to travelers such as congestion, closures and alternate routes.

Kiosks can also provide an important point of access to travel information networks in public locations, such as hotels, airports, truck stops, and retail establishments. Travel information kiosks may contain bus routes and schedules, real-time traffic information, listings of nearby attractions, and even rideshare matching services. To be effective, kiosks must be placed where they draw attention, but where they do not impede pedestrian flows.

Television

Commercial television stations in most major cities provide traffic reports to indicate incident locations, other congestion, malfunctioning traffic signals, and other traffic-related information. To get around the limited time that commercial TV will typically devote to traffic information, another possibility is through public access TV. "Many city governments are responsible for franchising cable TV service within the corporate limits of the city. As part of awarding the franchise to a company, many city governments offer their own programming on one or more of these decimated channels. Public access channels can be used by traffic management agencies to broadcast continuous traffics information during peak hours. Either "crawl" messages across the bottom of the screen or map displays accompanied by voice messages can be used to provide users with information. Traffic reports can also be provided by interrupting normal programming. The primary disadvantage of public access TV is that the information is only available to cable subscribers" (8).

Pagers

Alpha-numeric pagers can be used to provide owners with hourly traffic information for specified routes. This technology has already been tested as part of ITS programs in Seattle, Minneapolis, and New Jersey. A limitation of this technology is the small number of characters that can be broadcast in a given message.

PDAs

Personal Data Assistants (PDA's) function at a higher level of sophistication than do pagers. By adding radio frequency communications technology, PDAs allow users to interact directly with travel information systems. This interaction allows users to obtain route planning assistance, traffic information broadcasts, and other information. Through keypad entry, the user can log on to the information system, request individually tailored information, and then log off. PDAs offer the user increased communication and information transmission and receiving power over alphanumeric pagers. However, their sophistication makes them harder to use and more expensive to purchase.

Internet

The increasing prevalence of Internet access at homes, in the workplace, and at schools, has made this medium an attractive, relatively inexpensive medium for motorist information. The user's ability to tailor information requests with a simple click is a key advantage. In the Seattle area, users can use the Internet to access a map of their commute area and see depicted the location of buses, in real time. Users in this area can also access a map of the freeway system, which is color coded to indicate travel speeds and congestion on given links.

2.3.2.3 Traffic Control

Traffic control strategies that may be applied to incident response and clearance are described below.

Traffic Signal Timing Adjustments

Traffic signals in many metropolitan areas are traffic-actuated, rather than based on fixed timing plans. They take in traffic data, typically gathered from embedded loops, which they use to optimize traffic flow. The goal of traffic actuated signal plans is to provide the highest possible level of service and safety. Procedures for setting traffic signals (allocating available green times to conflicting traffic movements) have advanced significantly in recent years. "We now have signals that respond to prevailing traffic flows, groups of signals that are sequenced to allow for a smooth though-low of traffic, and in some cases, computers controlling entire networks of signals" (11). Traffic signal timing adjustments can be made to manage arterial traffic operations and to support freeway operations during and after an incident.

Ramp Controls

In addition to the efficiencies achieved on arterial streets through traffic-actuated signals, traffic flow onto freeways can also be managed, through the use of ramp metering. Ramp metering can improve freeway traffic flow by reducing the turbulent flow conditions and congestion that often occur at entrance ramps. This improvement can be accomplished in two ways:

(1) By controlling the volume of on-ramp traffic that the freeway can accommodate without a breakdown in traffic flow on freeway through lanes. Here, the goal is to maintain the balance of the demand-capacity relationship and to avoid a breakdown of traffic flow in the downstream freeway segments (9).

(2) By controlling the rate of arrival of on-ramp traffic into the freeway lanes. "Here the goal is to break down the constant stream of traffic that is forcing its way into the head of the line at the freeway lanes. The ramp meter is used to control the number of on-ramp vehicles entering the freeway at any one time…such that any resulting "shock waves" can be dissipated within the freeway traffic stream before the next small increment of on-ramp vehicles arrives to enter the freeway" (9).

2.3.2.4 Response

Technologies that support enhanced emergency management are described below.

<u>Computer-Aided Dispatch (CAD)</u>

CAD combines computer and communications technologies to better manage communications among emergency responders community and their dispatch centers. Computer-aided dispatch systems are in place in thousands of fire, police, and other emergency service agencies throughout the country. Common CAD functions include:

- Assist dispatchers in tracking the status of field units and in assigning units to respond to an incident based on the urgency of the call, the field unit's proximity, and available equipment.
- Provide police and fire personnel with access multiple databases containing information on issues such as the haz-mat locations, national crime databases, and data from department of licensing and motor vehicles. These types of information can allow responders to assess potentially dangerous situations in advance. Some software packages allow responders to make a single entry on their mobile data terminal to access multiple sources, whereas in the past, multiple inquiries to the dispatcher were required.
- Point and click dispatching that allows a dispatcher to assign a call to a vehicle automatically by simply dragging and clicking the mouse onto the desired vehicle visible on an electronic map.
- Electronically track every dispatch "event" in case reconstruction is necessary. A complete history is thereby recorded and available on-line for problem resolution.
- Complex arrays of information, such as multiple contact lists, can be organized and easily accessed by the dispatch operator when it is contained in pull-down menus.
- Some CAD systems include electronic mail systems, which support sending automated e-mail messages to specified consoles, individuals, and groups Forwarding, acknowledgement, certification, repeating messages and other capabilities can be provided.

<u>Traffic Signal Preemption for Emergency Vehicles</u>

Traffic signal preemption has long been embraced by the public safety professionals, including police, fire, and emergency medical service providers. Traffic signal preemption supplies emergency vehicles with a green light to move them through congested intersections more quickly en route to an emergency scene. Typical systems rely on an emitter-equipped vehicle, a detector (usually mounted on the signal mast arm), a signal phase selector (installed within the signal controller cabinet), and software to upload settings, which eliminates the need to set parameters by hand.

Each emitter's communication signal is encoded with a unique vehicle identifier and user authorization code. The detector receives the emitter's message and transforms it to an electronic signal. The detector then sends the electronic signal to the phase selector in the signal controller cabinet. The phase selector validates the signal and requests priority control from the traffic controller. The phase selector presents a command request to the traffic controller. Command priority results in the system providing a green light to authorized vehicles after appropriate intersection timing is complete, usually within a few seconds (20).

Mayday Systems

In the event of a vehicle breakdown, accident or medical emergency, motorists and their passengers may be vulnerable, particularly if they are stranded at night or in rural areas. Mayday systems constitute an emergency vehicle location system that, when activated by the motorist or automatically due to crash, transmits a request for help, along with the vehicle's precise location, to emergency services personnel. Two separate technologies are available. The first is based on a cellular phone combined with a GPS receiver, which transmits both voice and data over an analog cellular modem. The motorist pushes a button on the cellular phone to establish a voice link with a private response center operation, which also views a screen display of the motorist's location. The second technology, a two-way pager combined with a GPS receiver, is based on the Cellular Digital Packet Data (CDPD) protocol, which is capable of transmitting data only—without voice. With the CDPD-based device, the motorist pushes a button designated for a specific type of emergency, which connects him or her with the response center. The private operator then forwards the request for the appropriate form of assistance to incident response agencies or private services and sends the motorist a message to confirm receipt of the call. In-vehicle Mayday systems are now offered as original equipment on some vehicles. As the use of these services increases, so will the burden on PSAPs and public agencies dispatch.

2.3.2.5 The Role of the Traffic Operations Center

Description

Traffic Operations Centers (TOCs) serve as the hub or nerve center of ITS and traffic control systems. TOCs are the central point at which information about the transportation system is collected, processed, and collated. Described in this section are accounts of how TOCs, with the infrastructure elements they house and integrate, can support the various stages of incident management.

The traffic information collected for, analyzed by, and disseminated from TOCs is key to effective incident management. Quick identification and verification of incidents makes it possible to respond rapidly with the proper equipment and personnel. It also allows motorists to receive information early enough to change their routing, which can reduce delay and the risk of secondary collisions. TOCs can further manage traffic by altering signal timing; activating dynamic message signs and Highway Advisory Radio (HAR); dispatching DOT support, such as service patrols and maintenance vehicles; and notifying affected jurisdictions.

The following are common goals and objectives of TOC's:

- To foster wide dissemination of real-time traffic information
- To improve traveler safety and travel times
- To enhance coordination between response and transportation agencies
- To maximize the capacity of the highway transportation system
- To reduce congestion through advanced communications and control technologies
- To collect and store data essential for the evaluation of incident management and traffic management programs and strategies

The traffic operations center serves as the focal point for communications and coordination among multiple agencies for incident management. They support detection and verification, response, site management, traffic management, clearance and motorist information. The TOC, by virtue of this comprehensive role can be the primary data collection point for traffic incident data to improve operations and support funding requests.

Although an integral part of incident management, detection is not a primary function of the TOC. Motorist use of the wireless telephone communications has grown exponentially over the past decade. As such, it has become the primary means of incident detection. A 1997 study in Washington State determined that over 80 percent of blocking incidents were first reported by cellular calls from motorists. Police, department of transportation staff, or volunteer service patrols, detected another 18 percent of these incidents. TOC staff detected a scant 2 percent. Multiple cellular calls for the same incident are the norm, with operators reporting up to 80 cellular calls per major incident. Multiple calls do, however, serve a purpose, since dispatchers frequently need to speak to several callers to accurately report the location, direction of travel, and other aspects of the incident.

Verification involves confirming that an incident has occurred, identifying its exact location and the direction of travel, and other details necessary to determine the appropriate response. Many TOCs are able to verify incidents with video monitoring systems. This is important because even minor incidents can have a serious effect on traffic flows when roadways are at or near capacity. Quick verification and response can mitigate incident impacts significantly. A before and after study of the TransGuide TOC in San Antonio, Texas, for instance, reported a 15 percent decrease in injury accidents, due in large part to improved incident verification.

Incident response is not generally a primary TOC function unless that TOC is part of a jointly operated center collocated with police and/or service patrol dispatch. Jointly operated centers do have the advantage of being able to coordinate response faster and more effectively because of the continuous working relationships and information sharing that characterizes their operations. They can also coordinate to prevent the dispatch of unnecessary personnel or equipment. TOCs that are linked to the police and/or fire Computer-Aided Dispatch (CAD) systems have proven very effective.

The role of the TOC in site management is usually one of safety and support. Keeping motorists informed, using traffic management programs to reduce traffic queues, and apprising responders of the best access routes to the incident, achieve this. Many TOCs routinely track the locations of maintenance equipment, such as dump trucks and sweepers. This too facilitates timely and appropriate site management. Managing the traffic queue also entails watching for secondary collisions. Monitoring for blocking disabled vehicles and sending assistance to them can also support site management and reduce overall incident duration.

If closures or alternate routes are required, TOCs can play a role in identifying the optimal route, informing affected responders (and the media) and altering traffic signal and ramp meter controls in order to keep the alternate route plan functioning smoothly.

Clearance entails more than getting disabled vehicles and debris off the roadway. It also means using TOC capabilities to clear the queue as quickly as possible once the roadway is clear. It can also mean assisting with actual cleanup and clearance. Operators in a TOC can evaluate an incident and send the appropriate equipment for clearance prior to its request. Spilled loads, for example, can be handled more quickly when the TOC has the authority to send cleanup equipment based on what they see on their video monitors, without having to wait for the police or other responders to reach the scene, assess the situation, and request assistance.

TOCs may also play a significant role in clearing incidents that require specialized equipment. Sweepers, cranes, loaders, dump trucks, and sanders are key to quick clearance of spilled loads, overturned trucks, fuel spills, and guardrail damage. Proactive TOCs maintain a list of equipment available from both public and private sources. Proactive maintenance programs may have a sander available even in summer months. Maryland 's CHART program, for instance, keeps a loader and a sand truck on call for all truck wrecks on the Capital Beltway.

Motorist information dissemination is generally a primary TOC function. Public-private partnerships have allowed media outlets to use DOT generated real-time video feeds of traffic flows, incident information, construction information and special events traffic data. Live video feeds are routinely used for television traffic reports.

Some centers, such as the one operated by Arizona DOT in Phoenix, provide statewide traveler information, which is also transmitted to neighboring states. Through the Arizona DOT Highway Closure and Reporting System, motorists and media can determine conditions on major highways statewide, 24 hours a day. The center can also control Variable Message Signs throughout the state when district offices are closed.

TOCs can also disseminate information through the Internet, kiosks, special telephone lines, and pagers. Although any single method may only reach a small number of motorists, cumulative effects can be substantial.

The TOC can also be used to document the use of DOT equipment and personnel, which is essential in seeking response cost reimbursement from at-fault motorists or their insurance companies in major incidents. Recovery of damages can help fund the incident management programs.

<u>TOC Management Issues</u>

DOT agencies attempting to get CAD data from the police for incident management purposes often face obstacles. Police agencies have a high level of security and maintain confidentiality of records for all investigations, wanted checks, and criminal records. As such, law enforcement agencies may be reluctant to release even minimal information to other agencies for fear that it will compromise their system's integrity. Moreover, police in many areas have yet to be persuaded that the sharing of their data provides them with any benefit. However, these issues can be resolved. For example, although Seattle Washington's TOC employs only DOT personnel, real-time data are shared with the Washington State Patrol. The patrol 911 center is equipped with DOT-provided video monitors capable of displaying the metropolitan area's entire freeway system. Meanwhile, all incident-related CAD information from the WSP is displayed on workstation monitors at the TOC. The result is an effective system that isn't co-located.

Voice communications are another concern. The ability of different agencies to communicate by radio is typically very limited. Some agencies will not allow anyone from another agency to access their radio frequency; still others will not take on additional responsibilities, such as dispatching service patrols, because they lack sufficient staffing and because such tasks would interfere with their primary mission.

Another institutional issue relates to responders from various agencies who do not perceive the potential value of a TOC. Such agency staff may be accustomed to solving problems in their own way, without involving the DOT, except in rare cases (e.g., those that require DOT equipment, substantial traffic control, or infrastructure repair). DOT staff who are interested in developing a cooperative TOC may have trouble gaining other agencies' respect and support from other responders unless they can demonstrate their agency's own value in protecting public safety through incident response.

2.3.2.6 Infrastructure Issues

Among the most important issues related to the planning, development, implementation and operation of ITS infrastructure that supports incident management functions is the development of the National ITS Architecture. An ITS architecture defines the institutional and technical linkages necessary to plan, design, implement, operate and maintain ITS. The National ITS Architecture, adopted in 1996 and updated in 2000, provides the technical and institutional framework to guide the coordinated deployment of ITS by public agencies and private entities alike. It defines the functions performed by ITS components and the various ways in which components can be interconnected. Although the architecture is national in scope, it can be tailored to meet the stated needs for regions, corridors, and transportation authorities. Use of the National ITS Architecture benefits state and local transportation agencies, alike by helping to save time and money in achieving maximum benefits by implementing integrated ITS.

Using the National ITS Architecture can foster the inter-operability of ITS systems across jurisdictions and other ITS services that may already exist, or may be implemented in the future. This is especially important as it relates to incident management, given that many times incidents can have a regional impact on the operation of transportation systems.

Using the National ITS Architecture also fosters the implementation of ITS without losing investment in existing systems when future systems are developed and implemented. In addition, using the National ITS Architecture saves public and private entities time and money because it contains a majority of the up front analysis and planning information necessary to design and deploy successful ITS. This includes project definitions and requirements, information exchange requirements, system evaluation criteria, cost development information, communications analysis, and the identification of benefits of deployment specific to ITS.

Other benefits that can be expected with deploying ITS using the principles of the National ITS Architecture and standards include:

- Interoperability - The National ITS Architecture has identified where standards are needed for system interoperability. Because the National ITS Architecture is serving as the common foundation for ongoing ITS standards development work. Using standard interfaces will provide a foundation for national and regional interoperability and even interchangeability of some devices used in ITS traffic management, even though they may be from different manufacturers.
- Increased competition - By requiring use of open standards (non-proprietary), multiple vendors will be able to meet the standards and be able to respond to RFPs. Support and upgrades will also be available from multiple potential sources, avoiding the problems of being locked into one source. Competition among vendors will reduce prices while encouraging innovation and efficiency.
- Future expandability - By designing within a common framework and using open standards, an environment that integrates legacy systems with new ITS applications will be created. This will allow functionality to be added as needed.
- Increased transportation system integration - The open nature and structure of the National ITS Architecture and use of standards-compliant components will make integration of complex traffic management components and regional systems easier. Improved integration of systems operated by different agencies will permit effective information sharing and more effective use of resources. Seamless traveler services across agency lines will become a reality.

Although the National ITS Architecture is composed of several thousands of pages, referring to a hyper-linked compact disc edition facilitates navigation through it. Meanwhile, a US Department of Transportation Publication entitled, “Developing Freeway and Incident Management Systems Using the National ITS Infrastructure,” (15) is available to assist practitioners in using the National ITS Architecture in several development tasks including:

- Identifying goals and objectives
- Identifying potential technology solutions
- Planning and designing the system
- Funding the program
- Procuring ITS services, hardware, and software
- Implementation

Further emphasizing the value of utilizing the principals of the National ITS Architecture is a provision contained in the Transportation Equity Act for the 21st Century (TEA-21) requiring ITS projects funded with Highway Trust Fund (including the Mass Transit Account) to conform with the National ITS Architecture, and with applicable or provisional standards and protocols. Detailed information on the provisions of this requirement are provided by the USDOT and is available on the Internet at http://www.its.dot.gov/aconform/aconform.htm.

2.3.3 Elements of Successful Incident Management Programs

2.3.3.1 Service Patrols

Freeway service patrols have been cited as a very effective element of incident management programs. They can be extremely effective in reducing incident detection time, as well as the overall duration of the incident. Service patrol programs utilize roving vehicles to patrol congested and/or high incident freeway sections. The objectives of freeway service patrols include identifying incidents or disruptions in the traffic stream; minimizing incident duration; restoring full capacity to the facility; and reducing risks of secondary crashes to motorists and injury to responders. Service patrols are typically capable of clearing the majority of incidents without the need for further assistance.

At major incidents, service patrols often play other roles, which may include assessment of the equipment and manpower needed to clear vehicles and debris; coordination with other responders; and traffic control (which often entails creating a buffer between incident responders and traffic). In speeding incident detection and clearance, service patrols reduce congestion, the waste of fuel, vehicle emissions, and the potential for secondary accidents.

Of the over 70 freeway service patrol programs currently operating around the US, 45 have been initiated since 1990. Although the majority of these programs use publicly owned and operated vehicles, 21 are based on partnerships with private sector companies. Following are brief case studies of service patrol programs in Chicago, Minneapolis, San Francisco/Oakland, and Northern Virginia/Washington, DC.

<u>Chicago, Illinois</u>

Chicago's service patrol program, which was kicked off by the Illinois Department of Transportation (IDOT) in 1960, is one of the country's oldest and most successful. The Emergency Traffic Patrol (ETP) initially consisted of several pickup trucks operating during peak periods only. Today, the program, known as the "Minuteman" program, has a much broader scope than other service patrols. Whereas most programs focus on removing minor incidents, the Minuteman program is part of the entire incident response program for IDOT and can clear large truck and cargo spill incidents as well as minor incidents. The program operates around the clock and includes 35 emergency patrol vehicles (the size of a medium-duty tow truck), 11 light utility 4 x 4's, a sand truck, a step van, a tractor/retriever, two 50-ton and two 60-ton heavy-duty recovery units. Every vehicle in the fleet is equipped with heavy-duty push bumpers. One of the country's larger programs, ETP staff includes 76 positions:

- Fifty-five patrol drivers, who are known as "Minutemen"
- Three shift supervisors
- Eight foremen
- Two mechanics
- A storekeeper
- An equipment technician
- Five building and office staff, and
- A patrol manager

IDOT Minutemen receive comprehensive initial training and frequent ongoing and re-certification training. The patrol operation encompasses 12 beats, which are organized along overlapping shifts and routes to provide extra coverage on high-incident sections. All beats are patrolled 24 hours a day, 365 days a year.

In all, the ETP logs an estimated 1.8 million miles per year. Minutemen typically spend up to 15 to 20 minutes with a motorist at a disabled vehicle. If the disability cannot be corrected, the Minutemen call a motor club or the State Police to order a tow. The Minutemen can transport motorists off the freeway if they so request. Although disabled vehicles are relocated to a shoulder, accident investigation site, or nearby exit, the service patrol does not tow vehicles beyond these points.

The annual IDOT budget for Chicago's program is between $3.5 and $4 million, two thirds of which goes to pay personnel costs. Another $600,000 funds equipment maintenance and replacement and $500,000 are devoted to general operating costs. State motor fuel and vehicle registration taxes support this program, funding for which is appropriated annually.

A 1990 program evaluation estimated that Chicago's ETP eliminates some 9.5 million vehicle hours of delay per year. The ETP reports the following average clearance times:

- 9 minutes for shoulder incidents,
- 12 minutes for incidents blocking one lane,
- 22 minutes for incidents blocking two lanes,
- 40 minutes for major incidents that block three or more lanes.

Based in part on this finding, a conservative benefit-cost ratio of 17:1 was calculated (assuming the value of time at $10 per hour). Public support for the program is high, as demonstrated by the 900 thank-you letters received each year, which affirm the program's value and the use of tax dollars to support it.

<u>Minneapolis, Minnesota</u>

Minnesota's Highway Helper program began in December 1987. The program initially operated out of the Minnesota DOT (MnDOT) District maintenance office during peak periods only. In January 1990, the number of routes was expanded from three to six, with each route measuring 10 to 13 miles in length. In March 1993, the program was relocated to the Minneapolis Traffic Management Center, and patrol coverage was extended to daytime off-peak hours.

Today, the Highway Helper staff includes one Highway Helper Senior (a supervisor), 12 full-time "Highway Helpers," and two part-time Highway Helpers. Eight half-ton pickup trucks are divided between two shifts, 4:30 am to 12:30 pm and 12:15 pm to 8:15 pm, Monday through Friday. The patrol recently added weekend coverage.

New Highway Helpers complete a six-day training program that was developed jointly by the State Patrol, the Minneapolis Fire Department, and MnDOT staff. Each trainee then rides with an experienced Highway Helper for a minimum of two weeks to become familiar with routes and procedures.

The Highway Helper annual operating budget runs at approximately $610,000 a year. Personnel costs account for $500,000 of the budget, vehicle expenses account for about $60,000, and general operational costs absorb another $50,000. Until recently, the program was funded exclusively with state funds from Minnesota DOT. However, the recent addition of two part-time drivers is being 80 percent funded with federal CMAQ funds. In all, federal funding now covers about 10 percent of the program budget.

A 1995 program evaluation estimated that the Highway Helpers saved motorists approximately 284,000 vehicle hours a year. A cost-benefit ratio of 5:1 was calculated using the estimated delay reduction, estimated fuel savings, and a dollar value of time of $10 per hour. A 1996 independent study of public opinion of the patrol showed that 76 percent of the public was aware of the program and that 87 percent considered the program a good use of tax dollars. Fully 96 percent of the motorists who have returned some 1,500 comment cards since March 1993 rate the program as "excellent."

San Francisco/Oakland, California

The Bay Area Freeway Service Patrol (FSP) program has been in operation in the Oakland/San Francisco area since August 1992. Caltrans, the California Highway Patrol (CHP), and the Metropolitan Transportation Commission Service Authority for Freeways and Expressways (MTC SAFE) jointly manage the FSP program. This program relies vehicles and operators supplied by local private towing firms. All three agency sponsors are involved in program management and evaluation. The CHP handles supervision, scheduling, dispatching and driver training. MTC SAFE handles contracting with the private tow companies that provide the drivers and patrol vehicles.

In its early days, the FSP covered five routes, for a total of 30 centerline freeway miles. Today, the coverage area has been expanded to 20 routes and 218 centerline freeway miles. Normal hours of operation are 6:00 am to 10:00 am and 3:00 pm to 7:00 pm, on weekdays. The program consists of 50 light duty tow trucks, one pickup truck, 135 drivers, and a CHP dispatcher. Three of the tow trucks are being evaluated for their performance using CNG fuel. New patrol drivers must complete a three-day CHP training class and are required to attend quarterly safety meetings.

Patrol drivers spend up to 10 minutes trying to repair disabled vehicles. If the vehicle cannot be repaired within this limit, the driver will offer to tow the vehicle to the nearest drop site. Abandoned vehicles are tagged by the FSP and must be removed from the freeway within 48 hours. Motorists can notify police of an incident from call boxes located along some of the patrol routes. The CHP receives around 1,800 calls per month from the call box system.

The Bay Area FSP program assisted with 97,230 incidents in 1996. Patrol drivers detected approximately 92 percent of these incidents, while the other 8 percent was dispatched by CHP on the basis of 911 calls, call box reports, and police calls.

The FSP's annual budget is estimated at $6 million. Approximately 60 percent of program funding comes from state funds, 30 percent from local funds, and 10 percent from federal funds. A 1991 evaluation of the program resulted in a benefit/cost ratio of 3.5:1. The benefit-cost calculation encompassed savings in time, fuel, and vehicle emissions.

Northern Virginia/Washington, DC

The Safety Service Patrol began operation in the Arlington/Alexandria/Washington, D.C. area in 1978. The patrol initially operated two shifts between 4:00 am and 8:00 pm Monday through Friday. Hours of operation were expanded to the 24 hours a day, seven days a week in 1993. Four shifts provide continuous coverage. Housed in the Virginia Department of Transportation Traffic Operations Center, the Safety Service Patrol is staffed by an operations manager, a supply supervisor, a training supervisor, three support personnel, and four teams, each of which includes a patrol supervisor, a patrol leader, and 12 drivers. In addition to a 10-day training program, new drivers must pass a one-day test on equipment use and skills.

The patrol covers 10 routes and 87 centerline miles. Equipped with 50 three quarter-ton utility vehicles, the patrol logs an estimated 170,000 miles per month. Also part of the incident management program are tow trucks stationed at the American Legion and Woodrow Wilson bridges; a one-ton crew cab pick-up with hydraulic tools; and two crash cushion trucks (each equipped with VMS, portable signs, 1,000 cones, and 30 cases of flares). The program includes 14 trailer-mounted VMS units. It also includes an airborne video unit that is mounted on a helicopter that can link to a monitor in a van dispatched to major incident sites to relay overhead images. Up to ten vehicles at a time have been deployed.

The Safety Service Patrol assisted at 39,100 incidents in the one-year period between July 1995 and June 1996. Traffic control assists accounted for 37 percent of the assists; disabled vehicle repair (including fuel, tire changing, water, minor mechanical repairs, jump starts, etc.) for 28 percent; and cell phone calls to tow companies for 13 percent. The remaining assists were categorized as follows: 8 percent for directions, 7 percent for checking and logging abandoned vehicles, 4 percent for accident assistance, and 2 percent for debris removal.

The Safety Service Patrol annual budget is approximately $3 million, all of which is provided by state funding through the Virginia DOT.

2.3.3.2 Post-Incident Debriefings

Post-incident debriefings can be very effective for identifying areas for improvement, as well as confirming the value of practices that are working well. Effective debriefings serve as a forum in which conflicts and inefficiencies are identified and steps are taken to resolve or eliminate them. Debriefings can be also be helpful in developing and maintaining lines of communications and relationships among responders from different agencies and departments. The lessons learned and articulated in the course of debriefings can be used in coordinated fashion to enhance team activities.

Upper management from responding agencies should be aware that debriefings are part of an ongoing process of program improvement and coordination so that they can intervene when needed to help resolve conflicts or to ensure that sufficient resources are supplied. Agency on-scene supervisors, critical participants, and additional persons who are needed to review the incident should attend debriefings. If everyone involved in the incident attends, the meeting might be very large. Major incident debriefings may include police, fire, EMS, service patrol, towing and recovery providers, hazardous materials responders, and others, depending on the circumstances (e.g., the US Coast Guard, the National Transportation Safety Board, etc.).

Typical steps in the debriefing process include the following:

- The incident chronology is recreated (using visual aids such as videotapes or maps where helpful);
- Each agency offers input on aspects of the response that worked well and poorly;
- Each agency offers suggestions for improvement;
- Suggestions are discussed, with consensus established as to corrective action;
- The results of the debriefing are documented (e.g., who attended, observations, and action items).

To ensure that results of the debriefing are positive, it is important that the facilitator of the debriefing maintain a frank, but non-confrontational tone for the meeting, and that he or she conclude the meeting on a positive note. In terms of timing, it is desirable to hold major incident debriefings as soon as possible following the response. "Conducting the debriefing immediately after the incident ensures that all of the affected agencies are present at the debriefing, and efforts to schedule future meeting will not be necessary. If a debriefing meeting cannot be scheduled immediately following the incident, then the meeting should be scheduled no later than seven days after the incident" (12).

2.3.3.3 Documentation and Evaluation

Incident management programs must compete for limited funding with traditional, better understood projects such as bridge resurfacing and roadway widening. In order to become and remain competitive for funding, incident management programs must be able to quantify and articulate their value, relative to cost. Being able to provide a credible estimate of the benefits of a given incident management program requires systematic data collection. Ideally data critical for program evaluation purposes are collected as a routine element of operations.

It is also important that program planners recognize the importance of gathering or compiling baseline data prior to implementing their systems. Unless there is a basis for comparison, it will be impossible to assess a program's initial impact.

The following are among the most commonly used statistics in evaluating incident management programs:

- Number of service patrol assists
- Average elapsed time from incident occurrence to detection
- Average elapsed time from the point at which the IRT is called out until its arrival on-scene
- Average elapsed time to normal traffic flow restoration

The Washington State Department of Transportation's (WSDOT) incident response program developed a FoxPro relational database in 1993 to organize and store incident records. This database, which has evolved in several respects, is still in use. WSDOT IRT members collect a wide and comprehensive range of data for each incident to which they respond. Data are entered onto a portable computer in the field. Although each report contains a large amount of data, data entry is not onerous because the computer program simply prompts the user to fill in pop-up fields. Once the IRT member returns to his or her regular workplace, the report is downloaded to a centralized database from a diskette. One important piece of data is the state patrol case number, which facilitates data correlation for tracing and research purposes (13).

Data elements that are entered into the WSDOT incident response database are identified in Table 2-4.

Table 2-4: WSDOT incident response database elements

CATEGORY	INFORMATION
Location (City and County)	• Nearest city • County in which the incident occurred, by code
General Information	• Name of person preparing the report • Date of the report • Date of the incident • Time of the incident • Time the IRT received the call to respond to the incident • Time the first IRT member arrived at the scene • Date and time incident ended • Time last IRT member left the scene • Repair notes
WSDOT Personnel	• Number of WSDOT employees involved • Number of hours each was at the incident site
Location (WSDOT Region and Maintenance Area)	• WSDOT Region and Maintenance Area in which the incident occurred • Regional Maintenance Area number
Highway/Route Information	• State route number and nearest milepost number • Description of the intersection state route and milepost number not available • Travel direction of affected lanes • Lanes closed (i.e. Ramp, single lane, multiple lanes, all lanes in one direction, or all lanes in both directions) • Roadway surface • Reason for road closure (i.e., single-vehicle accidents, multiple-vehicle accidents, fatal accidents, hazardous and non-hazardous material spills)
Travel Conditions	• Weather conditions (i.e., rain, snow, fog, wind, calm and clear • Road conditions (i.e., dry, wet, ice-covered, snow-covered) • Light conditions (i.e., day, dawn, dusk, or night—night with street lights on, night with street lights off, or night with no street lights at all)
Agency Participation	• Agencies present at the incident site (WSDOT, Washington State Patrol, Department of Ecology, County Emergency Services, Fire Department, County Police, City Police, or other)
Equipment	• WSDOT equipment used • Incident Response Team equipment used • Non-WSDOT equipment used
Materials and Maintenance	• IRT vehicle materials used • Follow-up maintenance

Table 2-4: WSDOT incident response database elements (cont.)

Clean-up	• Delayed cleanup until off-peak time • Conditions at the incident scene (i.e., presence of hazardous materials, non-hazardous materials, fuel spillage, fire, flammable liquid, corrosive material, explosive material, radioactive material, or toxic materials) • Agency responsible for cleanup
Traffic Control	• Lane where the incident originated • Detour route, if applicable • Occurrence of incident in construction zone • When lanes opened
Investigation	• Method of Washington State Patrol investigation (i.e., tape, total station equipment) • WSP accident and case number (if applicable) • Lead investigating agency (WSP, county, city) • Number of vehicles involve in the incident • Number of injuries, • Number of fatalities
Number of Vehicles	• Number of vehicles by type (e.g., one bus, two passenger cars, and a taxi)
Causing Party's Vehicle Type	• Type of vehicle the causing party was driving
Driver and Vehicle Identification	• Driver's last name, first name and middle initial • Driver's license number • State or province in which the licenses was issues • Vehicle license number of the party at fault • Vehicle year, make, model, and vehicle identification number • State or province that issued the vehicle license of the party at fault • Insurance of the party at fault • Insurance company
Comments	• Description of cargo that was cleared from incident, how it was disposed of, or whether it was stored, etc. • Or other information/comments

An independent team of faculty and research engineers evaluated WSDOT's incident management program four years after the database was developed in 1997. The report that resulted is unusual, first, because so few incident response programs have been evaluated; and second, because the evaluation is so comprehensive, both in scope and in research methods. In fact, it serves as strong example of a rigorous, well-documented program evaluation.

The evaluation was based on three measures of effectiveness: (1) congestion mitigation, (2) benefit to cost ratio, and (3) positive public perception. In addition to the thousands of records contained in the incident response database, the evaluation elicited additional data via several instruments, including surveys of IRT members; surveys of other

WSDOT personnel and other incident responders; and surveys of the motoring public. The researchers used a hazard-based duration modeling approach to evaluate the factors that determine incident duration, and the whether incidents had grown shorter since program implementation.

The evaluation revealed substantial benefits associated with the program, including a 12 percent drop in the time required to clear an incident over a two-year period. Another positive finding was a benefit-to-cost ratio estimate in the range of 4:1 to 13:1. The evaluation also pointed out areas for improvement.

2.4 INCIDENT MANAGEMENT PROGRAM BENEFITS

The greatest benefits of an effective incident management program are achieved through the reduction of incident duration. Reducing the duration of an incident is fostered by:

- Reducing the time to detect incidents
- Initiating an expedient and appropriate response
- Clearing the incident as quickly as possible

Substantial reductions in response and clearance of incidents can be achieved through the implementation of policies and procedures that are understood and agreed upon by each player in the incident management process.

Benefits resulting from an effective incident management program can be characterized as both quantitative and qualitative. A description and examples of both types of benefits are provided below.

2.4.1 Quantitative Benefits

No consistent standard has been identified that can be uniformly applied to evaluate the quantifiable benefits of an effective incident management program. In part, this results from the relatively diverse structure and operations of incident management programs. Each program is developed to meet the unique identified needs of the given region. Incident management programs are also generally developed to fit within the existing institutional framework. In addition, baseline data against which to measure a new program's benefits (e.g., incident response times) are rarely available. In any case, quantifiable benefits generally associated with an effective incident management program include:

- Increased survival rates of crash victims
- Reduced delay
- Improved response time
- Improved air quality
- Reduced occurrence of secondary incidents
- Improved safety of responders, crash victims and other motorists

The following provides examples of quantifiable benefits that have been attributed the successful implementation and operation of incident management programs.

Gowanus Expressway/Prospect Expressway – Brooklyn, New York

The incident detection system that has been implemented as part of the Gowanus Expressway/Prospect Expressway rehabilitation project includes an automated detection system and 20 CCTVs. Other devices deployed to support incident management functions include highway advisory radio (HAR), variable message signs (VMS), and a construction information hotline. The benefits attributed to the deployment and operation of this system includes a 66 percent reduction in the time required to respond to all incidents. In addition, the time required to aid motorists with vehicles that have broken down has been reduced by 19 minutes (23).

Traffic and Incident Management System (TIMS) - Philadelphia, Pennsylvania

This system is helping traffic avoid highway incidents and emergencies on I-95 through the implementation and operation of alternate routes. The system has helped decrease freeway incidents by 40 percent, cut freeway closure time by up to 55 percent, and has reduced incident severity rate by 8 percent (24).

TransGuide – San Antonio, Texas

The incident management system functions that have been implemented as part of Texas DOT's involvement in the FHWA sponsored Model Deployment Initiative include the following:

- Digital communications network
- DMS
- Lane control signals
- Loop detectors
- CCTV

Among the benefits attributed to the implementation and operation of these systems are:

- 35 percent reduction in total accidents
- 30 percent reduction in secondary accidents
- 40 percent reduction in accidents during inclement weather
- 41 percent reduction in overall accident rate
- 20 percent reduction in incident response time (25)

CHART – Baltimore, Maryland/Washington, DC

This program is in the process of expanding to more automated surveillance with lane sensors and video cameras on the freeway system in the Baltimore/Washington metropolitan area. An evaluation of the initial operation of this system shows a benefit/cost ratio of 5.6:1. A majority of the benefits that are associated with this system result from a 5 percent (2 million vehicle-hours per year) decrease in delay associated with non-recurrent congestion (26).

Highway Helper, Minneapolis – St. Paul Minnesota

The Minnesota Highway Helper Program has been found to reduce the duration of stalled vehicles by 8 minutes. Stalled vehicles represent 84 percent of the calls to which Highway Helper service patrol vehicles respond. Annual benefits due to reduced delay are estimated at $1.4 million, while operating costs is only $600,000 a year (27).

2.4.2 Qualitative Benefits

Just as with quantifiable benefits, no consistent standard has been identified that can be uniformly applied to evaluate the qualitative benefits of an effective incident management program. Qualitative benefits generally associated with an effective incident management program include:

- Improved public perception of agency operations
- Reduced driver frustration
- Improved quality of life
- Improved coordination and cooperation of response agencies

Identifying and documenting examples of qualitative benefits is difficult in large part because, few if any studies on these benefits have been conducted. The qualitative benefits of an incident management program are generally derived through the operating agencies' interaction and communication with the traveling public.

Qualitative benefits are, however, important because they can provide a basis to justify additional funding for incident management programs. For example, the Illinois DOT receives between 800 and 900 thank-you letters a year from motorists who have been assisted by the Minuteman Service Patrols. These thank-yous constitute a powerful demonstration of public support for the program—in both their volume and content.

One qualitative benefit that is very hard to measure is increased efficiency of agency operations through the coordinated use of resources and personnel and the elimination of duplicated efforts.

3 Operational and Technical Approaches to Improving the Incident Management Process

3.1 PURPOSE

This section of the Incident Management Handbook describes effective practices in incident management. The discussion is categorized according to the stages in the incident management process described in Section 1.4:

- Detection
- Verification
- Motorist Information
- Response
- Site Management
- Traffic Management
- Clearance

Within each activity area, the purpose of the activity is briefly described followed by effective techniques to meet the objectives of the activity.

Previous documents have also provided descriptions of a wide range of options for managing incidents. A particularly comprehensive approach and listing of a wide variety of incident management options can be found in "Framework for Developing Incident Management Systems" (28). The intent of this section is not duplicate previous efforts, but to supplement them. The activities described in this section focus on field responders and effective techniques they can use to improve incident management. Some new material is presented, along with updated perspectives on activities described elsewhere.

3.1.1 Intelligent Transportation System (ITS)

As noted in Section 2, ITS technologies play a key role in incident management. Although ITS technologies are most heavily utilized in detection, verification, and motorist information, some can be applied to aid in response, site management, and traffic management. The following discussion describes ITS technologies at each stage of the incident management process.

3.2 DETECTION

The first phase of incident management is detection. Incident detection is the process that brings an incident to the attention of the agency or agencies responsible for maintaining traffic flow and safe operations on the facility. Incident victims are most vulnerable from the time of the incident until the first responder arrives. Traffic is also likely to be most disrupted during these initial moments of the incident. The more quickly an incident is detected, the more quickly the appropriate response can be dispatched. Quick response minimizes the exposure of those involved in the incident, speeds the implementation of traffic control, reduces the duration of the traffic flow, and minimizes overall incident impact.

It is important to detect incidents quickly and accurately. Improvements in incident detection algorithms aimed at both reducing the time it takes to detect an incident, and increasing the accuracy of detection also continue.

Most TOCs experience trade offs between improving detection time and reducing false claim rates. With the market penetration of cellular telephones, linkage of all services and TOCs, incident detection time and accuracy can be improved.

3.2.1 Techniques

Methods commonly used to detect and verify incidents include the following:

- Wireless telephone calls from motorists
- Closed circuit TV (CCTV) cameras viewed by operators
- Automatic vehicle identification (AVI) combined with detection software
- Electronic traffic measuring devices (e.g., video imaging, loop or radar detectors) and algorithms detecting traffic abnormalities
- Motorist aid telephones or call boxes
- Police patrols
- Aerial surveillance
- Department of transportation or public works crews via two-way radio
- Traffic reporting services
- Fleet vehicles (transit and trucking)
- Roaming service patrols

Figure 3-1: CCTV Camera

These techniques can be grouped into three categories:

- Citizen reports: mobile telephone calls from motorists, motorist aid call boxes,
- Electronic techniques: CCTV, AVI, electronic traffic measuring, and
- Reports from professionals: police patrols, aerial surveillance, department of transportation or public works crews, traffic reporting services, service patrols

<u>Citizen Reports</u>

Using citizen reports to detect incidents requires very little equipment cost outlay on the part of public agencies. In fact, costs are limited to the telephone and dispatching systems that the operators will use. If structured such that calls are answered at existing dispatch centers, such as E911 centers, the marginal cost of implementing these systems is very low. A potential issue is that many calls may be received for the same incident. As such, staffing must reflect the volume of incoming calls and the effort to route them correctly.

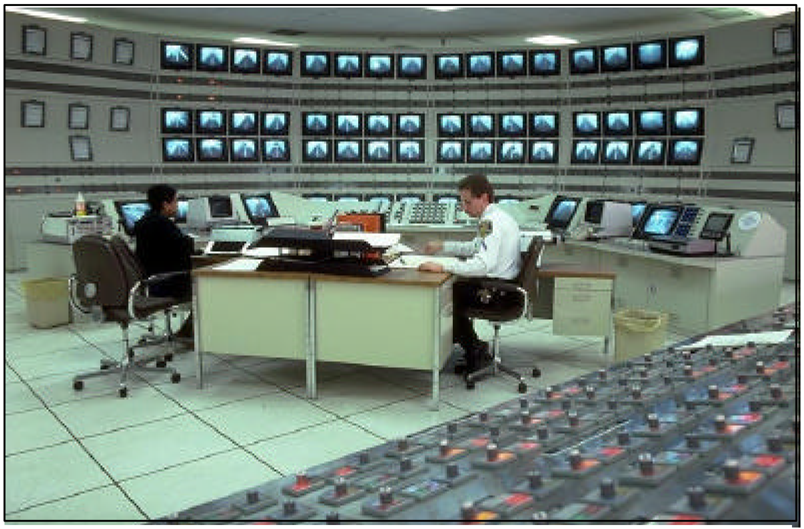

Figure 3-2: TOC operators observing monitor wall

In urban areas, the time required to detect an incident by citizen wireless calls would be very difficult to improve upon, especially during peak traffic hours. However, when traffic volumes are light or in more isolated areas, it may not be wise to rely on cellular calls. One mechanism that has been used successfully to provide an opportunity for citizens to call for help or to report an incident is the motorist aid call box. These systems are installed in the highway right-of-way and provide stranded motorists or passerby a mechanism to notify an incident response agency about a problem. Most modern call boxes use voice communications technology allowing the motorist to communicate directly with an operation or dispatch center. Other call boxes consist of a button to send a signal indicating the need for assistance. Most areas that have installed call boxes place CCTV near the call boxes to verify that a call has been placed and to assess the type of situation prompting the call.

With the reduction in cost of wireless communication, the call box has given way to the motorist aid telephone. These systems are usually solar powered cellular telephones located on a pole near the shoulder of the roadway. Stranded motorists or passersby's simply lift the receiver and a call is automatically placed to an operations or dispatch center. An operator answers the call, and the rest of the process is much like that for motorists calling on their own mobile phone.

Because of the prevalence of personal mobile phones, investment in motorist aid telephones or call boxes should be directed to areas where stranded motorists are most vulnerable (e.g., long bridges, tunnels, and areas with very limited shoulders) and in isolated areas where motorists are often stranded.

Electronic Techniques

A fairly detailed description of electronic techniques for detecting incidents is included in Section 2. These techniques consist of closed circuit television cameras or systems that detect vehicle movement or traffic flow. The systems themselves do not inherently detect incidents. They require either a human operator to view their output or software that detects the difference between normal traffic conditions and incident conditions.

As noted previously, traffic operations centers are rarely the first to detect an incident. To provide full coverage of an area's critical roadways, most CCTV systems have many cameras, often several hundred. It is very difficult for a few operators to monitor all cameras at all times. Closed circuit television systems viewed by an operator are generally more successful at verifying an incident and then monitoring its status than at detection. Although CCTV systems are crucial to overall traffic and incident management, they should not normally be used as the primary detection method. However, in some cases, where it is crucial to detect an incident in a relatively confined area very quickly under the entire range of traffic flow conditions, CCTV can be the best solution. One example of such a situation is in a tunnel. Incidents in tunnels can be extremely hazardous. Operators monitoring the short distance of a tunnel with sufficient coverage of CCTV cameras usually outperform any other detection mechanism.

Electronic traffic detection systems (e.g., inductance loop or radar detectors, video imaging, or automatic vehicle identification or location systems) can be used in two ways to detect incidents. Operators can view the output of these systems and determine when unusual circumstances occur that might be caused by incidents. Usually detection information takes the form of output on a graphics map that indicates congestion or traffic speeds by changing the color of the roadway segments. When speed drops or congestion increases suddenly or in areas that don't normally experience those conditions, the operator may suspect that an incident has occurred. To be effective, these systems must be combined with a quick and reliable verification mechanism, usually CCTV. The operator, upon suspecting that incident has occurred, views the CCTV image from the location closest to the suspected incident for verification.

The second way to use traffic detection systems to spot incidents is through computer software that compares traffic detection output to normal traffic conditions. If specified abnormalities occur, or if large variations from normal occur, then the software produces an alarm that identifies the location of the suspected incident. The process the software uses to make this comparison is known as an incident detection algorithm. There are many incident detection algorithms that have been developed using a variety of statistical or analytical methods. They have varying detection rates and false alarm rates under different traffic conditions. Once the algorithm identifies a potential incident, the operator verifies that one has occurred by using CCTV, as discussed above.

Incident detection algorithms generally require relatively high traffic flows in order to detect an incident. Even under favorable traffic flow conditions, many algorithms suffer from high false alarm rates or are much too slow to be the initial means of detecting an incident. Although efforts are underway to improve these algorithms, and while there is potential for them to become very important in incident detection, currently they are usually outperformed by other incident detection techniques, particularly motorist reports using mobile phones.

There are some situations in which incident detection algorithms perform well, particularly unique conditions where a limited area needs to be monitored and much where closer spacing of detection devices can be installed cost-effectively. Electronic detection systems may be of critical importance in areas with no mechanism for motorists to report incidents. However, in general, they should be installed to monitor overall traffic conditions, to provide input to traffic control systems (such as ramp meters and traffic signals), to produce performance and planning data, and provide traveler information, rather than specifically to detect incidents. Once in place, these systems can be effective as secondary or backup incident detection mechanisms.

Reports from Professionals

A variety of public agency personnel routinely travel the roadways. These people can provide an effective mechanism to detect incidents. Police patrols, aerial surveillance, department of transportation or public works crews, traffic reporting services, fleet vehicles such as transit and motor carriers, and service patrols can serve as incident reporting sources. It is important that these personnel know who to contact and what information to provide as well as having a communication mechanism to make the report. Once the call comes in to an operations or dispatch center, it could be handled with higher priority than other motorist calls. The major benefit is that the agency staff caller can usually verify the incident and may be able to be the first responder.

3.3 VERIFICATION

Incident verification encompasses confirming that an incident has occurred, determining the exact location and direction of travel, and obtaining and assessing as many details about the incident as possible.

3.3.1 Techniques

Incident verification is usually completed by operations center personnel who communicate with incident responders on scene and view incidents on monitors. However, the verification process may be very lengthy for hazardous material incidents. Methods that may be used to verify incidents include:

- Closed circuit TV cameras viewed by operators
- Dispatch field units (e.g., police or service patrols) to the incident site
- Communication with aircraft operated by the police, the media, or an information service provider
- Combining information from multiple cellular phone calls

Regardless of how the incident is verified, the goal is to quickly confirm the incident location and to gather as much information as possible to determine what resources to send to the scene. Once verified, information about the incident is communicated to the agencies and personnel responsible for response as quickly as possible. The more information provided early and accurately, the more quickly the appropriate resources can be dispatched. Efficient communication among agencies is an important element of the verification process.

Closed Circuit TV cameras

CCTV systems allow operators to remotely view an incident scene and visually verify the incident. As mentioned in the discussion on detection, CCTV systems are more effective at verifying incidents, monitoring response and clearance activities, and monitoring overall traffic conditions than at detecting incidents. CCTV, if available, can provide vital information to start response quickly. However, agencies should not rely on CCTV systems to fully determine the needed response. CCTV can verify that an incident exists, but field responders will be needed to fully assess the incident and determine the full complement of response units needed.

Where CCTV is available, operators can quickly locate the camera closest to the reported incident and, if they have a clear field of view, perform an initial assessment of the incident severity and initial resources needed to respond to the incident. CCTV images can be shared electronically with other agencies and other traffic operations and communication centers. Sharing camera images allow personnel from a variety of agencies with specific expertise to aid in verifying and assessing incidents quickly without the need for them to travel to the scene.

CCTV systems should be designed so that they are close enough together to provide continuous coverage. They must also be located such that they provide views around curves in the roadway. Cameras should be high enough to see over structures.

<u>Dispatch field units (e.g., police or service patrols) to the incident site</u>

The first responder on the scene verifies that an incident has occurred, confirms the location, and begins assessing the incident to determine what resources are needed to respond and clear. On scene personnel provide the most reliable incident verification and the most complete information on the incident.

<u>Communication with aircraft operated by the police, the media, or an information service provider</u>

Aircraft patrol some metropolitan areas during peak commute periods, usually to provide traffic reports to the public or to support enforcement efforts. Aerial surveillance can be a very valuable tool in detecting and verifying incidents. Aircraft can verify the location of the incident and provide the initial assessment of the situation. If aircraft patrols are not being operated in an area, it is not likely that instituting them exclusively for incident management would be cost effective. However, they can provide a valuable incident detection and verification service where they are already being used.

<u>Combining information from multiple mobile phone calls</u>

As mentioned earlier in this section, motorist calls using mobile phones have become the primary means of incident detection in most urban areas. In many cases, a large number of mobile phone calls are received for a single incident. Usually it is difficult to get all of the physical details from a single passing motorist to fully verify an incident. Call takers can be trained to obtain more information about an incident from subsequent callers. This technique encourages callers to continue making voluntary calls to report incidents. In such situations, mobile phone calls have functioned as the verification mechanism.

3.4 MOTORIST INFORMATION

Dissemination of motorist information is one of the primary services provided by many TOCs on a regular basis. Public-private partner ships have allowed media outlets to use DOT generated real-time video feeds, traffic flows, incident information, construction information, and special event traffic data. Live video feeds are routinely used for television traffic reports.

3.4.1 Techniques

Methods commonly used to disseminate motorist information include the following:

- Commercial radio broadcasts
- Highway advisory radio (HAR)
- Variable message signs (VMS)
- Telephone information systems
- In-vehicle or personal data assistant information or route guidance systems
- Commercial and public television traffic reports
- Internet/on-line services
- A variety of dissemination mechanisms provided by information service providers (ISP) to inform motorists about the occurrence of incidents and prevailing traffic conditions

Motorist information should be disseminated after an incident is cleared and until traffic flow returns to normal conditions. In some cases, if an incident occurs during a peak period, information may be disseminated for several hours.

<u>Commercial radio broadcasts</u>

Traffic reports on commercial radio have been a traditional means by which motorists receive traffic information, including incident-related warnings. This is probably the most heavily used mechanism for traffic information. Commercial radio stations receive the traffic information they use in their reports from a variety of sources. They may have traffic spotters on the ground or traffic reporters in aircraft. They may receive their information from public transportation agencies, either by calling them directly or by using systems that these agencies establish to provide this service, such as congestion maps, video snapshots, or incident reports on the Internet or live CCTV video images. They may monitor public agency (especially police) radio frequencies. They may use a combination of these sources. Many radio stations subscribe to a traffic reporting service that obtains its information through any combination of these mechanisms.

A cooperative effort between public agencies and radio stations can provide benefits to both. In cooperating, the public agencies can communicate important incident-related information to motorists, who will be more prepared and perhaps able to avoid the incident scene. In turn, the radio stations obtain accurate information for their listeners. To be most effective, public information should be consolidated and provided to the media from a single source, which saves the media time, and thereby gets information out to the motoring public more quickly.

Radio traffic reports do have some limitations. The amount of time available for traffic reports is limited. As such, it is not always possible to provide all pertinent details on all of the incidents occurring at a given time. Insofar as traffic reports are scheduled at specific intervals, incidents that occur shortly after one report are not normally reported until the next scheduled broadcast. In addition, motorists may not hear about an incident until after they have passed a decision point. Finally, coverage throughout the day is uneven. In some areas, there may not be any traffic reports during off-peak periods. As a result motorists may remain unaware of major incidents.

Highway advisory radio (HAR)

HAR is described in Section 2. HAR can be permanently installed at fixed locations or can be mounted on a trailer or truck and moved among various locations. HAR's primary advantage is that it allows continuous incident communications. HAR is controlled remotely, from a location such as a TOC.

Figure 3-3: HAR station with warning lights

Among disadvantages of HARs is that motorists must tune their radios to a separate frequency to access the information. If the message is not kept current and accurate, reflecting actual conditions the HAR system's credibility is diminished. Finally, the length of the recording may not allow as much information to be delivered as desired. However, if the message is too long, motorists may not be able to hear the entire message before they are out of the transmitter's range. Experience indicates that HAR requires a fairly high level of maintenance effort to keep it well-tuned and operating smoothly.

Variable Message Signs (VMS)

VMS technologies are described in Section 2. Incident management agencies, usually departments of transportation, use these signs to display critical information about downstream incidents and to recommend alternate routes. VMS can be installed permanently at fixed locations or mounted on a truck or trailer for mobile flexibility. Agencies can program the VMS message remotely, and some systems will generate messages automatically for a set of pre-determined conditions. An advantage of VMS is that they provide information to all motorists traveling toward an incident.

A disadvantage of VMS is that the effective message length is limited. Generally, a motorist needs to read the message twice to fully comprehend it. Freeway speeds and physical sign dimensions limit the amount of text a motorist can read while in view of the sign. At times, it may be difficult to convey the necessary message in clear and concise wording.

<u>Telephone information systems</u>

Telephone information systems provide travelers with a phone number they can call to obtain the latest traffic information. These systems can provide information with a live operator, frequently updated recorded information, or automated traffic condition information using electronic detector information and digitized, synthesized, or concatenated voice. Telephone information systems, sometimes referred to as highway advisory telephone (HAT), can be a standard telephone number or a shortened number (for ease of memorization). Some areas offer free mobile calls. In fact, the USDOT petitioned the Federal Communication Commission in 1999 to reserve a three-digit number (511) throughout the country for traveler information. On July 21, 2000, the FCC assigned 511 as the nationwide telephone number for traveler information. Just as people needing emergency aid can call 911 from virtually any phone in the United States, 511 will provide people needing traveler information a number they can call from any phone.

Regardless of the type of technology used in the telephone system, incident information must be updated frequently. Systems with recorded information should be updated at least every five to ten minutes during peak periods in urban areas. Automated systems normally cannot accurately detect incidents or provide details about the incident, unless they use text-to-speech systems that can "read" incident information from a computer file. As with any motorist information system, telephone information systems rely on timely, accurate information that reflects current incident conditions.

Telephone information systems use readily available equipment (the telephone) that most people have access to. These systems provide information upon demand, especially through the use of mobile phones. However, telephone numbers need to be well publicized in order for travelers to remember the number and think about calling it when they want or need information. Recorded or automated systems either require the caller to listen through information throughout the calling area or require callers to choose items from an interactive menu to get information more tailored to their interests. In either case, the caller has to pay particular attention to hear the information of interest or select the correct option.

In-vehicle or personal data assistant information or route guidance systems

Many travelers want access to a motorist information system that they can use any time, anywhere, including in their car. They want to be able to actively seek traveler information pertinent to their trip, and they'd like to have a system that alerts them to conditions that might affect their travel. In-vehicle or personal data assistant traveler information systems provide mobile access to information. These systems deliver information to travelers through a variety of wireless communication technologies, including mobile telephone frequencies, FM or AM sideband frequencies, or paging frequencies. This information may be delivered through a digital pager, a personal data assistant, a palmtop computer, or a computer in their car.

Figure 3-4: In-vehicle navigational device

Private sector companies provide these systems to customers, who generally subscribe to the service for a fee. As in other private sector initiatives, the companies offering these services can gather their own information, use information provided by public agencies, or combine the two. It is beneficial for incident management agencies to cooperate with private sector information providers so that more people can access timely, accurate incident information. Ultimately, this reduces the burden of information delivery for public agencies.

The market for in-vehicle and personal information devices has not yet fully developed. It is unclear how many people will subscribe to traveler information services. However, these systems do provide the promise of getting very specific incident information to the travelers that need it the most at times when they have the most flexibility to avoid the incident scene.

Commercial and public television traffic reports

Commercial television stations in most urban areas are incorporating traffic reports into their morning news programs. Many of the television stations that air traffic reports subscribe to a commercial traffic reporting service. They must collect their information from the same sources used by commercial radio broadcasters. Some have access to, and display, live video images from CCTV systems in their areas. These reports can be beneficial to travelers planning their morning trips, especially when major disruptions, such as incidents occur. A challenge with this is that airtime is very limited for these reports, so very little detail can be provided, and there may not be time to cover all of the traffic problems in an urban area in one report. However, these reports are provided through an easily accessible medium (television) that many people use before going to work in the morning. It does offer, although, a valuable planning tool and cue for some to search for more detailed information through other systems.

More detailed traffic information can be provided on television stations dedicated to traffic information or on some channels with limited programming. These options are generally only available on cable television. Some community access channels or public school channels provide airtime for traffic information in the mornings, during both peak commuting times, or throughout the day. Some traffic operations centers are set up to allow television broadcasting out of their facility. Under the Smart Trek MDI, the University of Washington developed a traffic reporting application that automatically sequences through a series of live CCTV images and displays the Seattle area congestion map, which uses data from loop detectors to display levels of congestion on the freeway system (30). The application was designed for a 60-second time slot, but can also be cycled through continuously.

Dedicated traffic channels provide the benefit of being available whenever a traveler wants information. In general, they do not have the same time limitations, so more detailed information can be provided. As with commercial television traffic reports, they are most useful for pre-trip planning. Dedicated traffic channels generally have a more limited audience because they are generally found only on cable television. If provided on a community access station, the channel may not cover the entire urban area. As television traffic reporting develops, coverage of major incidents may increase. Agencies involved in incident management activities should consider a cooperative or collaborative effort with area broadcasters to develop this resource to disseminate incident-related information.

Internet/on-line services

The development of the Internet and the World Wide Web has presented opportunities to deliver incident information to the traveling public in a variety of formats. CCTV snapshots, freeway system congestion maps, and construction, special event, and incident information are often provided on websites. Incident locations can be displayed on the congestion map by placing icons where incidents are active. Text explaining the incident situation, estimates of how long traffic will be affected, and whether alternate routes are recommended can be displayed also. Some systems scroll or display this information on the congestion map page, and some have separate pages with incident information. This incident information may be entered by hand specifically for the Internet application. Some systems rely on incident information streams intended for other purposes. With the advent of CAD systems for response personnel, some systems use the data generated by incident response dispatch systems, automatically filter the information for incidents only, allow for operators to add to and refine the incident report, and display this information on the website.

Websites can be used directly by the public or by traffic reporting services as one of their sources of information. Websites have become very popular sources of traffic information. For the month of April, 1999, the Washington State Department of Transportation's website of Seattle area traffic information received 52,673,858 "hits" in 5,774,022 page views, and 348,178 user sessions (31). Websites can provide information in many different formats to provide information best suited to a variety of users. Websites may be developed by public or private sector organizations. With wireless communication, handheld, palmtop, and in-vehicle computers can also access websites, making websites useful for both pre-trip and en-route information.

Even with the increase in access to the World Wide Web, there are still people who do not have access to websites. People have to actively seek out the traveler and incident information on the websites. Except for the emerging web access from mobile computers, the information can only be used for pre-trip planning. Overall, even with tremendous promise of web based information, there needs to be other information delivery mechanisms to provide incident information to motorists and people without web access.

<u>Information Service Providers (ISP)</u>

Many of the specific information delivery systems and mechanisms discussed above are provided in partnership with private-sector information service providers (ISPs). ISPs provide a valuable service to public sector incident management agencies by delivering important incident information to their customers. There have been very effective partnerships established between agencies and ISPs. Public agencies provide data and information about incidents and the ISPs supplement the data, if need be, and deliver the information to end-users. This cooperative effort provides a cost-effective mechanism for agencies to get critical incident information to the traveling public. Agencies should consider how best to package and deliver their information to ISPs, recognizing that the easier it is for ISPs to use the information, the more likely it is for the information to get to the end-user.

3.5 RESPONSE

Incident response entails deployment of the appropriate personnel, equipment, communication links, and motorist information media as soon as it is reasonably certain that an incident has occurred. Appropriate response requires understanding the incident's nature, scope, as well as understanding the steps and resources necessary to clear it and restore normal roadway conditions.

3.5.1 Techniques

Several techniques have been adopted throughout the country to improve incident response. Following is a description of some of them, along with tips for their implementation.

<u>Intra- and Inter-agency Communications</u>

Effective incident response requires that agencies be able to communicate reliably with their own personnel. Communication links that must be established include:

- Operations center -to- operations center
- Operations center-to- response vehicle
- Response vehicle-to-response vehicle

Effective communications must also be established between personnel from different agencies. In many cases communications between responding agencies that work together on a regular basis can be improved by purchasing of compatible radio systems. Equally important is a mutually agreed upon standard language, or "lingo."

Personnel and Logistics Support for Response

Some incident management programs have assembled personnel lists and contact numbers, as well as cataloging available agency resources. They vary from basic contact lists identifying who responds to incidents within a geographic area, to detailed and comprehensive manuals or guides. These resources can speed response and reduce incident duration by providing responders and dispatch personnel with a consolidated, readily available data source.

The initial list should include geographic agency responsibility; radio frequencies; talk groups; primary and back-up phone numbers; and FAX numbers. It should identify key personnel and pager numbers for 24-hour contact. Organization charts are also helpful. Personnel and agency contact lists can be expanded into Incident Management Team Resource Guides by cataloging equipment, material, and the availability of personnel with special skills. An example could be a bucket truck or bridge 'snooper' to hoist a structural engineer to inspect a bridge struck by a truck. A listing or map of fire hydrant locations on the freeway system is another example of resource documentation that would be beneficial to a responder: in this case a fire fighter.

The next step should be to identify a wide variety of potential incidents or freeway emergencies that may require the services of specialty contractors or government agencies. Once prepared, the guide should be distributed to all the response agencies and their dispatch centers. A regular update schedule should be established.

Examples of special services or equipment that may help resolve major freeway incidents or transportation emergencies include the following:

- Highway construction, maintenance, and environmental contractors
- Traffic control contractors, barrier wall suppliers
- Trucking services, dumps, flatbeds, and roll-off dumpsters
- Heavy equipment rental, end loaders, cranes, street sweepers
- Truck tire and heavy equipment repair services
- Temporary manpower
- Livestock handling, transportation, and rendering services
- Large-animal veterinarians
- Sand, soda, lime, and absorbents
- Grain loading equipment

This list includes only some of the services to consider. Several multi-agency sessions should be used to identify others of interest in any particular area.

Equipment Storage Sites

Equipment and materials can be stored near areas that have high incident rates. Keeping equipment and materials nearby reduces response times. Equipment stored at these sites may include trailers containing traffic control equipment (signs, cones, flags, etc.) specifically reserved for incident management. Thought must be given to determine what resources would be most feasible to be kept at these sites. Field responders should be consulted as to which materials and equipment they most often need, and whether it is currently available.

Agreements must be established between responders regarding material and equipment use. Local conditions and common incident types usually determine initial material and equipment supply types and levels. Restocking needs must be considered, with responsibility for this duty assigned. Material and equipment lists can be refined in the course of restocking and inventorying. One challenge is the lack of sufficient storage space in urban areas. Storage sites must be secure to ensure that resources are available when needed.

<u>Interagency Agreements</u>

Interagency agreements provide a mechanism via which incident response agencies and service providers can establish goals, objectives and procedures. Interagency agreements vary greatly depending individual area's needs and priorities. They are often used to specify responsibilities and procedures across jurisdiction and disciplines.

It is critical that the directors of each signatory agency fully support the agreements. In addition, it is important to recognize that interagency agreements are not effective unless all agency staff understand them. Even infrequent agency responders should be included in interagency agreements. For example, in some areas, city police respond to freeway incidents. As such, they should be included in certain interagency agreements regarding incident response. Response protocols among agencies should also be included in some interagency agreements. For example, some service patrol programs, but not others, are allowed to clear disabled vehicles until a police officer arrives.

Mutual aid agreements are also important to facilitate resource-sharing resources and to save time. For example, equipment in a construction zone should be available to help clear roadways, and an agreement to establish this practice should be set up at the start of construction.

Media partnerships and agreements can also be very helpful. Some incident management programs have forged working relationships with radio reporters and media pilots. Communication with traffic reporting pilots can be extremely helpful in managing traffic queues. The closer the partnership between agencies and the media, generally, the better the relationship and the stronger the program.

Appendix B provides a sample memorandum of understanding signed by members of the New England Region of the I-95 Corridor Coalition. Also contained in Appendix B is an interlocal agreement for regional transportation management developed established in the Houston metropolitan area.

<u>Advanced Response Vehicles</u>

Advanced Law Enforcement Response Technology (ALERT) vehicles are being tested in Texas and Virginia. ALERT vehicles contain a variety of systems that can be used to improve incident management. ALERT vehicles provide a mobile communications platform that provides voice, video, and data communications among response vehicles and between vehicles and operations centers.

As noted in Section 2, emergency response vehicles can be equipped with Automatic Vehicle Location (AVL) systems in order to improve and speed incident response. These systems typically use global positioning systems (GPS) to transmit precise vehicle location information to dispatch centers in real time.

3.6 SITE MANAGEMENT

Site management is defined as the process of
- Accurately assessing incidents,
- Properly establishing priorities,
- Notifying and coordinating with the appropriate agencies and organizations, and
- Maintaining clear communications with each responder.

Figure 3-5: Incident site involving multiple responders

Ensuring the safety of response personnel, incident victims, and other motorists is the foremost objective of site management. To be effective, responders and commanders at the incident site need accurate information about the incident's current status, overall progress toward clearance, and the equipment needed to complete the process. Effective site management requires continual assessment of the site and the needs of the responders.

Effective site management also requires understanding and respect for the priorities of other responders while working together cooperatively and productively. Regular planning, training, and communications with other responders produce the best results. Those managing the incident site must also have enough authority to determine courses of action, commit agency or other resources, and otherwise do their jobs without having to wait for guidance or approval from superiors who are not on site.

3.6.1 Objectives

The objectives of incident site management include the following:
- Increasing safety for crash victims, motorists, and responders
- Coordinating the activities of the responders
- Decreasing the impacts of incidents on the transportation system

- Improving interagency communications and cooperation, and
- Maximizing use of personnel and equipment

It is difficult to measure the benefits of site management. It is generally accepted that incident sites that are managed by experienced personnel that work together professionally can significantly reduce the length of incidents. Agencies that have a plan of action for managing incident sites that they have coordinated with the other agencies will be much more successful in keeping confusion and delays to a minimum.

3.6.2 Techniques

Equipment Requirements

Site management equipment consists of those items that help incident commanders manage people and resources. The most important site management equipment is used to provide communications among all incident responders.

Different agencies do not typically have means of direct communications. Many times they rely on traffic operations centers or communications centers to relay information. In addition to their radios, they may use cellular telephones, scanners, pagers, or CB radios to gather or disseminate information. Improvements that allow for direct communication among responders include installation of one agency's radios into other agencies' response vehicles; use of common radio frequencies for incidents and emergencies; alternative communications devices; and trunked 800 Mhz radio systems.

Resource lists containing the following types of information can also enhance site management related communications:
- Response agencies by area
- Telephone, fax and pager numbers
- Alternate contacts
- Available equipment and its location
- Available supplies or materials
- Anticipated response times
- Location of fire hydrants
- Equipment storage sites
- Interagency agreements

Other equipment may also be helpful in the site management includes
- Vests or arm bands
- Flag or other object to identify the command post
- Laptop for recording chronological information on scene management
- Camera
- White boards
- Lighting
- Extra batteries for all portable electronic devices

Current wireless communication and computer technologies provide the capability to send and receive video and data from the incident scene. Video, ranging from full motion to snapshot or still images, of the incident scene can be transmitted from the incident site to a traffic operations or dispatch center. Likewise, video from CCTV surveillance cameras and real-time congestion or traffic data can also be transmitted from the traffic operations center to the scene. In the Seattle metropolitan area, for instance, the capability to transmit snapshot video images and real-time congestion information to the incident site has been deployed under the Smart Trek MDI project (30). This technology allows incident responders to better assess incident impacts so they can determine the best field response. The project also equipped incident response vehicles with video cameras. Snapshot images from these cameras can be uploaded to the traffic operations center and the Washington State Patrol dispatch center to provide operators with more information about the progress of clearing the incident so they can better coordinate their efforts and better inform the media and traveling public about the status of the incident.

Figure 3-6: Incident responders coordinating strategies

Technology is also being used to enhance the ability of emergency medical professionals to prepare for and treat incident victims. One such system, called LifeLink, was pioneered in San Antonio as part of the TransGuide MDI effort. The LifeLink System provides a mobile video, voice, and data link between ambulances in the field and a hospital emergency room or trauma center. The link uses wireless communication technology to transmit information from the ambulance to a nearby receiver that transfers the information to Texas DOT's fiber optic communication system in place in freeway rights-of-way. From this point, the information is transmitted to the hospital.

The LifeLink System utilizes this mobile communication network to conduct real-time videoconferencing between an ambulance and a physician at the hospital and to transmit vital signs from the medical data instruments in the ambulance to equipment in the hospital. The LifeLink System utilizes standard communication protocols. This system allows physicians to more effectively direct the care for the most seriously injured incident victims; as such, it is expected to increase the probability of surviving serious injuries incurred in an incident (32).

In a similar effort, the Washington State Department of Transportation is piloting a concept to upload images from a digital camera to a secure website. Emergency medical technicians will be supplied with digital cameras and a portable computer. One technician will take digital photos of the vehicles involved in the incident and upload the images using wireless communication. Physicians at the emergency room or trauma center will be able to access the secure website, view the photos, and begin to assess the likelihood and type of trauma that the victim may be experiencing. The physicians will be better prepared to treat victims when they arrive (30).

Another use of technology that will help in incident site management is the use of automatic vehicle identification (AVI) transponders, or "tags," on truck cargo that indicate the type of material being transported. When a material spills, if the cargo is equipped with an AVI tag that identifies the material, incident responders could use a portable reader to determine what the material is and whether it is defined as hazardous. This information will speed the request of the appropriate resources to clear the spill, which will in turn speed clearance overall.

Multi-Agency Considerations

Multi-agency response complicates scene management. Poor communications can delay and inhibit the flow of the most current information. Requests that have to be relayed through multiple communication centers are often too late. Site management can often be fragmented with priorities being set by more than one agency without being conveyed to other responders. Priorities vary from one agency to the other, and coordination is required at the earliest time possible.

The person managing the incident scene should look for the key personnel from other agencies and initiate the coordination necessary to formulate a plan. They should seek input and encourage involvement by the other responders in the decision-making process. Tasks should be identified, prioritized, and communicated to each agency on scene or needed at the scene. Communications issues should be a priority for interagency planning. Response agencies that already have a regular working relationship need to ensure that they have the capability to communicate directly.

Responders are effective when they maintain continuous communication with other agencies and their own personnel. Timing of procedures breaks down if close coordination and cooperation are not maintained.

Placing Response Vehicles at Incident Scenes

Vehicles arriving at an incident site may be used to protect the site and the responders, to deliver equipment to the scene, or for use to perform recovery and clearance. Vehicle placement can be critical to the smooth flow of traffic around the site. In general, vehicles should be placed to protect the scene and provide access to needed equipment while minimizing the number of lanes occupied by the vehicles. Since incidents are nearly always unique, a hard and fast set of rules regarding vehicle placement would be difficult to understand and apply.

However, there are several considerations that experienced and thoughtful responders use when arriving at the scene of an incident on a congested freeway or busy arterial. First, who has already arrived? If an emergency agency has already protected the scene and it will be safe to undertake whatever activity is necessary, the responder should make every attempt to minimize distraction or additional lane restrictions that might result from the placement of the arriving vehicle.

For police, the best use of the late-arriving officers may be to stay behind the backed up traffic to warn motorists of the backup. It may also be to direct traffic through the scene, direct tows or other responders into appropriate, functional locations, or assist with priority actions as needed. To minimize traffic disruption, paperwork can be completed out of sight of passing motorists after the site has been cleared.

Figure 3-7: Response vehicles staged at the incident scene

When response to a motor vehicle crash is required, fire departments often send two or more vehicles to the scene, which constitutes a complete “team” by their standards. This however can affect the ability of traffic to move around or through a crash scene. Some fire departments have developed a practice of placing their equipment where it can be functional, but not further inhibit traffic. An engine is sent to most reports of injury accidents. This is beneficial because it can provide maximum protection for the firefighters, and it usually carries equipment they need to treat injuries. When other responders protect the scene, and there isn’t an obvious fire threat, the engine can park on the shoulder, behind, or in front of the units at the scene without closing additional lanes. This same procedure should be used for all other fire vehicles.

Experienced responders leave room for the transport vehicle for injured victims ahead of or on the shoulder adjacent to the vehicle containing the injured. If it is ahead, they park it 60 feet ahead to allow a tow truck to begin hooking up while the final extrication of the injured is made. The transport unit can then leave the site without maneuvering around other response equipment.

When a fire hose is needed, fire departments should consider deploying the hose from an engine parked on the shoulder. This allows for quicker restoration of traffic when the damaged vehicles are removed because recovery of the hose will be accomplished out of the traveled lanes. Some fire departments that respond to incidents on a regular basis have the hose reel-mounted on the front bumper. They do not deploy the hose unless there is an imminent threat of or an actual fire.

The Phoenix, Arizona, Fire Department has a sound policy for dealing with freeway responses. The first fire unit entering the freeway is assigned the responsibility of determining the needs for additional fire equipment. The other fire units responding stop and stage on a surface street adjacent to a freeway on-ramp. They wait for definitive direction from the first unit at the site and, if they are not needed, they return to active status without entering the freeway. This practice keeps their equipment from becoming trapped in backed up traffic on the freeway and has the added benefit of minimizing the number of emergency vehicles at the incident scene.

Tow companies can also participate in making incident scenes more efficient and orderly. Tow and recovery service providers dispatched to the incident can make sure that they park in a location that doesn't cause further traffic delays. They can also reduce the "light show" by turning off overhead lights if they are in a position protected by other response vehicles. They should try to position their tow trucks so they can move into position for removal of wrecked vehicles without disrupting traffic. Ahead of the wreckage in the same lane is usually a good location to stage for removal.

Incident Command System (ICS)

Effective incident site management can be facilitated by an incident command system (ICS). Fire departments were the first to develop formal incident command procedures to clarify command relationships for large incidents. An incident command system is a formalized system that lends consistency to the way agencies and service providers function in an emergency and fosters efficiency by eliminating the need to develop response plans for each incident.

The system is based on the command and staff structures used by the military and defines the roles and duties of the different managers required for an incident based on its size, complexity and duration. The ICS provides a planned and organized approach to the management of incidents and emergencies. It is expandable and flexible but clearly designates one person as incident commander. ICS should be viewed as a set of guidelines in which each responder understands his or her roles and responsibilities. Components of an ICS include:

- Common terminology – Common language should be used by all responders.
- Modular organization - As the size and complexity of an incident or emergency change so will the amount of human and technical resources be required to effectively manage the incident. ICS structure should allow for this expansion and contraction as needed.
- Integrated communications - Effective communications are critical. Messages exchanged among responders must be received, understood, and acknowledged.
- Unified command structure - A structure should be in place to identify the individual in-charge managing the incident. As the complexity of an incident changes, the ICS must be able to expand to include involvement of multiple agencies and service providers.

- Consolidated action plans - Action plans should identify goals and objectives, other agency roles and resources, and procedures from the beginning of the incident until the end. Written action plans should be required when an incident requires response from more than one jurisdiction or when the duration of the incident exceeds that of the initial responder's shift.
- Manageable span of control - The number of resources, both technical and human, under the control of one person should be limited to that which enables the person to effectively manage those resources.
- Designation of incident facilities - Incident facilities, including command posts and staging areas, should be identified to facilitate expedient response, ensure the safety of responders, and improve interagency communication and cooperation.
- Comprehensive resource management - Those responsible for response to incidents and emergencies should be aware of existing resources, as well as their status and locations.

ICS can also be very informal. When agencies are accustomed to working together on short-term incidents, they do not wear Incident Command vests or identify a command post, but they still work together to resolve the incident. This usually occurs when the response is small from each agency. Responders often recognize one other and go about their business in a professional and cooperative manner. However, when incidents are larger or more complex than usual or a large number of agencies become involved, ICS is a must for proper site management and incident resolution.

<u>Unified Command Structure</u>

Not all incident responders have been trained in the incident command system. Sometimes command personnel from one agency, acting as incident commanders, don't always understand the priorities of other agencies. Differing priorities and missions increases the potential conflict and often decreases the effectiveness of response. The latest version of the Incident Command System (ICS), which calls for "Unified Command Structure" when multiple agencies respond, has helped solve some of these issues. Multi-agency response operations under this process are smooth and highly professional. Responders from a variety of agencies continue to work on improving this process.

The unified command structure provides a management structure to facilitate cooperative participation by representatives from varying agencies and/or jurisdictions. It encourages the incident commanders of the major agencies to work together in a unified command post. The functions of this unified command include the following:

- Provide overall response direction
- Coordinate effective communication
- Coordinate resource allocation
- Establish incident priorities
- Develop incident objectives
- Develop strategies to achieve objectives
- Assign objectives within the response structure
- Review and approve incident action plans
- Insure the integration of response organizations into the unified command structure
- Establish protocols

When unified command is effectively applied, benefits that it can provide include:

- Allowing all parties with functional or jurisdictional interests to work together,
- Maintaining a cooperative environment,
- Promoting common objectives,
- Avoiding duplication of operational tasks or activities,
- Enhancing efficiency of individual agencies,
- Promoting teamwork, and
- Reducing the likelihood of single-minded decisions.

Figure 3-8: Unified command has fostered coordination and cooperation for many agencies

A common question and source of confusion to a large number of personnel from all types of organizations is "Who is in charge"? The first official responder at the site of any incident is in charge until relieved by higher authority. That first responder is responsible for assessing the incident, making the site safe, providing emergency care for anyone injured, and summoning the proper response.

Under the unified command post approach, when other responders arrive, the incident commander is the commander of the agency that has the priority mission at the time. For a major freeway accident involving severe injuries, for example, Fire or Emergency Medical Services (EMS) will probably assume the role of incident commander until the injured are treated and removed. The police would logically direct the next task, the investigation. Depending on the circumstances, the command role could then be assumed by who ever is in charge of clean up. It might be towing or DOT. If there is an environmental cleanup, the command may revert to the federal Environmental Protection Agency (EPA), the US Coast Guard, the state EPA, or a private cleanup firm. If road repairs are required, it may revert to the DOT maintenance supervisor.

During this process, the other agency incident commanders participate in decision-making and support the incident commander. They provide direction to the personnel in their own agencies and maintain their participation in the unified command until they no longer have a role at the incident.

Occasionally, responders will defer to the opinions of others that may have more experience with a particular kind of incident. This may occur when an unusual incident takes place that few have encountered before. The key to success is always open and objective communication among the key responders from each agency and from them to their subordinates.

3.7 TRAFFIC MANAGEMENT

With all of the complexities of simply managing the response and clearance activities, it would be easy for responders to solely concentrate on efforts to complete these tasks or to conduct investigations. However, some consideration must be given to traffic, not just from the perspective of how traffic affects the incident, but also how the incident affects traffic.

With few exceptions, traffic control is not the primary concern of most responders. A common result is that motorists and travelers who are unfamiliar with an area are left to find their own way past the incident scene. Traffic is often unnecessarily delayed. With that delay come costs in terms of lost time, fuel waste, and pollution. This shortsighted approach to incident management can also generate secondary collisions, which result in injury, property damage, and additional risk to responders.

Actions by the responders when they reach the scene, both in regard to the incident itself and to traffic affected by the incident, has a tremendous bearing on the safe and successful resolution of the incident. Perhaps the single most important aspect of incident management is the recognition that traffic and its smooth and safe movement is critical.

Traffic management is the application of traffic control measures at the incident site and on facilities affected by the incident. The goals are to minimize traffic disruption while maintaining a safe workplace for responders. Traffic control measures can be categorized into those that are intended to improve traffic flow past the incident scene and those that are intended to improve traffic flow on alternate routes. Techniques to improve flow past the incident include the following:

- Establishing point traffic control at the scene,
- Managing the roadway space (opening and closing lanes, blocking only the portion of the incident scene that is needed for safety, staging and parking emergency vehicles and equipment to minimize impact on traffic flow), and
- Deploying appropriate personnel to assist in managing traffic (e.g., state police, local police, and service patrols).

Techniques to improve traffic flow on alternate routes include:

- Actively managing traffic control devices (including ramp meters, lane control signs, and traffic signals) in the areas where traffic flow is affected by the incident, and
- Designating, developing, and operating alternate routes.

Both categories are important, however, it is critical that safe traffic control at the incident scene be established as quickly as possible. The management and control of traffic at and around an incident scene plays a significant role in determining the overall impact of the event. The job of handling an incident is not a series of individual tasks to be completed, but a coordinated team effort designed to expedite clearing the scene, protecting those involved, and reducing the effect or impact on traffic. Incident management also must include a process to provide motorists with information and direction.

A hierarchy of traffic management activities can be developed. As with all aspects of incident management, effective traffic management starts with planning for the needed actions. After the planning and preparation are complete, the first field task is to establish a safe incident scene by establishing appropriate traffic control. This task must be completed for all incidents, although minor incidents may require little traffic control. For incidents with a greater impact on traffic flow, the next set of tasks is to implement traffic management measures away from the site to improve traffic flow on alternate routes as motorists pick their way around the incident. For major incidents that severely affect traffic flow, alternate routes may need to be established. Appropriate motorist information should be disseminated during all three of these field phases.

Figure 3-9: Traffic management at the incident site

3.7.1 Preparing for Effective Traffic Management

Effective traffic management once an incident occurs requires planning and preparation. Responders who may be responsible for establishing traffic control at incident scenes need to have material and equipment available, or to know where it can be found. Those responsible for modifying traffic control devices to improve traffic flow on routes affected by the incident must be familiar with the functionality of traffic control devices and how to operate them. If alternate or diversion routes will be used, they must be planned, and those who will implement the routes must know how.

3.7.1.1 Availability of Traffic Control Material

Traffic control materials that will be needed immediately include cones or flares to set up a safe lane closure taper. Most responders should carry flares. Some incident response vehicles can carry enough cones to set up a safe incident site. Portable, usually Velcro and fabric, lane closure and transition warning signs can also be carried by a traffic management responder. Arrow boards and portable variable message signs may be needed for longer-term closures. The people who will be expected to set up traffic control should know the location of these resources and agreements should be in place to use the signs and who should deliver the signs to the incident scene.

3.7.1.2 Knowing What Traffic Control Devices Are Available

One of the quickest and most cost-effective traffic control strategies entails use of existing devices. DMS and HAR, for instance, can be used to alert motorist of upcoming incidents and can direct them to change lanes in advance of the scene. Ramp meters can be used upstream of the incident to limit the flow of traffic through the incident. Metering rates downstream of the incident can be increased to encourage motorists to use ramps that will not funnel them through the scene. Traffic signal timing can be adjusted to discourage traffic from traveling toward the incident and to provide increased green time for alternate routes to get past the incident.

3.7.1.3 Alternate Route Planning

When a major incident occurs that severely limits roadway capacity, motorists will naturally find ways to divert around the incident. Some regions have chosen to formally establish alternate routes to direct traffic on the routes that are best suited to handle this increased traffic demand. If a region chooses to implement alternate routes, it is critical that all agencies affected by the implementation and operation of alternate routes are involved in every step of planning for them. What appears to be the most logical alternate route to an outside operating agency in fact may not be acceptable to local stakeholders. Diversion practices are also discussed in detail in the National Cooperative Highway Research Program Synthesis 279, “Roadway Incident Division Practices.”

<u>Initial Screening of Facilities</u>

Detailed maps may be an effective way to initially screen facilities. The initial screening of alternate routes should include evaluation of:

- Distance traveled prior to re-entry
- Classification of roadway (freeway, principle arterial, minor arterial, collector, neighborhood street)
- Surrounding environment (residential, commercial, industrial)
- Complexity of route (number of facilities, number of turns)
- Proximity of schools
- Proximity to other traffic generators (e.g., shopping malls)

It is critical that the agency responsible for operating the facilities be involved in the initial screening.

<u>Evaluation of Facilities</u>

Once the potential facilities have been preliminarily evaluated, a more detailed evaluation of the facilities should be completed. This evaluation will require that site visits be conducted and the routes be driven. In addition, it may be beneficial to videotape these routes so they may be further evaluated after returning from the field. Evaluation criteria should include:

- Grades
- Existing traffic volumes
- Existing traffic control devices
- Width
- Curvature
- Surface condition
- Signing
- Fuel availability
- Overhead clearances
- Structure and weight restrictions
- Heavy pedestrian flow
- Turning radii
- Number of intersections
- Potential for deployment of temporary control devices

<u>Signing Plans</u>

Signing plans should be developed to support the operation of alternate routes. The effectiveness of using signs to divert traffic to alternative routes can also be greatly enhanced by the use of traveler information sources. These plans may include the use of:

- Fixed dynamic message signs
- Alternate route markers
- Portable dynamic message signs
- Other portable signs and barriers

Signing plans must also be developed using the guidelines set forth in the Manual on Uniform traffic Control Devices (MUTCD).

3.7.2 Improve Traffic Flow Past the Incident

After an incident has occurred, it is critical to establish a safe work site as quickly as possible. As discussed in previous sections, responder vehicles are generally used to protect the scene initially. More formal traffic control should be initiated as soon as possible. Two primary concepts that should be the focus of traffic management personnel are establishing point traffic control at the scene and managing the roadway space.

3.7.2.1 Establish Point Traffic Control at the Scene

In order for traffic to move smoothly and safely past the incident, traffic control needs to be established at the scene. If lanes or roadways will be closed, traffic needs to be channelized to merge into lanes or shoulders that will remain open to traffic. Cones or flares can be used as channelization devices to establish the lane closure tapers. Arrow boards and portable variable message signs should be considered to provide advance warning of the closure. Portable fixed message signs that warn motorists of the lane closure transition should also be considered.

If the incident will result in a very long-term closure (several hours to days), more elaborate traffic control measures, similar to those needed for a construction or maintenance work zone, should be implemented. Shoulders and even the oncoming lanes can be channelized to provide a lane of travel around the scene. The Freeway Management Handbook presents example traffic control plans for lane closures, shoulder utilization, and utilization of an oncoming lane of traffic (contraflow) (9). Responders who will set up traffic control at the incident scene should be familiar with the requirements of the Manual on Uniform Traffic Control Devices (MUTCD). The traffic control area should be periodically driven, and the traffic control devices should be visually inspected to make sure that they remain in the proper position and that they are in good working order.

3.7.2.2 Manage the Roadway Space

The primary concepts in managing the roadway space are twofold: (1) to close only those lanes that are absolutely essential for protection of the incident responders and victims; and (2) to minimize the time that those lanes are closed. The number of lanes that must be closed may change with the stage of the incident management and clearance efforts. This means that traffic control may be established and then changed several times during a single incident.

The incident responder(s) responsible for traffic management will need to keep informed about the planned sequence of work to clear the incident. They should continually assess the impacts of the incident on traffic flows and monitor the extent of the queues. This information should be communicated to operations center staff who, in-turn, can pass the information on to the motorist information functions. Information can also be passed on from the center, as discussed in the previous section on site management, to those responsible. This information should be used to determine refinements to the active traffic control plan.

It is important to have sufficient personnel on the scene to adequately establish and maintain appropriate traffic control. Transportation agency (usually traffic or maintenance) personnel generally set up and patrol the work area. Police personnel may be needed to direct traffic. Service patrol operators can be used to support this function as well.

One of the most critical aspects of managing the roadway space is to seek out and use a variety of methods to reduce the duration of each phase of the incident. It is important to reduce the impact of the incident by reducing the number of lanes that are closed. The goal should be to reduce the closure from a full closure, to a directional closure, to a multiple-lane closure, to a single-lane closure, to a shoulder closure. Methods for reducing the duration of incidents or the number of lanes closed may include:

- Immediately move any vehicle which can move under its own power
- Equip responders with push-bumpers to facilitate expedient clearance
- Open individual lanes as soon as they are cleared. In some cases this opportunity occurs when one of the response vehicles leaves the scene.
- Clear incident scenes from left to right, gradually yet systematically shrinking the scene and moving toward the right shoulder and the nearest freeway exit.
- Encourage, when possible, the first responder from any agency to remove accident debris or a small portion of a spilled load to clear one or two lanes. Simply sweeping broken headlight glass can open a lane of travel.

- Pour oil dry or sandbags onto small spills to restart traffic flow in one lane.
- Require the first arriving wrecker to aggressively clear travel lanes first in a safe manner.
- Do not allow elaborate rigging, cargo off-loading, vehicle repairs, or the loading and securing of cars on roll back (flatbed) wreckers until all the travel lanes are cleared
- Make sure that appropriate type and number of tow units is requested very early in the incident.
- Consider including in towing and recovery agreements the requirement that all wreckers that respond freeway incidents have push bumpers installed. This includes heavy-duty units and flatbeds.

When a police investigation is needed at an incident site, the natural tendency is to immediately close the roadway. However, thought should be given to this decision. Traffic may be allowed to continue until adequate scene safety and traffic control resources have responded and are in place to do a coordinated closure that reduces the likelihood of secondary collisions. Traffic may also continue to flow through the scene until the investigative resources are on scene and ready to do their portion of the investigation. Well-organized responders groups who have a clear understanding of effective incident management keep closures to the minimum.

3.7.3 Improve Traffic Flow on Alternate Routes

It is unacceptable for traffic to be stopped because of an incident for a long period of time without the implementation of a coordinated, well-planned operational policy to route traffic around the incident. Long-term incidents, especially those requiring the closing of multiple lanes or full closures, have a significant negative impact on highway system capacity. These incidents can require a huge commitment of resources, just to provide minimal traffic control. Long closures, perceived as being poorly managed, have been the impetus to start or seek improvements in incident management programs in several areas. The public and media are very critical of, and concerned about, long closures especially if they believe the situation could have been managed better.

3.7.3.1 Actively Manage Traffic Control Devices

When an incident occurs that results in traffic diverting to other routes, whether a result of using a planned diversion route or because motorists seek a less congested route, measures should be taken to manage the increased traffic on alternate routes. Incident management personnel should consider modifying the operation of existing traffic control devices to better manage the traffic flow on alternate routes.

Variable message signs and highway advisory radio can be used to provide information on the incident or to direct traffic to the most appropriate alternate route. Ramp metering rates should be adjusted to account for changes in traffic flows. Traffic signal timing should be adjusted to account for changing traffic conditions. Personnel from the agencies responsible for operating these traffic control devices will need to implement the changes, unless there is an agreement in place that allows others to do so. In either case, all affected agencies should be kept informed of the traffic control strategies that are in place. It is critical that all agencies work toward a commonly understood goal since freeways and arterial streets are operated by different agencies. Close cooperation and collaboration in these situations is usually facilitated by early planning efforts and ongoing interaction.

3.7.3.2 Establish and Operate Alternate Routes

When the initial responders determine that the incident is having a major impact on traffic and cannot be resolved in less than 30 minutes, action should be taken to account for motorists diverting to other routes (motorist information, use of the shoulders, manual control at the critical diversion points). If the situation is more complex and a long duration or full closure seems unavoidable, formal traffic diversion should begin immediately. As off-scene rerouting and diversion plans are being put into place, aggressive scene clearance should continue to be the primary focus at the point of the closure.

A high priority in rerouting traffic must be given to the vehicles trapped between the diversion point, usually the last upstream exit, and the incident site. In some cases these motorists can be allowed to proceed past the scene by opening a shoulder or even a portion of one lane for a brief period then securing the scene and continuing the incident management activities.

<u>Operational Procedures</u>

The operational procedures of implementing alternate routes must be developed to meet the needs of individual regions. The typical chronology of establishing an alternate routes include the following steps:

- Determination that an alternate route should be implemented
- Identification of most applicable pre-planned alternate route
- Notification of non-incident agencies that will be affected by the alternate routes
- Modification of traffic signal timings on alternate routes
- Activation of traffic control devices and traveler information sources
- Monitoring the alternate routes
- Communication with non-incident agencies affected by alternate routes
- Termination of the use of the alternate routes

<u>Inter-Jurisdictional Communications</u>

Not only are inter-jurisdictional communications essential in developing alternate routes, communication must be established and maintained though out the duration their operation. Inter-jurisdictional communications may be used to exchange information related to alternate route operations may include:

- Fax
- Phone
- Pager
- Response vehicle-to-center communications
- Center-to-center real time communications

An example of information interchange is the I-95 Corridor Coalition, which has provided an innovative method for its member agencies to communicate. It is called the Information Exchange Network (IEN). The I-95 Corridor Coalition covers 12 northeastern states from Maine to Virginia. The IEN provides the over 45 participating agencies the opportunity to communicate in a coordinated manner and to improve corridor-wide traffic and transportation management through information exchange. The network allows each agency to receive information about non-local events that affect congestion levels within their operational area, allowing them to take appropriate action to alleviate congestion. It also allows each agency to distribute information about their own events to the agencies operating facilities within the affected area.

Operational Evaluation

Once the alternate routes have been implemented, and operated, it is important that their operational performance be monitored. It is at this point when local stakeholders may have significant input as to how to improve the operations of the alternate routes. The opportunity to evaluate operations will be more easily provided when alternate routes are implemented for extended periods of time.

3.7.3.3 Reducing Long-Term Incident Duration

At major incident scenes involving fatalities, severe or multiple injuries, hazardous materials, vehicle fires or even spilled cargo, the prudent practice may be to close all travel lanes or initiate a full closure in at least one direction of travel. In most jurisdictions a roadway is considered closed when all travel in at least one direction is prohibited.

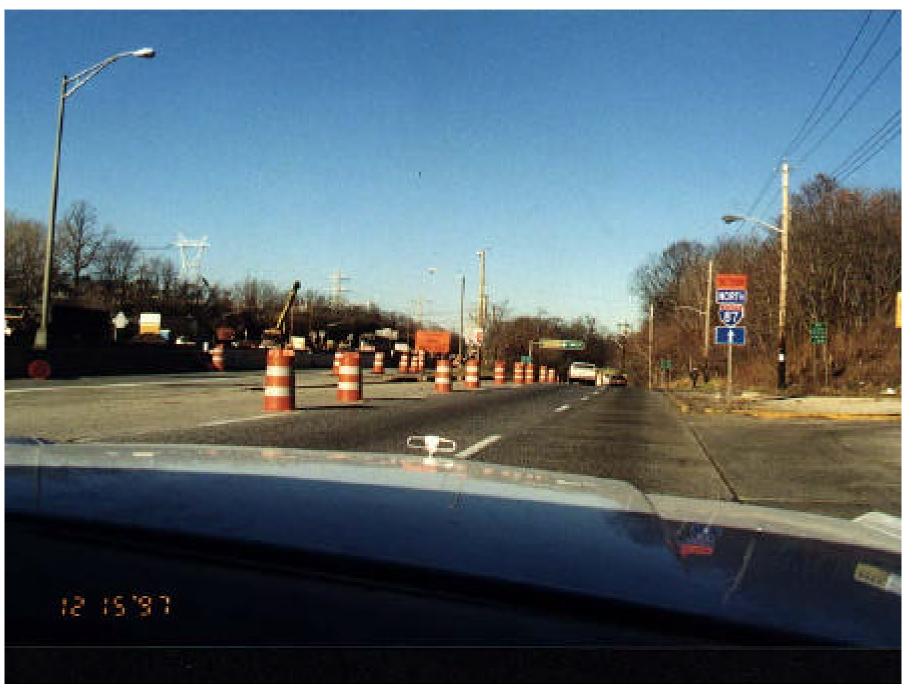

Figure 3-11: Long-term operation of alternative route

All the response agencies, Police, Fire/Rescue, EMS, DOT, and Towing and Recovery should be trained to ensure that closing the freeway is the last option. This action must be avoided if at all possible because of its significant negative effects on safety and traffic flow, not just in the immediate area, but on the surrounding roadway network and local communities.

Many times what appears initially to be a situation where all motorists will be forced to remain stopped or be diverted to exits and alternate routes can be resolved rapidly by clearing some of the affected lanes. Even taking action to clear a shoulder can be very beneficial in allowing some of the traffic to continue past the incident scene. If full closure is required later when all resources are in place to clear wreckage or for investigation, this step now provides a means to evacuate traffic trapped between the last exit used for diversion and the incident scene.

On-scene personnel at full closures need to remember that they have a limited view of the true impact of the incident. They can quickly be lulled out of the sense of urgency. However, at the end of the back up or queue high-speed traffic continues to come to a stop, with the continuous likelihood of a secondary crash. In some cases these secondary incidents are more serious than the original event. In addition long-term full closures lead to motorist confusion and frustration.

Responders should keep looking for ways to resolve the incident, even if it means changing the strategy as critical tasks are completed and as the scene stabilizes. The overall goal should be to minimize the duration of any necessary roadway or lane closure.

3.8 CLEARANCE

Clearance is the process of removing vehicles, wreckage, debris, spilled material, and other items from the roadway and the immediate area in order to return roadway capacity to normal levels. The objectives of improved incident clearance are to:

- Restore the roadway to its pre-incident capacity as quickly and safely as possible,
- Minimize motorists delays,
- Make effective use of all clearance resources,
- Enhance the safety of responders and motorists, and
- Protect the roadway system and private property from unnecessary damage during the removal process

Clearance is the most critical step in managing major incidents due to the length of time required to remove obstructions and restore traffic flow.

3.8.1 On Site Clearance Planning

This section discusses the importance of starting planning and organizing for clearance early in the site management process. It highlights the importance of having the right people make the right decisions on equipment and personnel.

Planning for efficient removal starts with the scheduling and deploying of response personnel. It continues through the process of selecting methods to remove all types of incidents; identifying the location, cost, and availability of resources; obtaining agreements for the use of resources; and establishing criteria for their use. Training for communications and response personnel is a vital part of the plan. The plan must be revisited regularly to ensure that it is current and appropriate.

Historical information on the location and types of incidents as well as the most effective methods for clearance can provide a strong basis for planning. Experienced response and communications personnel can provide substantial input to a clearance plan.

New technology review is also part of keeping the plan current. New types of debris recovery, towing, and response vehicles, as well as new equipment, can improve clearance. New investigative procedures may also allow faster completion of scene investigations.

3.8.2 Clearance Techniques

Tow trucks are the most common resource in vehicle removal. They are usually operated by private companies and may have a contract or work from a rotational list. Some public agencies use tow trucks to remove vehicles from bridges, tunnels and high-volume areas to a safe location to reduce clearance time. Private tow truck is then dispatched to this safe location and tows the vehicle.

Tow trucks have evolved, as vehicles have become more difficult to tow. Wheel lift slings, ramp trucks, and under-lift systems are some of the variations now available. Tow companies need specific information on the type of vehicle and situation so they can determine what equipment to dispatch.

Figure 3-12: Clearance of a tractor-trailer accident

Heavy-duty wreckers are used for removal or recovery of large trucks. They are not as plentiful as regular tow trucks due to their cost and the rarity of use. The availability of heavy recovery equipment is a factor in the clearance of major truck incidents. Use of outdated heavy-duty tow trucks with limited up-righting, lifting and recovery capability causes operators to work with lanes blocked, spending hours clearing wreckage. Operators require significant additional training and

experience to become proficient with this heavy-duty equipment. Companies that are experienced at towing large trucks may not have the experience or training to remove overturned trucks and may cause significant delays in their clearance. Some incidents may require more than one large wrecker and may require two companies to work together if the first company only has one large wrecker. Delays are common in such scenarios.

Service Patrols

Service Patrols are becoming more common in congested urban areas. They may consist of pickups or vans with limited towing or pushing ability, or they may be tow trucks. Service patrol vehicles, which usually operate during peak traffic hours, can reduce response and clearance time by removing most minor incidents quickly without requiring other assistance. They carry a variety of equipment, parts, and supplies to assist motorists, direct traffic, and increase scene safety. Experienced service patrol operators with vehicles that carry even a limited amount of clean up material can help reduce clearance times at larger incidents as well.

Service patrols may be operated by public or private organizations funded by public agencies, or they may be sponsored by private entities such as the media, auto clubs, car dealerships, or others. Minimum training requirements should be established based on the scope of the service program. See Section 2 for a more detailed description of service patrols.

Police Patrols

Police patrols may also be effective in clearing incidents and reducing associated delays. They can usually push vehicles out of the roadway or summon the appropriate assistance for more serious problems. Some officers carry jumper cables, water, or other supplies to solve some types of incidents quickly. They may also operate more specialized patrol vehicles that have additional equipment to improve incident clearance.

Liability for minor damage to vehicles pushed out of the roadway by patrol cars has led to recent consideration of limiting or eliminating the use of the push-bars even though use of push bumpers reduce delay and congestion. Agencies with severe budget problems may feel that they cannot absorb the cost of claims for minor repairs while other agencies are willing to accept these costs as “the cost of doing business,” within a larger scope of increasing public safety and maintaining transportation mobility.

Innovative Technologies

New techniques and technologies are available to improve clearance. A few companies have “Recovery Vehicles” that are designed to quickly remove overturned trucks. These vehicles have rotating cranes on a tow vehicle that can upright trucks faster without closing as many lanes. Experienced operators can upright even loaded vehicles in minutes reducing closures by hours. These trucks are expensive and operators must increase rates from normal large wrecker rates. They also require additional training and may require changes in policy or procedures to allow their use.

Automated debris recovery systems allow removal of debris from the roadway without stopping or having someone outside their vehicle. These vehicles can pickup large items at speeds up to 30 MPH. Smaller items require lower speeds. The vehicle can be used for routine maintenance when not responding to reports of debris.

3.8.3 Towing Company Issues

Private operators have traditionally provided towing and recovery services. The Towing and Recovery Industry in the US includes the full spectrum of companies in terms of size and capability, from a single truck operated out of a gas station or rural garage to huge truck fleets and multi-state road service corporations. Most start as small businesses serving the area in which they are located. In addition to providing towing, recovery, and road service to individual motorists or commercial truck fleets, many companies in this industry provide services to state and local agencies throughout the country by responding to traffic incidents. They tow and store abandoned vehicles and assist police and highway agencies by clearing vehicles, cargo and debris from the roadway. A large part of their revenue often comes from incidents and impounds on highway systems. Towing is a highly competitive business so public contracts are very important to tow companies. Without public contracts, some may not have enough business to survive. They are key elements in incident management programs, even those programs with separate service patrol operations. However, almost without exception, most areas have some tow operators that lack the necessary training, have vehicles that are ill-equipped, and lack motivation.

Figure 3-14: Private service provider removing over-turned tractor-trailer

Public perception of the industry has often been negative and legislative efforts to further regulate towing companies are common. Towing and Recovery industry leaders and articles in their trade publications openly discuss image, training and professionalism as some of the top challenges facing them. They have in fact made much progress and the recent industry focus on training and educational programs for operators is the major reason. In the past it was not uncommon for tow truck operators to be sent out on the street or freeway to learn the recovery trade by trial and error, with no formal training.

This new emphasis on professionalism through formal educational programs that combines classroom with hands-on sessions followed by testing is raising the standards of the industry. Incident Management programs around the country can assist these internal industry efforts by setting high performance criteria and establishing minimum levels of experience and requiring formal training for all operators responding to crash scenes. Setting and enforcing maximum response times along with very detailed and specific truck chassis and wrecker specifications that include boom lift capacity, winch and under-lift ratings and rigging and recovery hardware, will also help. The installation of push bumpers on heavy-duty wreckers used to clear freeway incidents is just one of the enhanced specifications to be considered.

Departments of Transportation and Public Safety agencies should allow only the best towing and recovery companies that meet these exacting requirements to be involved in incident management efforts. The objective or goal of raising or tightening these standards is to enhance efficient, expedited clearance procedures and incident scene safety. Uncooperative, unqualified or poorly equipped tow operators simply cannot be allowed to respond to incidents and must be screened from the rotation lists.

3.8.4 Wrecker Service Contracting

There are many methods used to secure towing or recovery services for highway incidents. The most common is the use of a rotation list. This practice involves someone at the incident scene, usually a police officer (but not always), calling for "the next tow on the list". The dispatcher, who takes the call from the field, calls the firm at the top of the rotation list to respond. There are many variations with daily, weekly, or monthly rotation but the most common method is on an incident-by-incident basis. Usually lists are maintained for light and heavy-duty equipment or by a designated wrecker class.

Some jurisdictions divide their roadways into 'tow zones' and have at least one towing firm on call to handle services within that zone. Sometimes multiple companies rotate the calls within each zone.

There are some areas that select sole service providers using an exclusive rights contract. These single source systems are sometimes based on low bid and others by "grandfathering" or patronage. In recent years numerous single provider systems have invoked controversy and have been challenged in the court system.

It is clear that there is no one method that is right for every jurisdiction. The establishment of a thorough screening process for pre-qualifying and a method for oversight, assuring compliance with a set of well written specifications and performance requirements, including a method for suspending or removing participants, is recommended.

It is critical that the relationship between private towing and recovery service providers and all other responders at the incident scene remain one of coordination and cooperation. A “model” towing agreement that was developed by the Towing and Recovery Association of America (TRAA) is included in Appendix C.

3.8.5 Removal of Truck Cargo

Large trucks involved in collisions or overturned are handled differently depending on local or regional procedures. Traditionally, every effort is made to salvage any contents even if it means long delays for traffic while trucks were off loaded and carefully up-righted. The cost of congestion can often be far greater than the value of the cargo. Truck owners or insurance companies are sometimes consulted before any removal is initiated. Some insurance companies are very progressive in their views of incident management, realizing the potential for secondary crashes, and favor quick removal by any means. Many of these companies routinely “total” the cargo for any overturn or major collision so cargo recovery is not necessary in their view. On the other hand, some companies frequently ask for their preferred tow companies or own employees to remove the cargo. Police and transportation officials should be aware of the tendency for insurance companies to “total” the cargo and pursue expeditious removal by using best and quickest methods available.

States with aggressive removal policies have implemented plans to push, pull, or drag the truck and/or cargo off the roadway to open traffic. This practice is successful but not yet wide spread, perhaps because of the lack of information on better methods. Although experience has shown that it is not a significant issue, liability is often cited as the reason not to implement more aggressive policies. Agencies involved in incident clean up should communicate with insurance companies and work to implement policies that will allow aggressive removal of spilled cargo.

3.8.6 Accident Investigations

Accident investigations have become more complex and take more time than in the past. Laws have increased traffic death or injury hit and run violations to felonies, which put a burden on the police to treat some traffic collisions as felony crime scenes.

Investigation of incidents that involve serious crashes, criminal cases or incidents that involve police officers can often close or severely affect a freeway for several hours. Evidence preservation and determining collision dynamics require specific procedures and take a significant amount of time. When collision scenes become crime scenes, they are routinely closed and access is limited to authorized personnel only. Investigators are methodical and thorough to avoid missing key evidence that may be destroyed when the scene is cleared. Criminal and civil court cases may drag on for years and decisions are often affected by the quality of the on scene investigation.

Investigative training gives priority to thorough investigations and allows the police to set the boundaries of the crime scene. Training seldom contains any discussion of limiting impacts on traffic and may not differentiate between closing a little used street and a heavily traveled freeway. Police also lack adequate traffic control equipment such as cones and signs to effectively control traffic around and adjacent to crash sites.

Technical crash investigators and re-constructionists are faced with the mounting challenge of keeping up with the expert witnesses they have to deal with in criminal and civil cases. Investigators have been pushed to become better and more thorough which often translates into more time at the scene to complete their tasks. The priorities for thorough investigation often come into conflict with the desire of transportation agencies to get roads opened as quickly as possible. Traffic officers often make traffic management a priority, which is often in conflict with the tasks of traffic or criminal investigators. There is often a difference of opinion as to what the priorities should be, even within the same police agency.

Experienced investigators are sensitive to the traffic situation and prioritize their work to facilitate movement of traffic. They will complete the tasks that must be done on scene and do the others off the roadway. They may complete the portions that allow partial opening of the roadway first provided there is adequate traffic control available to maintain their safety while finishing other investigative tasks.

Techniques for minor collisions can improve traffic flow substantially. Clearing these quickly to accident investigation sites or to locations away from the freeway will reduce delays significantly. Lane clearance helps, especially after emergency lights are turned off and vehicles are cleared from the shoulder. These procedures minimize “rubber necking” that otherwise keeps traffic slow and congested as long as volumes remain high.

Experienced officers also anticipate how long certain actions will take and time the arrival of resources to avoid delays. If tows are needed, investigators or other incident responders should request them while other investigation or clearance activities are underway so they arrive when needed. Waiting to complete other tasks before asking for tow trucks can significantly delay clearance.

Accident investigations often require precise measurements of the crash scene prior to clearance. Fatal accidents will almost always have these requirements. The survey needed to take these measurements often causes the roadway to remain closed minutes or hours after the roadway is otherwise available for clearance. New techniques and technology advances have greatly improved the time required for the on-site surveys, including total station surveying systems and photogrammetry.

<u>Total Station Surveying Systems</u>

Total station surveying systems allow fast and efficient capture of on scene measurements. They can also be operated with fewer lane closures. A single person can operate newer equipment. The data is uploaded to a computer after clearing the incident. Scale drawings can be plotted from using computer aided drafting software packages.

<u>Photogrammetry</u>

Photogrammetry is quickly emerging as an alternative to total station measuring. Digital or film 35-mm still photographs are taken at divergent angles. The photographs are digitized so they may be entered into a computer. A software program has been designed to determine accurate measurements from the photographs. The Oregon, California, Arizona, Washington and Utah State Police are now using this system.

When new or enhanced incident management equipment or techniques are proposed, the lack of funding and lack of training time availability are often cited as barriers. Most police agencies that now use total station measuring devices, for example, were given the equipment through State DOT and FHWA funding.

Accident Investigation Sites

Accident investigation sites (AIS) provide a safe haven off the main roadway where further investigation, documentation or exchange of information can take place. The first AIS was installed in Houston, Texas in 1971. Sixteen sites were established adjacent to the Interstate 45 Gulf Freeway as part of a traffic management system. Eight of the sites are on city streets adjacent to the freeway, five are on previously unused space under freeway structures, two on city streets under the freeway, and one was on freeway right of way accessed from a city street.

AIS are in use in several cities. Chicago established locations as part of the freeway response program, "Minuteman". IDOT service trucks remove vehicles and Illinois State troopers conduct investigations at the AIS. If the vehicles need to be towed from the AIS, that is handled by private tow companies.

Accident investigation sites can be flexible in design and location. They may be located on an adjacent roadway, off ramps, or underneath freeway structures. In some cases, they may be located on private property such as a parking lot with the owner's permission. They should have the following characteristics:

- Concealed from freeway or roadway motorists
- Located near high incident locations, in congested areas, or areas without adequate alternate routes
- Minimum of 1,000 square feet
- Sufficient lighting
- Easy access for trucks towing vehicles
- Access to telephones
- Well marked
- Low cost

Accident investigation sites reduce incident-related congestion by removing vehicles to a location that is out of sight of the main roadway as quickly as possible. They also improve motorist and responder safety by reducing secondary and pedestrian accidents. Fuel consumption and pollution is reduced, as are delays associated with incidents including "rubbernecking". Fewer personnel are required for traffic control when policy allows expedited movement of vehicles to an AIS.

3.8.7 Ordinances Relating To Incident Removal

Part of any traffic management system must be the ability to remove vehicles or hazards quickly and legally. Police and DOT agencies have teamed their efforts and been successful in obtaining legislation to facilitate removal. Some agencies have used existing statutes pertaining to adherence to restrictive signs to post rules in congested areas. The goal of each of these approaches is to keep the highway free of hazards and to maintain optimum traffic flow.

Quick Clearance Policies

Quick clearance policies have been adopted in most major metropolitan areas of the country. These policies authorize the removal of vehicles from the shoulder of the freeway after a short period, usually 2 hours. The vehicles may be impounded to a tow company or simply removed to a holding area. Enforcement action against the driver of owner is optional depending on local policy. Most states that have longer waiting periods for removal, can remove vehicles in shorter periods of time if they determine the vehicle is a traffic hazard. The definition of hazard varies significantly from area to area and officer to officer.

Texas was the first state to enact a law that requires motorists involved in property damage accidents on or near freeways in metropolitan areas to move to a safe location. Florida law requires motorists involved in non-injury accidents or whose vehicles become disabled to move them to a safe location or get help to move them.

Other cities have also adopted similar ordinances to require motorists involved in non-injury collisions to move their vehicles out of the traveled portion of the roadway when the vehicle is operable.

With any of these policies, success is dependent on motorists knowing about the policy or regulation. It is extremely important to include an effective public information and education campaign when implementing a new quick clearance program. It is also a good idea to look for opportunities to reinforce this information periodically to keep the regulations and benefits of quick clearance fresh in motorists' minds.

Legal and Liability Issues

Although liability associated with fast removal policies is a large concern of some public agencies, history has shown that few claims are filed. The minor incidents such as pushing vehicles to a safe location lead to very few claims.

Impounding abandoned vehicles for being traffic hazards can lead to complaints or claims from motorists. These motorists are often upset about the cost more than the reasons for impounding their vehicle. Some states have an appeal process and, if the motorists can convince the hearing officer the impounding was unjust, the public agency may be liable for the towing costs.

Incidents with overturned trucks being removed by expedient means that damage the load and vehicle have lead to few claims. Some insurance company adjusters prefer the loads be off-loaded carefully. They may not understand that the reason for quick removal from congested roadways is to reduce the hazard potential, which also reduces liability. The few cases that have been brought against public agencies have resulted in the courts upholding the actions of the public agencies if they were done in good faith and in accordance with established policy and procedures.

The legal standard for liability due to negligence is; duty or standard, a breach of that duty or standard, an actual loss or harm and a connection between the breach of duty and the resulting harm.

3.9 SUMMARY

The material presented in this chapter is intended to be used to improve procedures and operations for managing incidents. When placed in the context of the rest of the handbook, a comprehensive approach to incident management emerges. Section 1 explained the scale of the problem of incidents in the United States, presented the incident management process, discussed roles and responsibilities of various responders, and identified some opportunities to improve incident management. Section 2 laid out a process for developing an incident management program, identified characteristics of a successful incident management program, and presented benefits of incident management. Finally, Section 3 provided tips on how to improve each step in the incident management process.

Appendix A – References

(1) I-35 Incident Management and the Impact of Incidents on Freeway Operation, Minnesota Department of Transportation, January 1982

(2) The Highway Safety Desk Book, International Association of Chiefs of Police, April 1996

(3) Intelligent Transportation Systems Impact Assessment Framework: Final Report, Volpe National Transportation Systems Center, September 1995

(4) "National Police Week Observed May 10-16", The Police Chief, International Association of Chiefs of Police, May 1998

(5) 1998 Fatality Analysis Reporting System, National Highway Traffic Safety Administration, US Department of Transportation

(6) Incident Management: Challenges, Strategies and Solutions for Advancing Safety and Roadway Efficiency – Final Technical Report, ATA Foundation in association with CambCambridge Systematics, February 1997.

(7) Lomax, Tim, Shawn Turner, Levinson, Herbert S., Pratt, Richard H, "Quantifying Congestion: Phase III Final Report, National Cooperative Highway Research Program, Transportation Research Board, National Research Council, September 1996.

(8) Jodi Koehne, Fred L. Mannering, and Mark E. Hallenbeck, "Framework for Developing Incident Management Systems" US Department of Transportation, Federal Highway Administration, August 1991.

(9) Carvell, James D., Kevin Balke, Jerry Ullman, Katherine Fitzpatrick, Lewis Nowlin, Christopher Brehmer, *Freeway Management Handbook,* US Department of Transportation, Federal Highway Administration, August 1997.

(10) Washington's Incident Response Team Program Evaluation. Dohee Nam, Fred L. Mannering, Jennifer Nee, Jodi L. Carson. Washington State Transportation Center, Seattle, WA, May 1997.

(11) Barton-Aschman Associates, Inc. "Incident Detection and Response System in North Dallas County," prepared for the Texas Department of Transportation, October 1993.

(12) Althauser, Jerry, State of Washington Incident Response Team Northwest Region Guidelines Revised (1998).

(13) "Database will Improve Management of Incident Response Data," TRAC Research Review, August 1994, Washington State Transportation Center, University of Washington.

(14) http://www.infoplease.com

(15) Developing Freeway and Incident Management Systems Using the National ITS Architecture, US Department of Transportation, Intelligent transportation System Joint Program Office, August 1998.

(16) Mitretek with support from Parsons Brinckerhoff Quade and Douglas and CH2M Hill. “Incorporating ITS into Corridor Planning,” Seattle Case Study.” Federal Highway Administration project number 099818E1-0A (draft) June 1999.

(17) Traffic Detector Handbook, Second Edition, Institute of Transportation Engineers. Washington, DC, 1991

(18) Walker, J., Alicandri, E., Sedney, C., and Roberts, K. “In-vehicle Navigation Devices: Effects on the Safety of Driver Performance,” Report number FHWA-RD-90-053. US Department of Transportation, Washington, DC, 1986.

(19) Mannering, Fred L. and Walter P. Kilareski, Principles of Highway Engineering and Traffic Analysis, New York, NY. John Wiley & Sons. 1990.

(20) *Traffic Technology International*, June/July 1998.

(21) Simmons, Lee, The National ITS Architecture: A Framework for ITS Infrastructure. Lee Simmons. http://www.tfhrc.gov/pubrds/pr97-10/p15.html

(22) “Intelligent Transportation Systems Standards Fact Sheet,” US Department of Transportation, October 1999

(23) Samartin, Kevin, *"Under Detection*," ITS: intelligent transport systems, May/June 1997.

(24) Taylor, Steven T., feature article, ITS World, Jan/Feb 1997

(25) Henk, Russell H. et al, "*Before-and-After analysis of the San Antonio TransGuide System*," Texas Transportation Institute, Third World Congress on Intelligent Transportation Systems, July 1996.

(26) COMSIS Corporation, "*CHART Incident Response Evaluation Final Report*," Silver Spring, MD, May 1996.

(27) Minnesota Department of Transportation, "*Highway Helper Summary Report - Twin Cities Metro Area*," Report # TMC 07450-0394, July 1994.

(28) Framework for Developing Incident Management Systems - Revised, Washington State Transportation Center, October 1995.

(29) Service Patrol Study: Greater Puget Sound Freeway System, Washington State Department of Transportation, January 1998

(30) Smart Trek System Engineering Requirement Specification, Version 2.0, Washington State DOT, July 9, 1999.)

(31) WSDOT Web Use Customer Satisfaction Evaluation Report (draft), Cluett, Chris, July 1999.

(32) Emergency Medical Services: LifeLink Model Deployment Initiative System Design Document, Southwest Research Institute, August 1998.)