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BEST PRACTICES IN TRAFFIC INCIDENT MANAGEMENT

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Jodi L. Carson, Ph.D., P.E.	

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16. Abstract

Traffic incident management (TIM) is a planned and coordinated program to detect and remove incidents and restore traffic capacity as safely and as quickly as possible. Over time, various tools and strategies have been developed and implemented in an effort to improve overall TIM efforts. This report describes task-specific and cross-cutting issues or challenges commonly encountered by TIM responders in the performance of their duties, and novel and/or effective strategies for overcoming these issues and challenges (i.e., best practices). Task-specific challenges may include obtaining accurate information from motorists, accessing the scene, and condemning a spilled load. Cross-cutting challenges may include interagency coordination and communication, technology procurement and deployment, and performance measurement. The reported tools and strategies for improving TIM range from sophisticated, high-technology strategies to simple, procedural strategies. Information pertaining to the relative effectiveness or measurable benefits tied to each strategy was obtained through (1) published and electronic information sources and (2) input from TIM personnel in California (Bishop, Los Angeles, Redding, and Stockton), Maryland (Baltimore), Tennessee (Chattanooga), Texas (Austin), and Utah (Salt Lake City). For many of the individual tools and strategies, a wide range of effectiveness was reported by locale, challenging the explicit identification of best practices and suggesting that local conditions related to the nature and extent of operation, maintenance, marketing, etc. have a significant impact on the perceived or measured success of specific TIM efforts. The National Traffic Incident Management Coalition (NTIMC) provides a unique forum for not only disseminating the information presented here but also for standardizing practices to consistently maximize the effectiveness of TIM efforts.

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EXECUTIVE SUMMARY

Traffic incident management (TIM) is a planned and coordinated program to detect and remove incidents and restore traffic capacity as safely and as quickly as possible. Over time, various tools and strategies have been developed and implemented in an effort to improve overall TIM efforts. The nature and extent of tools and strategies in use are highly variable across the Nation, reflecting different priorities, congestion effects, levels of program maturity, and investment. As a direct result, the reported effectiveness of individual or combined strategies is inconsistent.

To achieve a higher level of effectiveness in U.S. TIM efforts and to accelerate the implementation process, the objectives of this investigation were to (1) review and assess various TIM policies, procedures, and technologies to identify current "best practices" in the United States and (2) seek a synergistic partnership with the National Traffic Incident Management Coalition (NTIMC) to support both the identification of best practices in the United States and the implementation of these practices by State, regional, and local TIM partners.

Information to support this investigation was obtained through (1) published and electronic information sources and (2) input from TIM personnel in California (Bishop, Los Angeles, Redding, and Stockton), Maryland (Baltimore), Tennessee (Chattanooga), Texas (Austin), and Utah (Salt Lake City). Task-specific and cross-cutting issues or challenges commonly encountered by TIM responders in the performance of their duties, and novel and/or effective strategies for overcoming these issues and challenges (i.e., best practices), were considered. Task-specific challenges may include obtaining accurate information from motorists, accessing the scene, and condemning a spilled load. Cross-cutting challenges may include interagency coordination and communication, technology procurement and deployment, and performance measurement. The reported tools and strategies for improving TIM range from sophisticated, high-technology strategies to simple, procedural strategies.

Best Practice TIM Tools and Strategies

In response to common task-specific and cross-cutting challenges and impediments to TIM efforts identified in the United States, a number of potential tools and strategies for improving TIM efforts were identified, each having varying levels of reported effectiveness. For many of the individual tools and strategies, a wide range of effectiveness was reported by locale, suggesting that local conditions related to the nature and extent of operation, maintenance, marketing, etc. have a significant impact on the perceived or measured success of specific TIM efforts and challenging the explicit identification of best practices. Instead, task-specific tools and strategies generally reported to be most effective in enhancing TIM efforts include:

- field verification by on-site responders and closed-circuit television cameras to support incident detection and verification;
- media partnerships and dynamic message signs to support the provision of traveler information;
- instant tow dispatch procedures to speed response;
- on-site traffic management teams, local protocols for high-occupancy vehicle lane use during incidents, and responder injury tracking mechanisms to support scene management and traffic control; and
- service patrols, vehicle-mounted push bumpers, and major incident response teams to support quick clearance and recovery of minor to major incidents.

Tools and strategies generally reported to be most effective in addressing cross-cutting TIM challenges include:

- joint traffic/emergency management centers housing multiple agencies to enhance agency relations and institutionalize TIM;
- local and virtual TIM training to encourage joint and effective training among responders;
- a common mutual-aid radio frequency/channel and wireless information networks to enhance en-route and on-scene communications among responders from different agencies;
- expedited standards development processes and minimum interoperability requirements to encourage the cost-effective use of technology for TIM;
- a strong link between funding and performance and periodic TIM self-assessments (facilitated through the Federal Highway Administration's [FHWA] TIM self-assessment process) to encourage continued TIM program improvements; and
- development of a TIM strategic plan and the integration of TIM into local capital planning processes to ensure ongoing access to program resources and funding.

A myriad of other task-specific and cross-cutting tools and strategies were identified that have the potential to improve TIM efforts. These tools and strategies may offer significant benefit in response to a particular challenge, may have moderate to high reported effectiveness in one or more locales, or may offer moderate benefits at little to no cost.

Implementation

At a local, regional, or State level, TIM administrative or operations personnel considering implementation of a particular tool or strategy can refer to the appropriate references for published findings cited in this document or contact TIM practitioners participating in this investigation directly by telephone or email to obtain more information. Experiences that resulted in a low relative effectiveness rating may be of most interest to TIM administrative or operations personnel considering implementation of a specific tool or strategy, particularly if others have reported only positive experiences. Identification of potential pitfalls early in the implementation stage can help to ensure that the same shortcomings are not propagated and that the full effectiveness of TIM efforts can be realized.

At a national level, NTIMC provides a unique forum for disseminating the information presented here directly through its website and through participation in various outreach activities and events. The stated goals of NTIMC include promoting and supporting the successful development and conduct of local, regional, and statewide TIM programs through peer networking, mentoring, and knowledge exchange among public safety and transportation professionals and providing leadership in the development of multidisciplinary best practices, guides, standards, and performance measures in support of sound TIM activities.

As evidenced by the wide range of reported effectiveness for singular TIM tools and strategies among the various participating locales, longer term efforts of NTIMC should focus on standardizing practices to consistently maximize the effectiveness of TIM efforts. In many cases, this may require additional research to identify the local conditions related to the nature and extent of operation, maintenance, marketing, etc. that have a significant impact on the perceived or measured success of specific TIM efforts. More consistent implementation of TIM tools and strategies will not only enhance the cost-effectiveness of program operation but also its sustainability over time.

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INTRODUCTION

Traffic incident management (TIM) is a planned and coordinated program to detect and remove incidents and restore traffic capacity as safely and as quickly as possible. Over time, various tools and strategies have been developed and implemented in an effort to improve overall TIM efforts. The nature and extent of tools and strategies in use are highly variable across the Nation, reflecting different priorities, congestion effects, levels of program maturity, and investment. As a direct result, the reported effectiveness of individual or combined strategies is inconsistent. As noted through the Federal Highway Administration's (FHWA) TIM self-assessment process, much room for improvement currently exists. Based on 2007 input from 67 major urban areas in the United States, TIM efforts scored 58.3 percent out of a possible 100 percent (American Transportation Research Institute 2007). Participants were asked to respond to 34 questions related to program and institutional (30 percent), operational (40 percent), and communications and technology (30 percent) issues using a five-point relative scale ranging from 0=no progress in this area to 4=efforts in this area are outstanding.

As part of a continuing effort to improve TIM efforts in the United States, an international scan tour was conducted in April 2005 under the sponsorship of the FHWA Office of International Programs, the American Association of State and Highway Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP). Traffic incident management experts, representing law enforcement, fire and rescue, emergency medical services (EMS), transportation, and other perspectives, visited four European countries to assess and evaluate various procedures, practices, and technologies that might improve the effectiveness of U.S. incident management. Major issues of interest included TIM planning and training, on-scene operations, technology use, and program management and administration.

From the information obtained during the scan, the team formulated several recommendations to improve the effectiveness of TIM in the United States. One such recommendation led to the development of a National Unified Goal (NUG) for Traffic Incident Management by the National Traffic Incident Management Coalition (NTIMC). Developed through a consensus process, the NUG consists of three major goals related to (1) responder safety; (2) safe, quick incident clearance; and (3) prompt, reliable, interoperable communications; and 18 strategies for achieving those goals. NTIMC and its partners at the national level are working together to provide tools and guidance to assist State, regional, and local TIM partners in implementing NUG strategies.

Report Purpose

To achieve a higher level of effectiveness in U.S. TIM efforts and to accelerate the implementation process, the objectives of this investigation were to (1) review and assess various TIM policies, procedures, and technologies to identify current "best practices" in the United States and (2) seek a synergistic partnership with NTIMC to support both the identification of best practices in the United States and the implementation of these practices by State, regional, and local TIM partners.

Information to support this investigation was obtained through (1) published and electronic information sources and (2) input from TIM personnel in California (Bishop, Los Angeles, Redding, and Stockton), Maryland (Baltimore), Tennessee (Chattanooga), Texas (Austin), and Utah (Salt Lake City). Contact information for each of the survey respondents is provided in the appendix. Information sought included common challenges and impediments to TIM efforts in the United States as well as potential tools and strategies for improving TIM efforts. Information pertaining to relative effectiveness or measurable benefits tied to each strategy was also of interest.

Target Audience

The target audience for this document includes the following:

- Public Agency/Private Industry Operations Personnel—Public agency/private industry operations personnel, responsible for effecting efficient and effective TIM on a per-incident basis, will benefit from this information through specific examples of successful TIM strategies that could be adopted.
- Public Agency/Private Industry Management or Administrative Personnel—Public agency/private industry management or administrative personnel will benefit from this information by identifying, implementing, and promoting successful TIM strategies to encourage future program growth.
- State and Local Political Officials—State and local political officials will benefit from an abbreviated form of this information by identifying and supporting successful TIM strategies that provide significant safety- and delay-related benefits to their constituents.

Report Content and Organization

Following this introductory material, this report describes task-specific and overarching issues or challenges commonly encountered by TIM responders in the performance of their duties, and novel and/or effective strategies for overcoming these issues and challenges (i.e., best practices). Task-specific challenges may include obtaining accurate information from motorists, accessing the scene, and condemning a spilled load. Overarching challenges may include interagency coordination and communication, technology procurement and deployment, and performance measurement. Because information was gathered from TIM programs at various stages of development, the reported strategies for improving TIM also range from sophisticated, high-technology strategies to simple, procedural strategies. This report concludes with an identification of those TIM tools and strategies observed to be most successful and recommendations for NTIMC's role in supporting the implementation of these practices by State, regional, and local TIM partners.

TASK-SPECIFIC CHALLENGES AND STRATEGIES

Traffic incident management activities are typically categorized into five overlapping functional areas:

1. detection and verification,
2. traveler information,
3. response,
4. scene management and traffic control, and
5. quick clearance and recovery.

Actions taken in any one of the five functional areas may be concurrent with actions taken in a different functional area. For example, public information officers may be continuously giving out traveler information while scene management and clearance actions are being taken at the incident scene.

Responders may encounter various challenges in the conduct of these TIM functions. Over time, various tools and strategies have been developed and implemented in an effort to overcome the most common impediments and improve overall TIM efforts. Many of these tools and strategies offer potential benefit across multiple functional areas, with wide-ranging reported effectiveness. The remainder of this chapter describes common challenges and potential strategies for improvement for each of the five TIM functional areas. The relative effectiveness reported for each strategy is based upon input from TIM personnel directly participating in this investigation or benefits reported in published sources.

Detection and Verification

Detection and verification are the first steps in the TIM process. Detection is the determination that an incident of some type has occurred. Incidents may be detected in person by motorists or response personnel or automatically using electronic loop detectors and associated incident detection algorithms. Verification is the determination of the precise location and nature of the incident. Accurate and detailed information about the incident can help to ensure that the most appropriate personnel and resources are dispatched to the scene. Verification can be accomplished in the field utilizing on-site response personnel or remotely using closed-circuit television.

Effective incident detection and verification can improve access to the scene by incident responders, support appropriate personnel and equipment dispatch to the scene, improve responder safety by alerting them to potentially dangerous conditions at the scene (i.e., fire or hazardous materials), reduce secondary incidents, and save lives by ensuring that vehicle crashes are detected on low-traffic roadways.

Common challenges to effective incident detection and verification include:

- slow incident detection,
- inconsistent notification of incident responders,
- inaccurate incident reports, and
- dispatcher overload.

Table 1 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation. When such information was not reported by TIM practitioners, relative effectiveness ratings for select strategies were derived from benefits reported in published sources, as appropriate. Note that select detection and verification strategies may be most appropriate for distinct implementation in rural or urban environments. For example, motorist aid call boxes, automated collision notification systems, and frequent roadway identifiers may result in greater benefit

Table 1. Detection and Verification Challenges, Strategies, and Reported Effectiveness

DETECTION AND VERIFICATION STRATEGIES	Slow Detection	Inconsistent Notification	Inaccurate Incident Reports	Dispatcher Overload	REPORTED EFFECTIVENESS
Electronic Loop Detectors	●				Very Low-Moderate
Motorist Aid Call Boxes	●				*Low-Moderate* [1]
Automated Collision Notification Systems	●				*Low-Moderate* [1]
Incident Notification Protocol		●			Low
Field Verification by On-Site Responders			●		Moderate-Very High
Closed-Circuit Television Cameras			●		Moderate-Very High
Frequent Roadway Identifiers			●		Moderate-High
Dispatcher Training			●	●	Moderate-High
Enhanced 9-1-1/Automated Positioning Systems			●	●	Moderate

[1] *Reported effectiveness is based on benefits reported in published sources.*

when implemented in rural areas, while electronic loop detectors, closed-circuit television cameras, and service patrols are best suited to urban environments. Strategies such as dispatcher training are applicable in either environment.

Slow Detection. In urban areas, higher traffic volumes and a prevalence of cellular telephone users in the traffic stream generally result in quick and reliable incident detection times. In non-urban or remote areas, where passing vehicles are less frequent, incidents may go undetected for some time. Early detection helps to ensure prompt medical attention and a reduction in secondary incidents.

- **Electronic Loop Detectors.** Electronic or inductive loop detectors are the most common method of detecting vehicles and sensing incidents automatically. These loops rely on detecting changes in vehicle speed as vehicles pass over successive loops embedded in the roadway. The loop information (i.e., speed, loop occupancy) is interpreted by detection algorithms (software) to pick up patterns that are indicative of incidents. The accuracy of incident detection using electronic loops is limited at both low and high traffic volumes. Electronic loop detectors do not provide a means for verification.

  In 2004, the ITS Deployment Survey estimated that approximately 20 percent of all freeway miles in the United States were equipped with electronic loop detectors (ITS Deployment Survey Website 2008). Incident management personnel in Redding, CA, Baltimore, MD, Austin, TX, and Salt Lake City, UT, each reported utilizing electronic loop detectors and rated their effectiveness in speeding incident detection (as a stand-alone system) as "very low" to "moderate" in their respective locales. The poorest performance was reported in Baltimore, MD, (low) and Salt Lake City, UT, (very low) where cold temperatures and winter road surface conditions may have a detrimental effect on

electronic loop detector reliability. Evaluating electronic loop detectors combined with closed-circuit television cameras for verification, a study conducted in Maryland reported a benefit-to-cost ratio of 5.6:1, with most of the benefits resulting from a 5 percent (2 million vehicle-hours per year) decrease in delay associated with non-recurrent congestion (COMSIS Corporation 1996).

- **Motorist Aid Call Boxes**. Motorist aid call boxes are permanently mounted roadside communications devices that allow motorists to request assistance or report an incident. Typically, call boxes are installed at bridge or tunnel locations where incident impacts are significant or near more remote interstate interchanges where alternative communications services (e.g., cellular service, pay phones) are limited. Contemporary motorist aid call box systems support two-way voice communication that allows the exchange of additional information about the incident. Safety concerns have been expressed regarding the need for motorists to exit their vehicles and walk to use the call box, exposing them to passing traffic.

  In 2007, the ITS Deployment Survey estimated that approximately 10 percent of all freeway miles in the United States were equipped with motorist aid call boxes (ITS Deployment Survey Website 2008). Assuming a reduction of one injury per year and one fatality every 5 years, motorist aid call boxes installed along 39 miles of rural Interstate 85 in Georgia were estimated to yield a benefit-to-cost ratio of 2.76:1, with an associated cost savings of $329,820 (Kolb et al. 2000). In a public opinion survey conducted 1 year later, 97 percent of respondents felt that call boxes on rural interstates in Georgia were a good idea even though 64 percent of them owned cellular phones. Also, 78 percent of respondents indicated a willingness to pay a fee as part of their yearly vehicle registration to fund the installation and maintenance of additional call boxes (Kolb 2001).

- **Automated Collision Notification Systems**. More than a dozen commercial automated collision notification systems (ACNS) are currently on the market. Many of these products are available as factory-installed options on high-end luxury vehicles; others are installed as after-market products. Automated collision notification systems serve to improve detection of incidents in remote areas through either the automatic or motorist-initiated activation of an alarm and verification of a vehicle's location through the automatic transmission of location data. The most popular position location technologies include global positioning systems (GPS) and cellular geolocation techniques that rely on the time difference of cellular signal arrival and the angle of arrival.

  Automated collision notification systems typically utilize wireless communication and a third-party response center to notify the closest public safety answering point (PSAP) for emergency response. In anticipation of ACNS proliferation and subsequent increases in call volumes, emerging strategies are currently under investigation that would allow for direct communications between ACNS and PSAPs, eliminating the need for a third-party response center. Proposed strategies may utilize existing PSAP infrastructure, such as text telephone (TTY) systems required at all PSAPs under Federal law, or require various infrastructure upgrades depending on the nature of communications.

  In Erie County, NY, a field operational test found that ACNS reduced incident detection time from an average of 3 minutes to less than 1 minute. Maximum detection times for vehicles equipped with ACNS was 2 minutes, while the maximum detection times for unequipped vehicles was as high as 46 minutes (Bachman and Preziotti 2001). In 2007, the ITS Deployment Survey reported that law enforcement and fire and rescue agencies in 16 and 6 U.S. metropolitan areas, respectively, had access to data from ACNS to speed incident detection (ITS Deployment Survey Website 2008).

Inconsistent Notification of Incident Responders. Typically, public safety agencies, including law enforcement, fire and rescue, and EMS agencies, are the first to be notified of an incident through 9-1-1 dispatch. Notification of support incident responders, particularly transportation agencies, can be less consistent. If transportation agencies do not support 24-hour operations or promote an active role in TIM, public safety personnel may overlook their notification. In addition, if no formal guidelines are in place for notifying support responders, or if recently instituted guidelines are not being followed, support personnel notification may vary depending on the particular public safety personnel managing the incident.

- **Incident Notification Protocol**. To address the inconsistent notification of support responders when an incident occurs, Maryland formalized incident notification procedures in an interagency agreement between the Maryland State Police and the Maryland State Highway Administration. This agreement is intended to ensure that transportation personnel are notified consistently for each appropriate incident irrespective of different law enforcement officers managing the incident. To date, incident management personnel in Baltimore, MD, rated this mechanism as "low" in effectively standardizing an incident notification protocol in their locale.

Inaccurate Incident Reports. Motorists who carry cellular telephones are commonly the first to detect an incident and provide notification. While the expediency with which the incident is reported is beneficial, motorists may not provide accurate location information and may exaggerate incident severity. Motorists may use landmarks to describe the incident location rather than roadway identifiers and may confuse directional information. As a result, unnecessary, inadequate, or insufficient response resources may be dispatched to the incident scene.

- **Field Verification by On-Site Responders**. A common means of incident verification is through the initial dispatch of law enforcement personnel to the incident scene. Once on-scene, the officer assesses the incident, determines response needs, and requests appropriate response through dispatch. This method is particularly effective where traffic congestion does not unduly restrict travel time to the detected incident. Service patrols, described later in this document, can provide similar incident verification capabilities. Under congested conditions, roving service patrols may be quicker to arrive at an incident scene due to their likely closer proximity.

  Field verification by on-site responders was rated as "high" by incident management personnel in Redding, CA, and Chattanooga, TN, and "very high" by incident management personnel in Stockton, CA, Baltimore, MD, Austin, TX, and Salt Lake City, UT, in effectively enhancing the accuracy of incident reports in their respective locales. Incident management personnel in Bishop, CA, rated field verification by on-site responders as "moderate" in effectively enhancing the accuracy of incident reports. The range in reported effectiveness may be explained, in part, by differing degrees of interagency cooperation and coordination.

- **Closed-Circuit Television Cameras**. Closed-circuit television (CCTV) cameras provide limited-access video images for traffic-monitoring purposes. Improvements in picture quality, pan and zoom capabilities, and video data transmission rates have made CCTV a very useful incident verification tool. Whereas electronic loop detectors (described above) provide detection capabilities but no verification, CCTV cameras provide verification capabilities but only limited incident detection functions. Experience has shown that manual monitoring of CCTV images leads to a "blank stare"; even if an incident is visible on the screen, the viewer may not register it. The two technologies are best used in combination. As noted previously, a study conducted in Maryland reported a benefit-to-

cost ratio of 5.6:1 through the combined use of electronic detectors and CCTV cameras (COMSIS Corporation 1996).

In 2007, the ITS Deployment Survey estimated that approximately 36 percent of all freeway miles in the United States were equipped with CCTV cameras (ITS Deployment Survey Website 2008). As a stand-alone system, CCTV cameras were rated as "high" by incident management personnel in Redding, CA, Stockton, CA, and Austin, TX, and "very high" by incident management personnel in Baltimore, MD, Chattanooga, TN, and Salt Lake City, UT, in effectively enhancing the accuracy of incident reports in their respective locales. Incident management personnel in Bishop, CA, rated CCTV cameras as "moderate" in effectively enhancing the accuracy of incident reports. The range in reported effectiveness may be indicative of the perceived adequacy of camera coverage in each of the respective locales.

- **Frequent Roadway Identifiers**. Installing more frequent roadway identifiers, such as closely spaced mile markers, can help to ensure that motorists accurately report incident location. One-tenth of a mile spacing can provide motorists who report an incident with a visible marker from most reporting locations. Additional directional and route information can also be included on the markers.

  Incident management personnel in Bishop and Redding, CA, Chattanooga, TN, and Austin, TX, reported using frequent roadway identifiers and rated their effectiveness in enhancing the accuracy of incident reports as "moderate" to "high" in their respective locales.

- **Dispatcher Training**. The mission of dispatchers is to quickly, accurately, and completely convey the necessary information to the proper agencies, companies, and field personnel to get the right personnel and equipment to the scene as quickly as possible. Multiple incident reports can improve incident verification efforts if an efficient process for collecting information from calls is developed. By comparing responses from multiple calls, dispatchers can get a much clearer picture of the incident circumstances.

  Incident management personnel in Redding, CA, Baltimore, MD, and Austin, TX, rated the dispatcher training provided in their respective locales as "moderate" to "high" in effectively enhancing the accuracy of incident reports.

- **Enhanced 9-1-1/Automated Positioning Systems**. Enhanced 9-1-1 systems automatically associate a physical address or location with the calling party's telephone number and route the call to the most appropriate PSAP. The caller's location information is automatically displayed to the dispatcher. For incoming calls made from cellular telephones, a variety of automated positioning techniques are used. Cellular geolocation relies on the time difference of cellular signal arrival and the angle of arrival to determine incident location. The cellular telephone number and the cellular tower location or the latitude/longitude of the caller may be displayed. Global positioning systems utilize a chip installed in each cellular telephone to locate the originating call.

  Incident management personnel in Chattanooga, TN, and Salt Lake City, UT, reported using enhanced 9-1-1/automated positioning systems and consistently rated their effectiveness in enhancing the accuracy of incident reports as "moderate" in their respective locales.

Dispatcher Overload. Often, especially after the occurrence of a major incident, dispatchers receive multiple calls from motorists reporting the incident. These multiple calls can overload dispatchers and limit their attention to other emergencies.

- **Dispatcher Training**. Dispatcher training, described above, can also help to reduce the potential for dispatcher overload. Efficient processes for collecting and comparing information from multiple calls can reduce the overall level of effort expended by dispatchers.

  Incident management personnel in Redding, CA, and Austin, TX, reported using dispatcher training for this broader intent, rating it as "moderate" in effectively reducing potential dispatcher overload.

- **Enhanced 9-1-1/Automated Positioning Systems**. Similarly, dispatcher overload can be alleviated through the use of enhanced 9-1-1 systems, also described above. Enhanced 9-1-1 systems automatically display incident location information based on the calling party's telephone number, reducing the dispatcher's data capture and entry responsibilities.

  Incident management personnel in Chattanooga, TN, and Salt Lake City, UT, rated enhanced 9-1-1/automated positioning systems as "moderate" in effectively reducing potential dispatcher overload.

Traveler Information

Traveler information is the communication of incident-related information to motorists who are at the scene of the incident, approaching the scene of the incident, and not yet departed from work, home, or other location. This information serves to reduce traffic demand and improve responder safety at the incident scene, reduce the potential for secondary incidents for motorists approaching the scene, and allow motorists to alter their travel plans on the basis of current traffic conditions.

To ensure motorist cooperation, traveler information tools or strategies should (1) advise motorists of the nature and extent of the problem so that they may make intelligent choices about alternative routes or delayed trip departures; (2) provide information on possible courses of action such as alternative routes; and (3) when motorists are required to take certain actions (e.g., change lanes, reduce speed, divert), describe those actions clearly. Traveler 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.

Common traveler information challenges relate to:

- the provision of accurate traveler information and
- inconsistent dynamic message sign (DMS) use.

Table 2 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges, and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Accurate Traveler Information. The lack of a sophisticated surveillance system is often inappropriately blamed for poor traveler information. Miscommunication and a lack of communication among various responding agency personnel, dispatchers, and the media are more often the reasons. The accuracy or detail of information that is passed from responding personnel to the dispatcher is not always maintained when the information is passed to a third party. In addition, dispatchers and the media must try to assimilate sometimes conflicting information from a variety of sources.

- **Media Partnerships**. Most motorist information is broadcast over commercial AM and FM radio or television. As an indication of the importance of providing traffic-related information, private traffic-reporting firms that collect, package, and "sell" traffic information to the broadcast media have developed in many urban areas. Cooperative media partnerships help to ensure that public-sector

Table 2. Traveler Information Challenges, Strategies, and Reported Effectiveness

TRAVELER INFORMATION STRATEGIES	Accurate Traveler Information	Inconsistent DMS Use	REPORTED EFFECTIVENESS
Media Partnerships	●		Moderate-Very High
Dynamic Message Signs	●		Moderate-Very High
Field Verification by On-Site Responders	●		High
Incident Update Protocol	●		Moderate
Highway Advisory Radio	●		Low-Very High
Traveler Information Websites	●		Low-Very High
5-1-1 Systems	●		Low-Moderate
Standard Message Sets		●	Moderate-High
Dynamic Message Sign Use Protocol		●	Moderate-High

agencies are fully utilizing resource opportunities that exist. Effective media relationships require an understanding of media perspectives, needs, and limitations, as well as a media education effort to stress the importance of accurate and timely information. Interdisciplinary training or administrative traffic management teams may provide convenient forums for improving media relations.

Media partnerships were rated as "moderate" by incident management personnel in Redding, CA, and Chattanooga, TN; "high" by incident management personnel in Austin, TX, and Salt Lake City, UT; and "very high" by incident management personnel in Baltimore, MD, in effectively enhancing the accuracy of traveler information in their respective locales.

- Dynamic Message Signs. Dynamic message signs—also known as changeable or variable message signs—are useful for providing dynamic information regarding unusual conditions, guidance information regarding diversion, and advance warning of conditions ahead. Dynamic message signs can be combined with highway advisory radio (HAR), websites, and other technologies as part of a broader advanced traveler information system (ATIS). To ensure maximum effectiveness when communicating with the motoring public, the information has to be accurate and timely, and the signs have to be located carefully to support appropriate diversionary action. Signs can be permanently installed at fixed locations, or portable and mounted on a truck or trailer.

  In 2006, the ITS Deployment Survey reported at least 3,398 permanently installed and 1,362 portable DMSs used in major metropolitan areas in the United States (ITS Deployment Survey Website 2008). Dynamic message signs were rated as "moderate" by incident management personnel in Bishop, CA, and Baltimore, MD; "high" by incident management personnel in Austin, TX, and Salt Lake City, UT; and "very high" by incident management personnel in Redding, CA, and Stockton, CA, in effectively enhancing the accuracy of traveler information in their respective locales. The range in reported effectiveness may be explained, in part, by differing procedures for mobilizing portable DMSs, and posting and updating messages.

- **Field Verification by On-Site Responders**. Field verification by on-site responders is not only useful for verifying incidents, but also in supporting ongoing efforts to provide accurate traveler information as the incident management process progresses.

  Incident management personnel in Stockton, CA, reported using on-site responders to verify the appropriateness of posted DMS messages and to provide requests for updated messages as the incident management process evolves. These same personnel rated field verification by on-site responders as "high" in effectively enhancing the accuracy of traveler information.

- **Incident Update Protocol**. Incident duration is one of the most difficult pieces of information to report accurately, yet it is one of the most important to the motoring public. For incident responders, the dynamic nature of an incident and the uniqueness of each incident challenge accurately estimating duration. Duration is especially difficult to predict at larger scale incidents where a number of different agency personnel are performing many individual tasks. As such, the initial estimate should be periodically updated as the incident progresses to better reflect known conditions. Formalizing update procedures with step-by-step procedures or a standardized checklist helps to ensure that provision of the most accurate and comprehensive information does not get overlooked in the performance of other incident-related duties.

  Incident management personnel in Redding, CA, Stockton, CA, and Chattanooga, TN, reported using an incident update protocol and consistently rated its effectiveness in enhancing the accuracy of traveler information as "moderate" in their respective locales.

- **Highway Advisory Radio**. Highway advisory radio can be used in isolation or in combination with DMSs and other technologies as part of a broader ATIS to provide traffic information to motorists at or approaching an incident. Highway advisory radio primarily broadcasts at 530 or 1610 kHz on the AM band; roadside signing is commonly used to advise motorists to tune to the HAR frequency "when flashing." Highway advisory radio has a larger area of coverage than DMSs and can reach motorists farther upstream of an incident. In addition, HAR can provide longer, more detailed messages, including bilingual messages. Both portable and permanently installed HAR systems are available, with a transmission range of up to 1 and 4 miles, respectively. Highway advisory radio is only effective if the motorist tunes the radio to the proper HAR frequency.

  In 2007, the ITS Deployment Survey estimated that approximately 19 percent of all freeway miles in the United States were equipped with highway advisory radio (ITS Deployment Survey Website 2008). Highway advisory radio was reportedly used and rated as "low" in effectively enhancing the accuracy of traveler information by incident management personnel in Bishop, CA, Baltimore, MD, and Salt Lake City, UT. Conversely, incident management personnel in Austin, TX, Stockton, CA, and Redding, CA, rated HAR as "moderate," "high," and "very high" in effectively enhancing the accuracy of traveler information in their respective locales. The range in reported effectiveness may be indicative of the level of effort expended to maintain the traveler information broadcast on HAR. Proper HAR operation is personnel intensive; motorists will reject an information source that provides outdated or irrelevant information.

- **Traveler Information Websites**. The Internet has allowed transportation agencies to widely disseminate traveler information such as real-time traffic congestion, incidents, updates on construction activities, and other transportation-related information to the public. Traveler information websites can also be combined with in-field technologies such as DMS and HAR as part of a broader ATIS. The information is available 24 hours a day at a relatively low cost to the provider, and it can be accessed by users from home, from work, or en route if Internet access is available.

In 2007, the ITS Deployment Survey reported that at least 39 States utilize websites to provide traveler information (ITS Deployment Survey Website 2008). Approximately one-third of these websites are operated in conjunction with 5-1-1 telephone services described below. Incident management personnel in Redding, CA, Stockton, CA, Chattanooga, TN, Austin, TX, and Salt Lake City, UT, consistently rated traveler information websites as "moderate" in effectively enhancing the accuracy of traveler information in their respective locales. Traveler information websites were rated as "low" and "very high" in effectively enhancing the accuracy of traveler information by incident response personnel in Bishop, CA, and Baltimore, MD, respectively. The range in reported effectiveness may be indicative of the nature and extent of, and level of effort expended to maintain, the traveler information provided on the website.

- **5-1-1 Systems.** Similar to the national phone numbers for information (4-1-1) and emergencies (9-1-1), 5-1-1 was recently established as the national phone number for traffic and travel information. Travelers can dial 5-1-1 to access current information for specific routes and roadways, including traffic incidents, roadway blockages, lane closures, weather events, and, in some instances, transit and tourism information. State-level systems vary widely in functionality and may be managed by State departments of transportation, local transportation agencies, or local transit agencies. As noted previously, some States have incorporated companion web services that provide more extensive traffic and travel information.

  To date, 5-1-1 services are available in 33 States, providing access to more than 128 million Americans (47 percent) and almost 1 million Canadians (3 percent). The 5-1-1 Deployment Coalition estimates increasing accessibility to 70 percent of all Americans by 2009. Since its inception in 1999, more than 112 million calls to 5-1-1 have been registered nationwide (5-1-1 Deployment Coalition Website 2008). Incident management personnel in Bishop, CA, Chattanooga, TN, and Salt Lake City, UT, reported having 5-1-1 systems in place and rated their effectiveness in enhancing the accuracy of traveler information as "low" to "moderate" in their respective locales.

Inconsistent Dynamic Message Sign Use. Two different schools of thought exist regarding the use of DMSs during non-incident times. The first suggests that only emergency or incident-related messages should be displayed so that when it is necessary for motorists to be alert or take action, they will pay attention to the sign. Repetitious, non-emergency messages are thought to dull motorists' sensitivity to the message. The second school of thought views repetitious observance of the sign as a benefit. Non–incident-related information, such as carpool information or safety reminders (e.g., "Buckle Up"), accustoms motorists to observing the signs for traffic-related information. During an incident, it is likely that they will, out of habit, turn to DMSs for information. In addition, leaving the sign blank may lead drivers to believe that it is not working. Currently, there is no uniform practice.

- **Standard Message Sets.** Standard message sets help to ensure the posting of appropriate DMS messages and reduce the need for TIM personnel to redraft unique messages for each incident. To elicit the proper response from motorists, DMS messages must be short enough to be read and understood by a passing motorist. At typical highway speeds, the message posted on a DMS must be presented to motorists in about 8 seconds or less (Dudek 2004). This translates to eight words at 55 mph, seven words at 65 mph, and six words at 70 mph. Motorist comprehension can be improved if messages contain the same elements and presentation order. Recommended message elements include a brief description of the situation, the location of the situation, the effect on travel (i.e., delays, lanes blocked, etc.), and the action that the motorist should take (Dudek 2004).

  Incident management personnel in Bishop, CA, Redding, CA, Baltimore, MD, Austin, TX, and Salt Lake City, UT, reported using standard DMS message sets and rated their effectiveness in encouraging

consistent DMS use as "moderate" to "high" but expressed concern over the large number of individual messages developed to accurately reflect possible incident scenarios.

- **Dynamic Message Sign Use Protocol**. Although no national agreement exists on the use of DMSs during non-incident times (i.e., left blank or used to provide non-emergency messages), regional or State-level consistency in DMS use will improve their effectiveness. Conditioning motorists to a consistent use of DMSs provides the greatest potential for motorist compliance. If a situation arises that requires the usage of a specific DMS for more than one ongoing condition, message priority criteria should be used for displaying messages. A common ranking for message priority is safety, roadway closures, delay, emergency (i.e., Amber Alert), test, and public service information.

  In 2004, at least 73 major areas in the United States reported having policies or procedures in place that govern the display of messages on DMSs (ITS Deployment Survey Website 2008). Incident management personnel in Bishop, CA, Redding, CA, Austin, TX, and Salt Lake City, UT, rated the non-incident DMS use protocol established in their respective locales as "moderate" to "high" in effectively encouraging consistent DMS use.

Response

Incident response is the activation of a "planned" strategy for the safe and rapid deployment of the most appropriate personnel and resources to the incident scene. Information management plays an important role in response; providing the necessary information to the appropriate personnel is critical in achieving optimum response. Accurate information about an incident—such as its location, traffic impacts, vehicle types involved, presence of an injury or a fatality, and other special conditions (e.g., presence of a hazardous material)—is essential in determining the proper response. The level of required response is typically determined by an on-scene responder or by a dispatcher at a communications or traffic management center.

The objectives of improved response are to save lives through more rapid EMS response, ensure that responders reach the scene before the traffic backup becomes lengthy, make more efficient use of personnel and resources through "appropriate" response, and achieve a state of continued readiness for the rapid deployment of the appropriate resources to the incident scene and the area affected by it.

Common response challenges relate to:

- achieving optimum response and
- accessing the incident scene.

Table 3 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation. When such information was not reported by TIM practitioners, relative effectiveness ratings for select strategies were derived from benefits reported in published sources, as appropriate.

Table 3. Response Challenges, Strategies, and Reported Effectiveness

RESPONSE STRATEGIES	Achieving Optimum Response	Difficult Scene Access	REPORTED EFFECTIVENESS
Personnel/Equipment Resource Lists	●		Moderate-High
Towing and Recovery *Vehicle Identification Guide*	●		Moderate
Instant Tow Dispatch Procedures		●	*High* [1]
Motorcycle Patrols		●	Moderate-High
Towing and Recovery Zone-Based Contracts		●	Moderate
Enhanced Computer-Aided Dispatch		●	Moderate
Dual Dispatch Procedures		●	Low-High
Median Crossovers		●	Low-High
Traffic Signal Pre-emption		●	Low-High

[1] *Reported effectiveness is based on benefits reported in published sources.*

Achieving Optimum Response. Two common, yet undesirable, situations often result when incident response is initiated: under-response and over-response. Under-response results when too few resources or inappropriate resources are dispatched to the scene (e.g., dispatching a light-duty wrecker to an incident involving an overturned semi-truck). Typically, the inadequacy of the personnel or resources first dispatched is not realized until after they have arrived at the incident scene. When additional personnel or equipment is requested to the scene, the subsequent response usually takes much longer because traffic congestion from the incident reduces accessibility. Under-response more than doubles necessary incident response times. An inappropriate solution to the problem of under-response is to dispatch excess personnel or equipment to the scene. Equipment and personnel that are not needed at the scene can cause a bigger congestion and accessibility problem than the incident itself. In addition, over-response greatly reduces an agency's efficiency by committing personnel and resources unnecessarily. Agencies should instead strive for optimum response, with the correct equipment and appropriate number of personnel dispatched to the incident scene. Optimum response can be attained through improved incident verification techniques and better awareness among responders of the different information needs and capabilities of each agency.

- **Personnel/Equipment Resource Lists.** Problems with indirect communication and unnecessary calls to request personnel or equipment can be minimized through the use of personnel or equipment resource lists. Significant resource information may have already been compiled by local emergency management agencies that perform emergency response planning for hurricanes, tornadoes, earthquakes, chemical disasters, etc. Information compiled in the resource lists should include geographic or jurisdictional response areas, phone numbers, fax numbers, pager numbers, procedures for radio contact, alternative contacts, available equipment, available supplies or materials, and anticipated response times. This information should be provided for both daytime

and nighttime conditions, particularly for non-emergency, support agencies (e.g., transportation departments) that do not operate 24 hours a day. Resource lists should be regularly updated to ensure continued benefit.

In 2004, the ITS Deployment Survey reported at least 75 major metropolitan areas in the United States using personnel/equipment resource lists (ITS Deployment Survey Website 2008). Incident management personnel in Los Angeles, CA, Bishop, CA, Redding, CA, Baltimore, MD, Chattanooga, TN, Austin, TX, and Salt Lake City, UT, reported using personnel/equipment resource lists and rated their effectiveness in encouraging optimum incident response as "moderate" to "high."

- Towing and Recovery *Vehicle Identification Guide*. Available as 8.5-inch by 11-inch laminated cards, the Towing and Recovery Association of America's (TRAA) *Vehicle Identification Guide* can be carried in appropriate response vehicles to ensure that responders who are requesting towing and recovery services provide the necessary information to tow operators prior to dispatch. Key information includes the year, make, and model of the vehicle to be towed or recovered; the vehicle's classification under the U.S. Department of Transportation's classification scheme (examples of vehicle types in each class are depicted); the type of services required (i.e., impound, accident, recovery, motorist assist); and other pertinent vehicle information (i.e., tire condition, cargo contents, load status, etc.). Use of this guide helps to prevent inappropriate equipment/personnel dispatch, which in turn reduces overall incident duration resulting from sequential, redundant response.

  Incident management personnel in Baltimore, MD, and Austin, TX, rated the TRAA *Vehicle Identification Guide* as "moderate" in effectively encouraging optimum incident response. Austin, TX, only recently began utilizing the TRAA *Vehicle Identification Guide* as a tool to encourage optimum incident response.

Difficult Scene Access. Traffic congestion and roadway design are the primary reasons for limited access to the scene for incident responders. Traffic congestion complicates access to the scene for responders. Flashing lights, especially amber-colored flashing lights, seem to have little effect on traffic movement (i.e., few people move to the right when a vehicle with flashing lights approaches from the rear). Historically, wide roadway shoulders have supported emergency access when travel lanes are congested. In many urban areas, however, efforts to ease traffic congestion have resulted in wide shoulders being converted to general-purpose or high-occupancy vehicle lanes.

- Instant Tow Dispatch Procedures. To expedite response and removal of blocking disabled vehicles, instant tow dispatch procedures initiate response from towing and recovery personnel and law enforcement at the same time, essentially eliminating the verification process.

  In Washington, instant tow dispatch procedures are credited with saving an average of 15 minutes of lane blocking congestion each time it is used, with an associated cost savings for each instant tow deployment of approximately $20,000 to $35,000, depending on the location and traffic conditions. Eliminating the verification process may result in "dry runs" for towing and recovery companies. With a dry run fee of $25 per trip, the Washington State Department of Transportation reports paying under $100 per month for coverage along all State and interstate highways in King County (Seattle) (Washington State Department of Transportation 2007).

- Motorcycle Patrols. Motorcycle patrols, which can more easily maneuver in congested areas than larger response vehicles, allow trained personnel to reach and assess the incident scene more quickly. Motorcycle patrols can provide limited initial traffic control and scene protection prior to the arrival of additional resources.

Incident management personnel in Redding, CA, and Baltimore, MD, rated motorcycle patrols as "moderate" and "high," respectively, in effectively enhancing access to the incident scene in their respective locales.

- **Towing and Recovery Zone-Based Contracts**. The two most common contracting mechanisms for providing towing and recovery services include rotational lists or zone-based licensing. Based on responses from 29 U.S. jurisdictions, 55 and 21 percent utilized rotational lists and zone-based licensing, respectively (Dunn and Latoski 2003). The latter approach—under which a single private towing agency is assigned to respond to incidents occurring in a predefined geographic area or zone—offers the greatest potential for enhancing incident response. Under zone-based contracts, geographic coverage areas are generally defined to support reasonable physical driving distances and associated response times. In addition, towing and recovery operators develop a high level of familiarity with traffic and incident characteristics (i.e., congested or high-incident locations) in their area and potential alternate routes for quickly accessing the incident scene. Responders, too, develop a familiarity with the personnel and equipment capabilities of the designated towing and recovery company.

  Incident management personnel in Austin, TX, and Salt Lake City, UT, reported using towing and recovery zone-based contracts in their locales and consistently rated their effectiveness in enhancing access to the incident scene as "moderate."

  Irrespective of type, contracts may specify acceptable response times to incident scenes. Input from towing and recovery personnel is important in establishing reasonable response times that can then be strictly enforced. In Houston, TX, qualified contracted towing and recovery companies are responsible for responding within an average of 6 minutes to incidents on a designated section of State-owned freeways as part of their SAFEclear program. During the first year of the program, tow operators responded to more than 60,000 stalls and collisions; response times were under 6 minutes more than 87 percent of the time. Incidents were cleared in less than 20 minutes 72 percent of the time. An overall 10 percent reduction in the number of collisions on the freeways was also observed (National Traffic Incident Management Coalition 2006a).

- **Enhanced Computer-Aided Dispatch**. Enhanced computer-aided dispatch (E-CAD) systems—more commonly used by law enforcement, fire and rescue, and EMS—utilize automatic vehicle location (AVL) technologies to locate, dispatch, and route emergency vehicles closest to the incident scene to minimize response time. Enhanced computer-aided dispatch systems continuously update all information so that current field conditions can be viewed at any time.

  In 2004, the ITS Deployment Survey reported at least 43 major metropolitan areas in the United States using E-CAD systems (ITS Deployment Survey Website 2008). Albuquerque Ambulance, an EMS provider in New Mexico, uses a map-based computer-aided dispatch system that allows the dispatcher to provide en-route ambulance drivers with the exact location of an emergency and guidance on appropriate routes. The company's efficiency has reportedly increased by 10 to 15 percent (Taylor 1997). Incident management personnel in Austin, TX, rated E-CAD systems as "moderate" in effectively enhancing access to the incident scene.

- **Dual Dispatch Procedures**. In areas where traffic volumes are high, the distance between interchanges or crossovers is unusually long, or the exact location or direction of an incident has not been confirmed, dual dispatch procedures may be used to ensure the quickest response to an incident. Response units are dispatched in both directions; the first unit to locate the incident provides response, and the other units return to their station. Dual dispatch has proven to be successful in improving response times to incidents.

Incident management personnel in Redding, CA, rated dual dispatch procedures as "high" in effectively enhancing access to the incident scene. Conversely, incident management personnel in Chattanooga, TN, rated this strategy as "low." Benefits of dual dispatch procedures may not be fully realized if traffic volumes are high along all routes leading to the incident or if travel distances for supplemental (i.e., dual) responders are lengthy.

- **Median Crossovers**. Access to an incident is often a problem. Roadway geometrics or traffic congestion poses particular problems for large fire and towing/recovery equipment. Movable median barriers and emergency crossovers (U-turns) at key locations can significantly reduce response times for emergency and support vehicles. To accurately identify the most appropriate locations for improved emergency access, historical incident location data and input from all responding agencies should be considered. Procedures for ramp closures and the "wrong-way" escorting of response vehicles can also be developed to reduce response times to incidents.

  Incident management personnel in Bishop, CA, Redding, CA, and Austin TX, reported utilizing median crossovers and consistently rated their effectiveness in enhancing access to the incident scene as "moderate" in their respective locales. Comparatively, median crossovers were rated as "low" by incident management personnel in Salt Lake City, UT, and "high" by incident management personnel in Baltimore, MD, and Chattanooga, TN, in effectively enhancing access to the incident scene. The range in reported effectiveness may be indicative of the appropriateness of median crossover locations, their frequency, or—in cold weather environments—the effort expended in keeping the median crossovers passable (i.e., free of snow and ice) for incident response vehicles.

- **Traffic Signal Pre-emption**. Traffic signal pre-emption systems allow the normal operation of traffic signals to be temporarily interrupted, giving emergency vehicles priority by changing traffic signals in the path of the vehicle to green and stopping conflicting traffic. Emitters installed on emergency vehicles are generally calibrated to activate signals within a quarter mile. Traffic signal pre-emption systems can reduce response time for emergency responders and minimize the potential for conflict with another vehicle while the emergency vehicle is en route to the scene.

  Following implementation of traffic signal pre-emption systems at 22 intersections, Houston, TX, reported a decrease in the average emergency vehicle travel time of 16 to 23 percent (Traffic Engineers, Inc. 1991). Incident management personnel in Redding, CA, and Austin TX, consistently rated traffic signal pre-emption as "moderate" in effectively enhancing access to the incident scene in their respective locales. Comparatively, traffic signal pre-emption was rated as "low" and "high" in effectively enhancing access to the incident scene by incident management personnel in Salt Lake City, UT, and Baltimore, MD, respectively. The range in reported effectiveness may be explained, in part, by the number of intersections equipped with traffic signal pre-emption and the effort expended in maintaining the system to ensure ongoing functionality.

Scene Management and Traffic Control

Scene management is the coordination and management of resources and activities at or near the incident scene, including personnel, equipment, and communication links. The scene management phase of incident management occurs after responding agencies have arrived at the scene. Injured persons are immediately attended to, the incident scene is protected, and plans are formulated for scene documentation and wreckage or debris clearance. Successful scene management relies heavily on interagency cooperation and traffic management strategies. For minor incidents, scene management is relatively simple, usually involving just a single agency (e.g., a transportation agency) or a single agency and a company (e.g., a police agency and a wrecker company). Scene management becomes much more complicated as the severity of the incident increases. The number of responding agencies and companies and the number and complexity of individual tasks consequently increase.

The objectives of improved scene management are to effectively coordinate the activities of multiple agencies, improve interagency and intra-agency communications, maximize the use of personnel and resources, and improve the safety of motorists and responders through traffic management. Because much of scene management deals with personnel coordination, measured benefits of improved site management efforts are seldom available.

Common challenges to effective scene management and traffic control include:

- confusion over authority/roles,
- difficult on-scene maneuverability,
- responder safety,
- secondary incidents, and
- excess delay.

Table 4 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation. When such information was not reported by TIM practitioners, relative effectiveness ratings for select strategies were derived from benefits reported in published sources, as appropriate.

An additional challenge related to scene management and traffic control that is not listed here relates to limited on-scene communications. When agencies from different or multiple jurisdictions need to coordinate response actions on-scene, direct communications may be prevented by incompatible radio systems. Consequently, when responding to a major incident, agencies must cope with other, inefficient means of communications (such as relaying messages through multiple dispatchers, or using runners to hand-carry messages). As an example, law enforcement personnel may want to inform transportation personnel of the need to close a lane temporarily to remove the wreckage from the scene. The transportation personnel may be a significant distance upstream of the incident performing traffic control. Incompatible radio systems prevent the request from being made directly. The various tools and strategies that have been developed and implemented in an effort to overcome challenges related to on-scene communications are described later in this document under *Cross-Cutting Challenges and Strategies*.

Confusion over Authority/Roles. Response personnel at the scene of an incident are often required to make quick decisions that may have serious or even life-threatening implications. Disagreement among response personnel regarding the proper actions to take can lead to additional stress at the incident scene and can have a lasting, damaging effect on long-term interagency relationships. The question of who is "in charge" often arises when disagreement exists. One of the more common disagreements involves when to close a roadway to traffic. The disagreement over this issue stems from differing agency priorities. Transportation personnel traditionally have pressed to keep the roadway open to alleviate traffic congestion and prevent secondary incidents. Police and fire and rescue agencies have traditionally encouraged road closure to protect response personnel from passing traffic and to maintain the integrity of evidence at the scene.

- **Incident Command System.** The Incident Command System (ICS) is a federally adopted, on-scene command and control protocol that lends consistency to actions at an incident, clearly defines command, improves interdisciplinary communication, and more fully utilizes resources. The Incident Command System relies upon a unified command concept whereby management responsibility is shared for the incident, but ultimate decision-making authority rests with the incident commander. The incident commander designate depends upon the nature of the incident. A fire and rescue officer typically serves as incident commander on an injury crash scene that requires extrication of a victim. For a spilled load or other incident that impacts traffic flow but does not involve threats to life

Table 4. Scene Management and Traffic Control Challenges, Strategies, and Reported Effectiveness

SCENE MANAGEMENT AND TRAFFIC CONTROL STRATEGIES	Confusion over Authority/Roles	Difficult On-Scene Maneuverability	Responder Safety	Secondary Incidents	Excess Delay	REPORTED EFFECTIVENESS
Incident Command System	●					Low-Very High
Supporting Legislation for the Incident Command System	●					Moderate-High
Interdisciplinary Training	●					Very Low-Very High
Equipment Staging Areas		●				Moderate-Very High
Rapid Traffic Control Device Deployment		●	●	●		Low-Very High
Manual on Uniform Traffic Control Devices –Compliant Traffic Control Training		●	●	●		Low-Very High
Response Vehicle Parking Plans		●				Low-High
On-Site Traffic Management Teams			●			Very High
High-Visibility Safety Apparel			●			Moderate-Very High
Responder Injury Tracking			●			High
Emergency-Light Discipline			●			Moderate
Move Over Laws			●			Low-Moderate
Driver Education			●			Low-Moderate
Secondary Incident Definition/Tracking				●		Moderate-High
End of Queue Advance Warning Systems				●		Low-Very High
High-Occupancy Vehicle Lane Use Protocol					●	High-Very High
Responsive Traffic Signal Control Systems					●	Low-Very High
Alternate Route Plans					●	Low-High
Distinct Car/Truck Alternate Routes					●	Moderate-High
Alternative Traffic Signal Timing Plans					●	Moderate
Managed Lane/Variable Lane Closures					●	Low
Ramp Controls					●	Low
Decision Support Systems					●	*Very Low-Moderate* [1]

[1] *Reported effectiveness is based on benefits reported in published sources.*

or safety, a law enforcement officer may perform the command function. The first unit to arrive on the scene should always assume command; adjustments can be made as subsequent responders arrive on-scene. All agencies that have a responsibility at an incident cooperatively determine the overall incident objectives, strategies, planning efforts, integrated activities or actions to take place, and maximum use of resources. Transportation personnel, traditionally untrained in ICS principles, can refer to the *Simplified Guide to the ICS for Transportation Professionals* (Ang-Olson and Latoski 2006) to learn more.

In 2004, the ITS Deployment Survey reported at least 65 agencies in 58 major U.S. metropolitan areas operating under ICS principles; 26 were required to do so by law (ITS Deployment Survey Website 2008). Use of the ICS was rated as "low" by incident management personnel in Bishop, CA, and Chattanooga, TN; "moderate" by incident management personnel in Stockton, CA, and Austin, TX; "high" by incident management personnel in Los Angeles, CA, and Redding, CA; and "very high" by incident management personnel in Baltimore, MD, in effectively clarifying response personnel authority and roles in their respective locales.

- **Supporting Legislation for the Incident Command System.** To support implementation of the Incident Command System, supporting legislation may be required. In Washington, the following supporting legislation exists related to the Incident Command System:

  §70.136.030 Incident Command Agencies—Designation by Political Subdivisions. The governing body of each applicable political subdivision of this state shall designate a hazardous materials incident command agency within its respective boundaries, and file this designation with the director of community development. In designating the incident command agency, the political subdivision shall consider the training, manpower, expertise, and equipment of various available agencies as well as the Uniform Fire Code and other existing codes and regulations. Along state and interstate highway corridors, the Washington State Patrol shall be the designated incident command agency unless by mutual agreement the role has been assumed by another designated incident command agency. If a political subdivision has not designated an incident command agency within 6 months after July 26, 1987, the Washington State Patrol shall then assume the role of incident command agency by action of the chief until a designation has been made.

  §70.136.035 Incident Command Agencies—Assistance from State Patrol. In political subdivisions where an incident command agency has been designated, the Washington State Patrol shall continue to respond with a supervisor to provide assistance to the incident command agency.

  In 2004, the ITS Deployment Survey reported at least 47 major metropolitan areas in the United States having associated State laws or formal agreements legally specifying who is in charge at the scene of a traffic incident (ITS Deployment Survey Website 2008). Incident management personnel in Redding, CA, and Baltimore, MD, rated supporting legislation for ICS as "moderate" and "high," respectively, in effectively clarifying response personnel authority and roles.

- **Interdisciplinary Training.** Although the roles and priorities of the various agencies that respond to incidents are largely distinct, NTIMC's Training Task Force has identified essential TIM functions that can be commonly performed by various agency personnel in the document *Multidisciplinary Core Competencies* (National Traffic Incident Management Coalition 2008). For example, NTIMC recommends that all responders, regardless of discipline, be trained to position vehicles to support scene safety and expeditious exit of EMS vehicles, establish temporary traffic control, provide basic first aid to victims until EMS arrives, and assume incident command until replaced. NTIMC recommends cooperative roles for law enforcement and transportation personnel when establishing advanced traffic control and detour routes, with fire and rescue personnel providing assistance as

needed. Similarly, law enforcement personnel are primarily tasked with vehicle and debris removal, but transportation and fire and rescue personnel are urged to take an assistive role. Both fire and rescue and transportation personnel are expected to competently perform functions associated with cleanup of minor spills.

Interdisciplinary training, particularly in these common functional areas, will encourage more efficient and effective scene management. Interdisciplinary training opportunities may include operational training through tabletop exercises/scenarios or commercially available virtual incident simulation software or awareness training through local or national TIM courses. The National Highway Institute offers a suite of courses that includes *Managing Traffic Incident and Roadway Emergencies* (FHWA-NHI-133048A), *Managing Travel for Planned Special Events* (FHWA-NHI-133099), and *Using the Incident Command System (ICS) at Highway Incidents* (FHWA-NHI-133101). Additional TIM training-related information is provided later in this document.

A wide range of effectiveness was reported by TIM practitioners participating in this investigation regarding interdisciplinary training. Incident management personnel in Bishop, CA, Austin, TX, and Salt Lake City, UT, consistently rated interdisciplinary training as "moderate" in effectively clarifying response personnel authority and roles. Comparatively, incident management personnel in Chattanooga, TN, rated interdisciplinary training as "very low," and incident management personnel in Stockton, CA, and Baltimore, MD, rated interdisciplinary training as "very high" in effectively clarifying response personnel authority and roles. The wide range in reported effectiveness may be explained, in part, by considering the nature of training provided, its frequency, and its participants.

Difficult On-Scene Maneuverability. Accessibility to and maneuverability at the incident scene can be complicated by the incident response or emergency vehicles already at the scene. Traditionally, response vehicles have been parked where convenient without thought to access or roadway blockage. When a response vehicle must be moved, often the driver of the vehicle is not nearby, resulting in unnecessary delays at the scene.

- **Equipment Staging Areas**. For major incidents, significant and varied equipment may be required to clear the incident. Certain pieces of equipment that may be slow to mobilize—such as a front-end loader that needs to be loaded onto a flatbed trailer for transport—should be requested early in the incident management process to minimize lost time waiting for its arrival. Conversely, the early and intermittent arrival of equipment may compromise scene access and maneuverability. To enhance operations, a temporary staging area can be created to organize the equipment and designate its use. The staging area should be near the incident scene and easily accessible to responders.

  Incident management personnel in Salt Lake City, UT, Austin, TX, and Baltimore, MD, reported using equipment staging areas and rated their effectiveness in enhancing access to and maneuverability at the incident scene as "moderate," "high," and "very high," respectively.

- **Rapid Traffic Control Device Deployment**. The rapid and appropriate deployment of traffic control devices at the scene of an incident can improve access to and maneuverability at the incident scene for responders. Sufficient traffic control devices are commonly unavailable to non-transportation personnel. Roll-up warning signs can be carried in law enforcement or other response vehicles to provide early traffic control. Signs and cones can also be stocked on trailers and stored in strategic locations so that they can be quickly accessed and taken to an incident scene.

  Incident management personnel in Bishop, CA, Redding, CA, Stockton, CA, Austin, TX, and Salt Lake City, UT, consistently rated the rapid deployment of traffic control devices as "moderate" to "high" in effectively enhancing access to and maneuverability at the incident scene. Comparatively, incident

management personnel in Chattanooga, TN, and Baltimore, MD, rated the rapid deployment of traffic control devices as "low" to "very high," respectively, in effectively enhancing access to and maneuverability at the incident scene. The range in reported effectiveness may be explained, in part, by the nature and extent of traffic control devices available to incident responders, and the expediency with which these devices are mobilized and deployed.

- *Manual on Uniform Traffic Control Devices*–Compliant Traffic Control Training. Every effort should be made to conform to accepted traffic control standards. The use of standards meets driver expectations and reduces a public agency's potential for liability. Non-transportation personnel are often ill equipped and untrained to provide extensive traffic control at the scene of an incident. Because they are often first on the scene, however, enhancements to scene management could result if they are trained in *Manual on Uniform Traffic Control Devices* (MUTCD)–compliant procedures, despite limitations in available traffic control devices. The American Traffic Safety Services Association (ATSSA) offers the *Emergency Traffic Control for Emergency Responders* course aimed at law enforcement, fire and rescue, and towing and recovery personnel who respond to incidents or enforce traffic control in work zones. This course presents the temporary traffic control concepts included in Section 6.I of the *Manual on Uniform Traffic Control Devices*.

  In 2004, the ITS Deployment Survey reported that on-scene responders are familiar with MUTCD traffic control standards in at least 64 major metropolitan areas in the United States (ITS Deployment Survey Website 2008). Incident management personnel in Bishop, CA, Redding, CA, Austin, TX, and Salt Lake City, UT, consistently rated MUTCD-compliant traffic control training as "low" to "moderate" in effectively enhancing access to and maneuverability at the incident scene. Comparatively, incident management personnel in Baltimore, MD, rated this same strategy as "high" in effectively enhancing access to and maneuverability at the incident scene.

- Response Vehicle Parking Plans. Response vehicle parking plans serve to preserve maneuverability at the scene, ensure response personnel safety, protect response personnel at the incident scene, and maintain traffic flow past the incident. While it is not possible to develop parking plans to fit all incident scenarios, it is possible to develop guidelines or policies about how and where response vehicles should be parked so that travel lanes can be opened when they are no longer needed by responders. For example, all responding vehicles should be parked on the same side of the roadway on which the incident occurred. With the exception of vehicles parked to secure the incident scene, response vehicles should be parked on the shoulder to keep from blocking any additional lanes of traffic. Fire personnel are usually directed to park their vehicles directly behind or in front of the cars involved in the emergency, to minimize the disruption of traffic and to reduce the exposure of personnel and apparatus to danger. On-scene tow trucks, sand trucks, and other vehicles should be parked where they can be accessed and moved while not blocking lane-opening activities.

  Incident management personnel in Salt Lake City, UT, rated response vehicle parking plans as "high" in effectively enhancing on-scene maneuverability. Conversely, incident management personnel in Chattanooga, TN, rated response vehicle parking plans as "low" in effectively enhancing on-scene maneuverability. The wide range in reported effectiveness is likely indicative of differences in incident response personnel adherence to the response vehicle parking plan rather than differences in the effectiveness of the underlying plans. Unless response vehicle parking plans are integrated into emergency and support intra- and interagency training, consistent adherence to the plan among all incident response personnel will be challenged.

Responder Safety. Since 2003, 59 law enforcement, 12 fire and rescue, and 54 highway maintenance personnel have been killed after being struck by vehicles along the highway, according to the Bureau of Labor Statistics (2008). Data on towing and recovery industry occupational fatalities are not well tracked. However, TRAA anecdotally reports a loss of about 100 towing operators in the line of service annually (The Survivor Fund Website 2008). The occurrence of responder injury or "near misses" is much higher.

- **Rapid Traffic Control Device Deployment**. The rapid deployment of traffic control devices at the scene of an incident (described previously) not only improves access to the scene for responders but also provides a safe on-scene environment for responders performing incident management duties.

  Incident management personnel in Bishop, CA, Redding, CA, Stockton, CA, Austin, TX, and Salt Lake City, UT, consistently rated the rapid deployment of traffic control devices as "moderate" to "high" in effectively enhancing responder safety. Comparatively, incident management personnel in Baltimore, MD, rated the rapid deployment of traffic control devices as "very high" in effectively enhancing responder safety.

- ***Manual on Uniform Traffic Control Devices*–Compliant Traffic Control Training**. The use of accepted traffic control standards by all incident responders (described previously) not only improves access to the scene for responders but also provides a safe on-scene environment for responders performing incident management duties.

  Incident management personnel in Bishop, CA, Redding, CA, Austin, TX, and Salt Lake City, UT, rated MUTCD-compliant traffic control training as "low" to "moderate" in effectively enhancing responder safety. Comparatively, incident management personnel in Baltimore, MD, rated MUTCD-compliant traffic control training as "very high" in effectively enhancing responder safety.

- **On-Site Traffic Management Teams**. As noted previously, the rapid and appropriate deployment of traffic control devices at the scene of an incident can improve access to the scene for responders, minimize secondary incidents, and provide a safe on-scene environment for responders when performing incident management duties.

  To ensure adequate scene protection for incident responders, incident management personnel in Stockton, CA, reported using on-site traffic management teams to quickly and effectively establish proper traffic control. These same personnel rated on-site traffic management teams as "very high" in effectively enhancing responder safety.

- **High-Visibility Safety Apparel**. High-visibility safety apparel is defined as personal protective safety clothing that is intended to provide conspicuity during both daytime and nighttime usage. In November 2008, a new Federal regulation (*23 Code of Federal Regulations [CFR] 634*) went into effect that mandates the use of high-visibility clothing meeting American National Standards Institute (ANSI)/International Safety Equipment Association (ISEA) 107 Class 2 or 3 requirements by anyone working in the right-of-way of a Federal-aid highway. Incident responders are included in this definition.

  Incident management personnel in Bishop, CA, Redding, CA, Stockton, CA, Baltimore, MD, and Chattanooga, TN, consistently rated high-visibility safety apparel as "high" to "very high" in effectively enhancing responder safety. Comparatively, incident management personnel in Salt Lake City, UT, rated high-visibility safety apparel as "moderate" in effectively enhancing responder safety because of the lack of physical protection provided.

- **Responder Injury Tracking**. Injury tracking has largely been motivated by Occupation Safety and Health Administration (OSHA) recording and reporting requirements as defined in *CFR Part 1904*. These records are not specific enough in terms of the personnel, function, or event leading to the resulting injury to support accurate determination of responder injuries and fatalities resulting from TIM activities. Law enforcement personnel maintain distinct records and have developed companion websites to increase awareness of officer injuries and fatalities (i.e., National Law Enforcement Officers Memorial Fund Website: http://www.nleomf.com/TheMemorial/Facts/state.htm, The Officer Down Memorial Page, Inc.: http://www.odmp.org/). Recently, TRAA initiated a similar effort to record and increase awareness of towing and recovery operator injuries and fatalities (The Survivor Fund Website: http://www.thesurvivorfund.com/need.php). Accurate estimates of responder injuries and fatalities attributable specifically to TIM activities can help to elevate the importance of and investment in effective scene management and traffic control strategies.

  Incident management personnel in Baltimore, MD, reported tracking responder injuries and rated the effectiveness of this strategy in enhancing responder safety as "high." Increased information and awareness regarding responder injuries can encourage further investment in protective tools and strategies to enhance responder safety.

- **Emergency-Light Discipline**. In the initial stages of an incident, the appropriate use of emergency lights is essential for responder and motorist safety. Emergency lights help speed the response of emergency personnel to the incident and serve as a warning to approaching traffic of the presence of stopped or slowed vehicles in the area. However, the prolonged use of emergency lights at the scene of an incident can have detrimental effects. Emergency lights are often distracting and confusing to motorists, especially at night and for major incidents that involve a number of emergency vehicles. Emergency lights also contribute to congestion as motorists slow down to observe the cause of the flashing lights. As such, the use of emergency lights should be reduced as soon as sufficient traffic control (i.e., advanced warning signs and traffic control devices) has been established at the incident scene. Specific guidelines can be developed that include general emergency-light use procedures (i.e., turn off forward-facing emergency lights once on-scene; avoid using red or white flashing, strobing, or oscillating lights of any kind around merging lanes to avoid masking the directional arrow lights) and a phased approach for reducing emergency-light use concurrent with the deployment of traffic control devices for scene protection.

  Incident management personnel in Chattanooga, TN, reported using a local emergency-light discipline to minimize motorist distraction and confusion when passing the scene of an incident and rated its effectiveness in enhancing responder safety as "moderate."

- ***Move Over* Laws**. *Move Over* laws require drivers approaching a scene where emergency responders are present to either change lanes when possible and/or reduce speed with the intent of enhancing responder safety. *Move Over* laws are commonly included as extensions to pre-existing laws directing a driver to slow and pull to the side of the road to allow emergency vehicles with warning devices activated to pass. These laws have been modified to include driver guidance when approaching and passing stationary emergency vehicles along the roadside. Anecdotally, responders have expressed concern over the lack of *Move Over* law awareness among drivers and the challenges faced by law enforcement personnel tasked with performing incident management duties and concurrently enforcing *Move Over* laws.

  At the time of this investigation, all but seven States have enacted *Move Over* laws. Significant national initiatives, led by the *Move Over, America* partnership and the American Automobile Association (AAA), have contributed to the proliferation of these laws among States. The AAA initiative encourages enactment of *Move Over* laws that cover tow trucks and other roadside assistance vehicles in addition to law enforcement vehicles, fire trucks, and ambulances. Incident

management personnel in Bishop, CA, Redding, CA, Chattanooga, TN, Austin, TX, and Salt Lake City, UT, rated *Move Over* laws as "low" to "moderate" in effectively enhancing responder safety in their respective locales.

- **Driver Education.** Because the effectiveness of *Move Over* laws relies heavily upon driver cooperation, the Move Over, America partnership and AAA initiated concurrent national public information campaigns comprised of public safety announcements and other publicity efforts in an effort to raise awareness of driver responsibilities under these laws.

  Select States, such as Florida, have also included State-mandated driver education initiatives and enforcement directives as part of their legislation:

  > §316.126. 2 (c) The Department of Highway Safety and Motor Vehicles shall provide an educational awareness campaign informing the motoring public about the Move Over Act. The department shall provide information about the Move Over Act in all newly printed driver's license educational materials after July 1, 2002.

  Incident management personnel in Chattanooga, TN, and Austin, TX, rated driver education as "low" to "moderate" in effectively enhancing responder safety in their respective locales.

Secondary Incidents. Secondary incidents caused by unsuspecting approaching motorists may increase both the number and severity of injuries attributable to incidents and compound the impact of congestion and time taken to clear the roads. Minor incidents, if not cleared quickly, can result in more serious, major incidents. A passing vehicle may strike a disabled vehicle on the shoulder, seriously injuring the vehicle occupants or a pedestrian changing a flat tire on the side of the road. Major incidents can also lead to multiple minor incidents. If a traffic queue forms behind a major incident, minor incidents such as fender bender crashes are likely to occur. Each of these minor incidents, in turn, needs attention from response agencies. Incidents can be considered secondary to a primary incident if the time and location of the incident can be correlated with the primary incident, including the queue dissipation times. Accurately quantifying the actual number of secondary incidents is challenging; a high proportion of secondary incidents is likely minor and may never be formally reported to police agencies. Although no standard measure is defined to identify secondary incidents, most estimates suggest that between 14 to 18 percent of the total incidents are secondary in nature (National Conference on Traffic Incident Management 2002).

- **Rapid Traffic Control Device Deployment.** The rapid deployment of traffic control devices at the scene of an incident (described previously) not only improves access to and safety at the scene for responders but can also minimize the potential for secondary incidents involving approaching motorists.

  Incident management personnel in Los Angeles, CA, Bishop, CA, Redding, CA, and Salt Lake City, UT, consistently rated the rapid deployment of traffic control devices as "moderate" in effectively reducing the potential for secondary incidents. Comparatively, incident response personnel in Baltimore, MD, rated the effectiveness of this strategy for reducing the potential for secondary incidents as "very high."

- ***Manual on Uniform Traffic Control Devices*–Compliant Traffic Control Training.** Similarly, the use of accepted traffic control standards by all responders (described previously) can minimize the potential for secondary incidents involving approaching motorists, in addition to improving access to and safety at the scene for responders.

Incident management personnel in Bishop, CA, Redding, CA, and Salt Lake City, UT, consistently rated MUTCD-compliant traffic control training as "low" to "moderate" in effectively reducing the potential for secondary incidents. Comparatively, incident response personnel in Baltimore, MD, rated the effectiveness of this strategy for reducing the potential for secondary incidents as "very high."

- **Secondary Incident Definition/Tracking.** Incidents can generally be considered secondary to a primary incident if the time and location of the incident can be correlated with the primary incident, including the queue dissipation times. The challenge is that the definition of secondary incidents is not standardized, and many agencies do not even attempt to classify an incident as secondary, treating all reported incidents as separate, primary incidents. The occurrence of secondary incidents can point to the need for specific incident management strategies such as improved traffic control at the scene, faster clearance times, the use of traffic diversions or alternate routes, the provision of additional traveler information, and more.

  Incident management personnel in Baltimore, MD, and Los Angeles, CA, reported defining and tracking secondary incidents in their respective locales and rated this strategy as "moderate" and "high," respectively, in effectively reducing the potential for secondary incidents.

- **End of Queue Advance Warning Systems.** Static, arrow board, or dynamic message signs are commonly utilized to warn motorists of a downstream traffic queue. Arrow boards and DMSs used for this purpose are commonly portable, and mounted on trailers or installed on appropriate response vehicles. End of queue advance warning should occur far enough upstream to provide motorists with sufficient notice to slow and stop their vehicle, as necessary. The appropriate location varies depending on the speed limit, extent of congestion, and roadway geometrics that affect driver sight distance. Warning devices should be moved as needed to remain well in advance of the queue.

  Incident management personnel in Los Angeles, CA, Redding, CA, Stockton, CA, and Chattanooga, TN, rated end of queue advance warning systems as "high" to "very high" in effectively reducing the potential for secondary incidents in their respective locales. Comparatively, incident management personnel in Salt Lake City, UT, and Bishop, CA, rated end of queue advance warning systems as "low" and "moderate" in effectively reducing the potential for secondary incidents. The range in reported effectiveness may be explained, in part, by the nature and extent of traffic control devices available as part of the end of queue advance warning system, and the expediency with which these devices are mobilized and deployed.

Excess Delay. The *2007 Urban Mobility Report* states that motorists in 437 U.S. urban areas incurred $78.2 billion in congestion costs in 2005, with 52 to 58 percent of the total motorist delay attributed to crashes and vehicle breakdowns (Schrank and Lomax 2007). Roadway capacity reductions exceed the physical blockage resulting from an incident, exacerbating congestion and delay levels. The temporary obstruction of one and two travel lanes along a three-lane freeway is estimated to reduce the available capacity of the facility by 63 and 77 percent, respectively (Smith et al. 2003). Incidents located wholly on the shoulder of a roadway are estimated to reduce the available capacity of the facility by up to 17 percent, depending on the nature of the incident (Transportation Research Board 2003). Current TIM efforts are credited with reducing annual delay by 129.5 million hours with an associated cost savings of approximately $2.5 billion (Schrank and Lomax 2007). Cost savings attributable to reduced fuel consumption and harmful emissions are included in these estimates.

- **High-Occupancy Vehicle Lane Use Protocol**. Interim high-occupancy vehicle (HOV) lane use relies on the suspension of vehicle occupancy or vehicle type restrictions to temporarily encourage or mandate lane use by general-purpose traffic. High-occupancy vehicle lanes are typically open only to buses or cars with a minimum number of occupants. During a major incident, it may be useful to suspend HOV lane restrictions; the additional capacity in the HOV lane can replace, in part, the mainline capacity lost because of the incident. Interim use of HOV lanes during a major incident requires an effective traveler information system (i.e., a network of variable message signs and highway advisory radio along with media reports) to inform motorists of modified HOV lane use policies. Field personnel should actively direct the diversion process to ensure motorists are aware of the proper action. To maintain the credibility of HOV lanes, its use by general-purpose traffic should be considered a last resort in an incident management plan. Preferred alternatives may include the use of alternate routes or shoulders as travel lanes. A set of criteria that defines when HOV lanes should be opened for interim use is imperative to provide consistency. Specific criteria for interim use of HOV lanes generally consider the time it takes to clear an incident and the percentage of reduced capacity caused by the incident.

  In Virginia, if the operation of clearing a major incident lasts longer than 2 hours or if an incident blocks 50 percent of the main lanes in the peak direction, then the restrictions on the HOV lane will be lifted (Hoppers 1999). Incident management personnel in Los Angeles, CA, and Baltimore, MD, rated HOV lane use protocols as "high" and "very high," respectively, in effectively reducing excess delay.

- **Responsive Traffic Signal Control Systems**. Responsive traffic signal control systems use algorithms that perform real-time optimization of traffic signal splits, offsets, phase lengths, and phase sequences based on current traffic conditions, demand, and system capacity to minimize delay and reduce the number of vehicle stops. Responsive traffic signal control systems offer potential benefit to motorists who have been rerouted because of an incident. Currently, if an incident occurs on the freeway, traffic reroutes onto arterials or city streets. This additional and unexpected increase in traffic volume quickly results in congested conditions. Responsive traffic signal control systems "sense" the increased traffic demand using electronic loops, video imaging, or microwave sensors and automatically adjust the signal timings to improve traffic flow.

  U.S. deployments of responsive traffic signal control systems in Los Angeles, CA, Broward County, FL, Newark, DE, Oakland County, MI, and Minneapolis, MN, reportedly resulted in delay reductions of 19 to 44 percent, travel time reductions of 13 to 25 percent, and a decrease in the number of stops of 28 to 41 percent (Sussman et al. 2000). Simulation of a network based on the Detroit Commercial Business District indicated that responsive traffic signal control for detours around an incident reduced delay by 60 to 70 percent for affected paths (Glassco et al. 1997). Incident management personnel in Baltimore, MD, rated responsive traffic signal control systems as "very high" in effectively reducing excess delay. Conversely, incident management personnel in Salt Lake City, UT, rated responsive traffic signal control systems as "low" in effectively reducing excess delay. The range in reported effectiveness may be explained, in part, by the geographic extent of the responsive traffic signal control system, the performance of the algorithms in responding to real-time traffic conditions, and the effort expended in maintaining the system to ensure ongoing functionality.

- **Alternate Route Plans**. Alternative routes have the potential to reduce traffic demand at the scene and reduce delay and frustration for the motoring public. Appropriate alternative routes intended for use by the motoring public are often difficult to identify and require associated diversion plans to be effective. The designation of alternative routes can be politically charged; buy-in from all affected jurisdictions is required. When county or city roadways are utilized as alternative routes, appropriate

jurisdictions should be notified immediately so that they may adjust to accommodate the additional traffic flow.

Despite these challenges, the 2004 ITS Deployment Survey reported at least 62 major metropolitan areas in the United States with pre-planned alternate route plans serving certain sections of the freeway system (ITS Deployment Survey Website 2008). Common criteria for initiating traffic diversion to alternate routes are based on the type of incident (reported by 56 metropolitan areas), incident duration (reported by 59 metropolitan areas), incident location (reported by 53 metropolitan areas), number of freeway lanes blocked (reported by 55 metropolitan areas), and time of day (reported by 36 metropolitan areas). Sufficient personnel, traffic control devices, and signing are required to adequately convey diversion direction to the motoring public who are being asked or required to divert. Incident management personnel in Bishop, CA, Redding, CA, Stockton, CA, Baltimore, MD, Austin, TX, and Salt Lake City, UT, consistently rated alternate route plans as "moderate" to "high" in effectively reducing excess delay. Comparatively, incident management personnel in Chattanooga, TN, rated the effectiveness of this strategy in reducing excess delay as "low."

- Distinct Car/Truck Alternate Routes. During an incident, motorists may self-route to an alternate route or be directed to an alternate route by incident management personnel. Not all routes may be able to accommodate all types of traffic, particularly large trucks. Truck traffic requires sufficient infrastructure that can support heavy loads and accommodate larger vehicle dimensions. Bridge and overpass structures are commonly limiting factors along potential alternate routes. In such instances, distinct alternate routes may be identified for passenger car and truck traffic.

  Incident management personnel in Bishop, CA, and Stockton, CA, reported using distinct car/truck alternate routes in their respective locales and rated their effectiveness in reducing excess delay as "moderate" and "high," respectively.

- Alternative Traffic Signal Timing Plans. The use of alternative or modified traffic signal timing plans during incident events can effectively improve traffic flow by providing additional green time along designated alternate routes. Most traffic signal controllers allow multiple programs to be set. Response personnel can override the normal program manually, or in some cases the timing may be set remotely from a transportation management center (TMC). Alternate route signal timing plans can be developed in conjunction with alternate route plans.

  Incident management personnel in Redding, CA, and Baltimore, MD, reported using alternative traffic signal timing plans and consistently rated their effectiveness in reducing excess delay as "moderate."

- Managed Lane/Variable Lane Closures. Overhead lane control signals can be used in managed lane systems to permit or prohibit the use of specific lanes. When lane control signals are placed over the individual lanes of highway, vehicular traffic may travel in any lane over which a green signal is shown but shall not enter or travel in any lane over which a red signal is shown. For TIM, variable lane closures can be used to shift traffic out of downstream blocked lanes well in advance of the incident scene. Lane control signals can also be used to indicate interim shoulder or HOV lane operations.

  Incident management personnel in Salt Lake City, UT, rated managed lane/variable lane closures as "low" in effectively reducing excess delay. The low reported effectiveness of these systems may be explained, in part, by the level of effort required to actively manage lane use and the level of compliance from motorists.

- **Ramp Controls**. When large numbers of diverted vehicles attempt to merge onto an alternate freeway or back on the same freeway downstream of an incident, regular ramp-meter timing may create long queues, which may spill back onto local streets. Most ramp-metering controllers allow either queue override or queue adjustment to flush the queue and allow vehicles to enter the freeway. Queue override temporarily suspends ramp metering, while queue adjustment temporarily increases the metering rate to allow more vehicles to enter.

  Incident management personnel in Salt Lake City, UT, reported using ramp controls and rated their effectiveness in reducing excess delay as "low."

- **Decision Support Systems**. Many of the decisions made and the resulting actions taken at the scene of an incident are based on the good judgment of well-trained response personnel. Sometimes, inconsistent decisions result during similar situations simply because different responders are present. Expert systems or decision support systems aim to minimize the personal judgment that goes into the decision-making process. The goal of decision support systems is to assist incident management personnel in finding the appropriate strategies to manage incidents and in executing the steps required for their implementation.

  In Anaheim, CA, a real-time, knowledge-based decision support tool (Traffic Control Manager) was used to assist TMC personnel with selection of alternative traffic control plans and traffic signal control timing plans after the occurrence of an incident. Simulations indicated that the plans chosen by the decision support tool reduced average travel time 1.9 to 29 percent and reduced stop time 14.8 to 55.9 percent, compared to scenarios without the tool (Logi and Ritchie 2001).

Quick Clearance and Recovery

Clearance and recovery are the final steps in the incident management process. Clearance refers to the safe and timely removal of any wreckage, debris, or spilled material from the roadway. Recovery refers to the restoration of the roadway to its full capacity. It is important to emphasize, particularly in providing information to the motoring public, that an incident should not be considered "cleared" until the traffic backup has fully cleared. Motorists are most interested in their chances of encountering delay. If an incident has been reported cleared because the blockage has been removed, but motorists encounter significant delay in the traffic backup, an agency may lose credibility and the public's trust and respect.

The objectives of improved incident clearance and recovery are to restore full roadway capacity as quickly and safely as possible; enhance the safety of responders and motorists; make the most efficient use of resources, including equipment and personnel; and minimize delay and ease frustration for motorists. Effective incident clearance relies on effective equipment utilization (i.e., appropriate towing and recovery vehicles, push bumpers) and an awareness of legal authority to speed clearance.

Common challenges to effective quick clearance and recovery relate to:

- abandoned vehicle hazards,
- lengthy minor incident clearance,
- lengthy major incident clearance, and
- liability concerns.

Table 5 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation. When such information was not reported by TIM practitioners, relative effectiveness ratings for select strategies were derived from benefits reported in published sources, as appropriate.

Table 5. Quick Clearance and Recovery Challenges, Strategies, and Reported Effectiveness

QUICK CLEARANCE AND RECOVERY STRATEGIES	Abandoned Vehicle Hazards	Lengthy Minor Incident Clearance	Lengthy Major Incident Clearance	Liability Concerns	REPORTED EFFECTIVENESS
Supporting Legislation for Abandoned Vehicles	●				Very Low-Moderate
Driver Education	●	●			Very Low-Moderate
Service Patrols		●			*High-Very High* [1]
Vehicle-Mounted Push Bumpers		●			High-Very High
Incident Investigation Sites		●			NA
Quick Clearance Policy		●	●		Moderate-Very High
Clearance Time Goals		●	●		Low-Very High
Authority Removal Laws		●	●		Low-Very High
Driver Removal Laws		●			Low-Moderate
Major Incident Response Teams			●		High-Very High
Supporting Legislation for Spilled Loads			●		Moderate-Very High
Total Station Survey Equipment/Photogrammetry			●		Moderate-Very High
Alternative Means of Marking Evidence			●		Moderate-High
Towing and Recovery Quick Clearance Incentives			●		*Moderate-High* [1]
Towing and Recovery Training/Equipment Standards			●		Moderate
Fatality Certification/Removal Protocol			●		Moderate
Hold Harmless Laws				●	Moderate-High

[1] *Reported effectiveness is based on benefits reported in published sources.*

Abandoned Vehicle Hazards. When a vehicle becomes disabled because of a mechanical failure, gasoline depletion, flat tire, or some other reason, motorists seldom stay in their vehicle and wait for help. Many walk along the roadway shoulder or are transported by another passing vehicle to reach services. When responders stop to offer assistance and a motorist is not with a vehicle, their action is commonly limited to "tagging" the vehicle as abandoned (if the responder has that authority). Once a vehicle has been tagged as abandoned, motorists are allowed to leave a vehicle in its location often in excess of 24 hours and up to 72 hours. Results of the 2004 ITS Deployment Survey indicated that 47 percent of participating metropolitan areas allow abandoned vehicles to remain in the right-of-way for more than 24 hours (ITS Deployment Survey Website 2008). Sometimes vehicles remain on the shoulder of the roadway longer than the allowable time either because they were not detected and reported immediately by law enforcement personnel, or law enforcement personnel did not specifically check for the vehicle at the end of the allowable time period. Accurately enforcing the "time clock" requires vehicles to be tagged at the time of detection and shoulders to be actively patrolled to assure that vehicles are not left long beyond the time allowed.

Law enforcement personnel can typically expedite removal of abandoned vehicles that are deemed a hazard; negative public reaction to this action and competing law enforcement duties may limit this practice despite the safety risk. In 2005, North Carolina completed a 5-year study of abandoned vehicle crash involvement and found that a total of 1,300 abandoned vehicles were struck, resulting in 47 fatality crashes and over 500 injuries (I-95 Corridor Coalition 2007). On a national level, in 2007, the National Highway Traffic Safety Administration reported an estimated 418 fatalities resulting from multiple vehicle incidents occurring on the roadway shoulder (240 fatalities) and median (178 fatalities) (Fatal Accident Reporting System Encyclopedia Website 2008).

- **Supporting Legislation for Abandoned Vehicles.** Given the similar risk for being struck by passing motorists, supporting legislation that does not distinguish removal actions for attended or unattended/abandoned vehicles is most advantageous for speeding the clearance of minor incidents. Consistent legislation for attended and unattended/abandoned vehicles may also simplify both driver understanding and enforcement actions. Distinct legislation may also require motorists to remain with their vehicle, significantly reducing or eliminating the occurrence of unattended/abandoned vehicles. As an alternative, States can modify existing legislation specific to unattended/abandoned vehicles to reduce the amount of time that motorists are allowed to leave a vehicle in its location.

  A third strategy that may not require a change in existing legislation is to expand the definition of "hazard" to include unattended/abandoned vehicles on the roadway shoulder or median. In most areas, responders can legally remove any parked vehicle that is considered hazardous. Because the perception of a "hazard" varies widely among responders, removal of unattended/abandoned vehicles on the shoulder or median may not be consistently performed. Agreement between law enforcement, transportation, and other response personnel regarding what constitutes a hazard can encourage improvements in quick clearance in the absence or interim of legislation change.

  In 2004, the ITS Deployment Survey reported at least 21 major metropolitan areas in the United States having associated State laws that limit the amount of time unattended/abandoned vehicles are allowed to remain within the State right-of-way to between 0 and 4 hours (ITS Deployment Survey Website 2008). Safety-related statistics concerning unattended/abandoned vehicles on the shoulder or median can be presented as the basis for recommending legislative modifications. Incident management personnel in Redding, CA, and Austin, TX, rated supporting legislation for abandoned vehicles as "moderate" in effectively addressing abandoned vehicle hazards. Comparatively, incident management personnel in Baltimore, MD, rated the effectiveness of this strategy in addressing abandoned vehicle hazards as "very low." This low level of perceived

effectiveness may be indicative of a lack of enforcement action to ensure that the law functions as intended.

- **Driver Education.** Driver education can encourage motorist compliance with laws related to both abandoned vehicles and *Driver Removal* law responsibilities (described later in this document) in the event of a minor incident.

  When a vehicle becomes disabled, motorists frequently leave their vehicle unattended to obtain services. In the absence of or in conjunction with legislation that requires motorists to remain with their vehicle, driver education efforts can encourage motorists to stay with their vehicles to hasten vehicle repair, accommodate towing, and minimize traffic impacts. With extensive use of service patrols, law enforcement patrols, cellular phones, and traffic-reporting services in most major metropolitan areas, quick and efficient notice of incapacitated vehicles is enhanced. A significant incentive for motorists is that, by staying with their vehicle and receiving help from law enforcement, transportation, or publicly or privately sponsored service patrol programs, they may save money. Many motorist assistance services are free or require a nominal charge.

  Incident management personnel in Redding, CA, rated driver education as "very low" in effectively addressing abandoned vehicle hazards.

Lengthy Minor Incident Clearance. Minor incidents, the most frequently occurring type of incident, typically affect only the roadway shoulder, result in local traffic impacts, require response from a single agency or company, and require informal actions to be taken to clear the incident. Some minor incidents may be cleared by the party involved before a responder even arrives at the scene. These self-helped incidents are seldom reported to law enforcement agencies.

Few direct operational challenges exist when clearing minor incidents. Instead, the factors challenging the quick clearance of minor incidents tend to be institutional in nature. For example, response to minor incidents may be low in priority relative to other competing duties that must be performed by law enforcement or transportation agency personnel. As such, response times to minor incidents may be lengthy, particularly in areas where dedicated service patrol programs are not offered. Secondly, quick clearance of minor incidents may be restricted by current legislation or policy that prevents an unattended or abandoned vehicle from being immediately removed from the roadway. Minor incidents can also be perceived to be major incidents if responders lack adequate training. For example, incidents involving hazardous materials are often classified as major incidents because they require response from specially trained fire or hazardous material response personnel. Minor petroleum, antifreeze, or other non-cargo fluids spilled from the vehicle do not constitute a hazard; unnecessary clearance delay often results because responders incorrectly classify them as hazardous materials (National Traffic Incident Management Coalition 2006a). Delayed clearance of minor incidents increases the amount of time that response personnel are exposed to danger, potential for secondary incidents, and motorist delay and associated fuel consumption and harmful emissions.

- **Service Patrols**. Service patrols are universally accepted as the most effective tool for TIM (National Conference on Traffic Incident Management 2002). The Federal Highway Administration is currently promoting use of service patrols on all urban freeways on a 24/7 basis as full emergency response partners with law enforcement, fire and rescue, EMS, and towing responders, and is encouraging their sustainability by promoting public agency cost sharing and public/private partnerships (Arnold 2008). One example of such a public/private partnership exists in Pennsylvania where the Pennsylvania Turnpike Commission has partnered with the State Farm Insurance company to provide safety service patrols along designated routes.

Service patrols are popular in urban areas across the United States largely because of the flexibility in services offered, hours of operation, cost, and other considerations. Service patrols can be publicly operated by transportation or police departments or privately operated. Service patrol vehicles commonly include vans or small pickups, but also include heavy-duty large trucks. Service patrols can operate 24 hours a day or only in the peak period, and may rove highway corridors or be stationed at fixed points such as at tunnel entrances, bridge approaches, or elevated roadway sections. An estimated 130 distinct service patrol programs operate along U.S. freeways (Baird 2008).

Benefit-to-cost ratios for service patrol programs are variable, reflective of the range of reported operating conditions among programs. Consistently, however, the program benefits significantly outweigh the costs. Early benefit-to-cost ratios, reported between 1990 and 1996, range from 2:1 to 36.4:1 (Fenno and Ogden 1997). More recent benefit-to-cost ratios range from 4.6:1 to 42:1, with a median benefit-to-cost ratio of 9.99:1 and an average benefit-to-cost ratio of 13.3:1 (Baird 2008). Service patrol benefits most commonly include reductions in overall incident duration, secondary incidents, and delay, including associated fuel consumption and harmful emissions, attributable to their role in responding to and clearing minor incidents and providing scene protection during major incidents.

Overall incident duration has reportedly been reduced by 28.6 percent in Maryland (Chang et al. 2003), 12 to 36 percent in Salt Lake City, UT (Perrin et al. 2004), and 8 minutes for disabled vehicles in Minneapolis, MN (Minnesota Department of Transportation 1994), as a result of service patrols. Oregon reported a reduction in incident duration of 15 to 30 percent as a result of expanding their freeway service patrol program from part-time to full-time operations (Bertini et al. 2001). During the first year of operations at the "Big I" work zone in Albuquerque, NM, the use of on-site service patrols reduced the average incident response time to less than 8 minutes (Dumke and Doyle 2001).

Once on-scene, service patrol operators can quickly verify the incident, provide scene protection, request additional response that may be required, and establish traffic control as necessary, easing access to the scene for subsequent responders and enhancing on-scene safety. Atlanta, GA, reported a 69 percent reduction in secondary incidents and a related annual cost savings of $1,611,054 (Guin et al. 2006). Maryland reported a 28.6 percent reduction in average incident duration, leading to an estimated 377 fewer secondary incidents (Chang et al. 2003). Northwest Indiana reported an annual cost savings of $618,200 attributable to a reduction in secondary incidents (Latoski et al. 1999).

Reported benefits related to delay, including associated fuel consumption and harmful emissions, are also substantial. Atlanta, GA, reported saving 7.25 million vehicle-hours of delay over 1 year with an annual cost savings of $152,053,180. An associated reduction in gasoline consumption of 5.17 million gallons and a reduction in diesel consumption of 1.66 million gallons was estimated to save an additional $10,365,969 annually. Harmful-emission reductions of 2,457 tons, 186 tons, and 186 tons of carbon monoxide (CO), hydrocarbons (HC), and nitrous oxide (NOx), respectively, with related annual cost savings of $1,247,985, $15,626,587, and $3,368,436, respectively, were also reported. Maryland reported reduced delay of approximately 30 million vehicle-hours with an associated 5-million-gallon reduction in consumed fuel. Florida reported eliminating over 1 million vehicle-hours of delay with an associated fuel savings of 1.7 million gallons of fuel. Northwest Indiana reported an annual cost savings of $1,241,300 and $78,300 attributable to delay and fuel consumption reductions, respectively (Latoski et al. 1999). Minneapolis, MN, reported an annual cost savings of $1.4 million attributable to service patrols (Minnesota Department of Transportation 1994).

Customer satisfaction with service patrol programs is high. Of motorists surveyed, 95 and 97 percent rated the service patrol program as "excellent" in Atlanta, GA, and Minneapolis, MN, respectively (Guin et al. 2006, Minnesota Department of Transportation 1994).

Service patrols can support quick clearance of minor incidents or disablements by directly relocating the vehicle (i.e., using push bumpers or tow straps/chains) from the travel lane or shoulder to a safe refuge, eliminating the delay caused when a tow truck is needed. If a vehicle is simply disabled, service patrol operators may also provide gasoline, water, or minor mechanical repair services to quickly remedy the problem. During major incidents, service patrols provide an important traffic control and scene protection function (i.e., warning and guiding approaching motorists past the incident) that allows emergency and other response personnel to quickly access the scene, focus on performing duties for which they are specially trained without the distraction or concern for traffic control, and rapidly exit the scene to ensure speedy transport of victims to a medical center or to expedite the opening of blocked lanes.

- **Vehicle-Mounted Push Bumpers**. Push bumpers, mounted on response vehicles, are used to quickly and safely remove disabled vehicles from the shoulder or travel lanes, reducing the likelihood of secondary incidents and improving the safety of both response personnel and motorists. Push bumpers are commonly mounted on law enforcement and transportation agency vehicles, particularly those used in a service patrol capacity. Vehicles equipped with push bumpers are used to relocate vehicles out of immediate danger; towing and recovery vehicles are used to transport the vehicle longer distances as required.

  Incident management personnel in Redding, CA, Stockton, CA, Baltimore, MD, Chattanooga, TN, and Salt Lake City, UT, rated vehicle-mounted push bumpers as "high" to "very high" in effectively enhancing the quick clearance of minor incidents in their respective locales.

- **Incident Investigation Sites**. Incident investigation sites provide a safe refuge off the main roadway where further investigation or documentation can take place. Incident investigation sites should be easily accessible from the main roadway, yet sufficiently out of sight to prevent motorist delay caused by rubbernecking. In addition, incident investigation sites should be adequately signed, be lit, and provide enough space to accommodate multiple vehicles or a large truck.

  Incident management personnel in Stockton, CA, indicated using incident investigation sites but did not rate their effectiveness in enhancing the quick clearance of minor incidents.

- **Quick Clearance Policy**. A key agreement supporting TIM efforts is a quick clearance or "open roads" policy that binds agencies to quick clearance consensus by setting implied or explicit goals for clearing traffic incidents from the roadway. Quick clearance policies can help to speed the clearance of both minor and major incidents, subsequently enhancing responder and public safety and reducing delay.

  Examples include Florida's Open Roads Policy, Georgia's Open Roads Policy, Maryland's Removal of Vehicles from Roadway Interagency Agreement, New Hampshire's Quick Clearance for Safety and Mobility Interagency Memorandum of Understanding, Tennessee's Urgent Clearance of Highway Incidents and Safety at Incident Scenes Interagency Memorandum of Understanding, and Wisconsin's Interagency Freeway Incident Clearance Policy Statement.

  Incident management personnel in Redding, CA, Stockton, CA, and Chattanooga, TN, rated quick clearance policies as "moderate" in effectively enhancing the quick clearance of minor incidents. Incident management personnel in Los Angeles, CA, and Baltimore, MD, rated this same strategy as "high" and "very high," respectively.

- **Clearance Time Goals**. Explicit performance goals for clearing traffic incidents from the roadway help to ensure continued focus on quick clearance and improvement in operations. The most frequently used performance metric for TIM programs is average or maximum incident clearance time, defined as the time between the first recordable awareness and the time at which the last responder has left the scene (National Traffic Incident Management Coalition 2006b).

  California, Washington, and Florida have statewide 90-minute incident clearance targets. Utah's State performance goals are based on incident severity: 20 minutes for fender benders, 60 minutes for injury crashes, and 90 minutes for fatalities. Idaho takes a similar approach, with a statewide program for 30-, 60-, or 120-minute maximum clearance times, based on incident severity (National Traffic Incident Management Coalition 2006b). Incident management personnel in Los Angeles, CA, Stockton, CA, Austin, TX, and Salt Lake City, UT, rated clearance time goals as "moderate" to "high" in effectively enhancing the quick clearance of minor incidents in their respective locales. Comparatively, incident management personnel in Bishop, CA, and Baltimore, MD, rated this same strategy as "low" and "very high," respectively, in effectively enhancing the quick clearance of minor incidents. The range of reported effectiveness may be explained, in part, by the perceived attainability of and focus placed on local clearance time goals and the extent of commitment among incident management agencies in pursuing these goals. Broader TIM program performance measurement activities are discussed later in this document.

- ***Authority Removal* Laws**. *Authority Removal* laws provide authorization to a pre-designated set of public agencies—generally including State, county, and local law enforcement or State departments of transportation (DOTs)—to remove from the roadway damaged or disabled vehicles and/or spilled cargo determined to be a hazard. Driver and authority removal responsibilities may be defined within the same statute: if the driver is unwilling or unable to remove the vehicle or cargo, designated authorities may require or perform removal without the consent of the owner. *Authority Removal* laws may also include immediate tow-away policies to ensure the timely removal of disabled vehicles from roadway shoulders in highly congested, metropolitan areas. More commonly, separate *Authority Tow* laws are in place to support removal of incident-involved vehicles and/or cargo on the shoulder or roadway right-of-way to an off-site location (e.g., storage area, service station). To protect responders against liability resulting from their good faith actions, *Hold Harmless* laws (described later in this document) or related language often accompanies *Authority Removal* laws. The same pre-designated agencies authorized to remove damaged or disabled vehicles and/or spilled cargo from the roadway, as well as any qualified responder working under the direction of these agencies, are protected under *Hold Harmless* laws.

  Approximately half of all States have enacted *Authority Removal* laws. Incident management personnel in Chattanooga, TN, Redding, CA, Austin, TX, and Baltimore, MD, rated *Authority Removal* laws as "low," "moderate," "high," and "very high," respectively, in effectively enhancing the quick clearance of minor incidents. In locales where *Authority Removal* laws were rated as "low" or "moderate" in effectively enhancing the quick clearance of minor incidents, response personnel may lack awareness and/or be reluctant to exercise their full authority under this law.

- ***Driver Removal* Laws**. *Driver Removal* laws—also referred to as *Fender Bender, Move It,* or *Steer It/Clear It* laws—are considered key strategies for speeding clearance of non-injury, property damage only crashes, which account for the majority of all crashes on U.S. roadways. These laws, currently enacted in approximately half of all States, encourage or require drivers involved in incidents to move their vehicle out of the travel lanes if they can do so safely. In the case of a disablement involving an immobilized vehicle, *Driver Removal* laws commonly mandate that drivers immediately seek assistance to remove their vehicle from the travel lanes. Concurrent legislation or language that (1) protects the driver from liability resulting from their actions or (2) waives at-fault determination regarding the cause of the incident as a result of moving their vehicle is often included

to encourage drivers to expeditiously move their vehicle. *Driver Removal* laws are becoming more important over time. As the levels of congestion build on U.S. roadways, transportation and law enforcement personnel meet increasing TIM demands, in the context of their other duties and responsibilities. Public agencies are challenged to function with ever-increasing constraints on personnel and resources. *Driver Removal* laws that require drivers to take response action not only enhance the safety of those involved and of approaching motorists, but also allow transportation and law enforcement personnel to focus on other duties.

Hamlin et al. (2007) considered the benefits attributable to a *Driver Removal* law enacted in South Carolina. Microscopic simulation analysis estimated that implementation of the related legislation resulted in an 11 percent reduction in delay for minor incidents with one lane blocked. This reduced delay, in turn, resulted in an average cost savings of $1,682 per incident, which is significant when considering the number of minor incidents occurring on a daily basis in large metropolitan areas. Besides the effect on congestion and its associated impacts, the authors cited benefits related to the safety of road users and incident response personnel. Incident management personnel in Baltimore, MD, Chattanooga, TN, and Austin, TX, rated *Driver Removal* laws as "low" to "moderate" in effectively enhancing the quick clearance of minor incidents. This low level of perceived effectiveness may be indicative of a lack of enforcement action to ensure that the law functions as intended.

- **Driver Education.** Driver education can encourage motorist compliance with laws related to both abandoned vehicles (described previously) and *Driver Removal* law responsibilities (described previously) in the event of a minor incident. If a vehicle is involved in an incident but is still able to be driven, an understanding by motorists of their responsibilities to move the vehicle out of the travel way and to a safe refuge can significantly improve safety and reduce delay.

  Several States have developed publicity materials to raise awareness of driver responsibilities under *Driver Removal* laws (see Table 6). Incident management personnel in Austin, TX, rated driver education as "moderate" in effectively enhancing the quick clearance of minor incidents.

Table 6. Example *Driver Removal* Law Publicity Materials

Florida	***Move It—Yes You Can!*** Brochure, Billboard, and Media Kit http://www.metroplanorlando.com/site/partnerships/moveit.asp ***Move It—It's the Law*** Website http://www.fhp.state.fl.us/misc/News/Related/2006/FHPnews032006e1.htm
Georgia	***Be Smart. Steer It and Clear It*** Brochure www.i95coalition.org/Incident-toolkit/documents/Flier/Flier_Move_GA.pdf
Maryland	***Move It—It's the Law*** Brochure www.chart.state.md.us/downloads/readingroom/Move_It_Form.pdf
North Carolina	***Frequently Asked Questions Regarding the "Move Over" Law and "Fender-Bender" Law in North Carolina*** Website http://www.ncdot.org/traffictravel/
Ohio	***Quick Clear*** Website http://www.dot.state.oh.us/quickclear/quickclear.asp
Texas	***Steer It...Clear It*** Website http://www.houstontranstar.org/sici.aspx
Virginia	***Move It—It's the Law*** Website http://www.virginiadot.org/info/faq-moveit.asp

Lengthy Major Incident Clearance. Major incidents typically affect one or more of the travel lanes, result in area-wide or corridor-wide traffic impacts, require response from multiple agencies or companies, require a more formal response plan, may involve fatalities or hazardous materials, and may require investigation. Major incidents occur less frequently but produce more severe impacts.

A myriad of factors may challenge the quick clearance of major incidents. Response personnel from multiple agencies or companies must not only perform the duties for which they were trained quickly and effectively, but must also coordinate these activities among all responders in the context of the broader incident management process. Oftentimes, this coordination suffers because of technical and institutional inefficiencies in communications. Major incidents also often require response from specially trained responders (i.e., responders capable of performing accident investigation or hazardous material response and cleanup) and specialty equipment (i.e., rotating crane, front-end loader) that may be slow to mobilize. In either case, a lack of consensus regarding the importance of quick clearance among all response agencies will exacerbate the detrimental impacts of the incident.

- **Quick Clearance Policy**. Depending on how it is drafted, quick clearance policies can help to speed the clearance of both minor (described previously) and major incidents.

  In 2004, the ITS Deployment Survey reported at least 35 major metropolitan areas in the United States having associated policies and procedures facilitating the quick removal of heavily damaged vehicles and non-hazardous cargoes (ITS Deployment Survey Website 2008). Incident management personnel in Redding, CA, Stockton, CA, and Chattanooga, TN, rated quick clearance policies as "low" to "moderate" in effectively enhancing the quick clearance of major incidents. Comparatively, incident management personnel in Los Angeles, CA, and Baltimore, MD, rated the effectiveness of quick clearance policies in effectively enhancing the quick clearance of major incidents as "high" and "very high," respectively.

- **Clearance Time Goals**. Explicit performance goals for clearing traffic incidents from the roadway help to ensure continued focus on quick clearance and improvement in operations for major as well as minor incidents (described previously).

  Incident management personnel in Los Angeles, CA, Baltimore, MD, Austin, TX, and Salt Lake City, UT, rated clearance time goals as "moderate" to "high" in effectively enhancing the quick clearance of major incidents.

- ***Authority Removal* Laws**. As noted previously, *Authority Removal* laws provide authorization to a pre-designated set of public agencies—generally including State, county, and local law enforcement or State DOTs—to remove from the roadway damaged or disabled vehicles and/or spilled cargo determined to be a hazard.

  Incident management personnel in Redding, CA, Stockton, CA, and Austin, TX, rated *Authority Removal* laws as "low" to "moderate" in effectively enhancing the quick clearance of major incidents. Comparatively, incident management personnel in Baltimore, MD, rated *Authority Removal* laws as "very high" in effectively enhancing the quick clearance of major incidents.

- **Major Incident Response Teams**. Major incident response teams are typically comprised of high-ranking individuals from a variety of disciplines (e.g., law enforcement, fire and rescue, transportation) who train for and respond to major incidents together and who are available 24/7. With the advent of the National Incident Management System (NIMS) in March 2004, major incident response teams now have a formalized framework for effective operation. Relying upon ICS principles, NIMS enables responders at all levels from various agencies and jurisdictions to work

together more effectively and efficiently to manage major incidents. NIMS also promotes proven incident management practices, standardized personnel training and certification, communications interoperability, ongoing performance evaluation, and more to enhance overall TIM operations. Major incident response teams not only improve response to an incident scene but also enhance personnel interaction at the scene and support quick incident clearance. Quick clearance efforts benefit from the high level of familiarity among the various team members and their authority to mobilize the necessary personnel and equipment to respond.

Incident management personnel in Los Angeles, CA, Redding, CA, and Stockton, CA, rated major incident response teams as "high" to "very high" in effectively enhancing the quick clearance of major incidents.

- **Supporting Legislation for Spilled Loads**. Large truck incidents can add a unique challenge to the clearance process. Often, cargo transported by truck is spilled across the roadway, requiring not only the righting and clearing of the involved vehicle but also the cleanup of associated cargo. If the cargo is hazardous, response from specially trained spill response personnel is required. In addition, certain types of non-hazardous cargo—such as agriculture or livestock, or certain other perishable products such as food—may require certification from the Department of Agriculture or Health Department to confirm that the load was damaged and is unusable. Personnel from these agencies are not common incident management participants and as such may be slow to arrive at the scene. Supporting legislation that allows for the rapid relocation of non-hazardous cargo out of the roadway prior to their arrival supports quick clearance ideals designed to enhance public and responder safety and reduce delay.

  Incident management personnel in Salt Lake City, UT, and Baltimore, MD, rated supporting legislation for spilled loads as "moderate" and "very high," respectively, in effectively enhancing the quick clearance of major incidents.

- **Total Station Survey Equipment/Photogrammetry**. Traditional methods of collecting physical evidence at an incident scene (i.e., the base-tape method or coordinate method, triangulation method) can be time consuming and personnel intensive, resulting in unnecessary delay to the motoring public and responder risk. Two technology-based strategies for speeding incident investigation include total station surveying equipment (TSSE) and photogrammetry. Total station surveying equipment uses an infrared electronic distance meter combined with a rod-mounted prism to automatically measure the horizontal distance to an object; a theodolite, or electronic transit, to measure the horizontal angle to an object; and an internal level to measure vertical rise to an object simultaneously. Photogrammetry captures the necessary data through the process of analyzing and interpreting photos taken at the incident scene. For either system, data captured in the field can be further analyzed off-site using specialized software, reducing the length of time the roadway or lanes need to be closed. Both systems have been credited with significantly reducing the amount of time it takes to perform incident investigation while increasing the number of measurements able to be captured.

  Incident management personnel in Redding, CA, Stockton, CA, Austin, TX, and Salt Lake City, UT, rated the use of TSSE and photogrammetry as "moderate" to "high" in effectively enhancing the quick clearance of major incidents in their respective locales. Comparatively, incident management personnel in Baltimore, MD, rated the effectiveness of TSSE and photogrammetry in enhancing the quick clearance of major incidents as "very high."

- **Alternative Means of Marking Evidence**. As noted above, traditional methods of gathering evidence for an incident investigation require that nothing be moved from its resting place until officers can record its type and location. Using the base tape method, a "baseline" tape is laid through the

incident scene; the perpendicular distance from the baseline tape to each evidentiary item is manually measured and recorded. This investigative process is very time consuming and prevents concurrent incident management activities from taking place. To speed the investigative process, alternative means of marking evidence (i.e., using paint to mark the evidence, including vehicle positions and locations, and a camera to photograph the incident scene) can be used. Once marked and recorded, the incident scene can be cleared. Police personnel can later return to the incident scene at a time when traffic volumes are low, close the necessary portion of the roadway, and collect the information required as part of the accident investigation. The use of alternative means of marking evidence is also encouraged as a means to speed incident clearance prior to the arrival of technology-based incident investigation tools (i.e., TSSE, photogrammetry) on-scene.

Incident management personnel in Bishop, CA, Redding, CA, and Stockton, CA, rated the use of alternative means of marking evidence as "moderate" to "high" in effectively enhancing the quick clearance of major incidents.

- Towing and Recovery Quick Clearance Incentives. A combination of financial incentives for quick clearance, and pricing disincentives for slow performance, have successfully improved tower performance and reduced clearance times.

  For example, in 2004, the Florida Turnpike Enterprise implemented the Nation's first Roadway Incident Scene Clearance (RISC) program in an effort to meet Florida's Open Roads policy of clearing incidents from roadways in 90 minutes or less. Under this program, contract towing and recovery operators are required to respond to major incidents with two certified heavy-duty wreckers and a support vehicle carrying cleanup and traffic control equipment. Contractors earn a $2,500 bonus if they respond to the incident site within 60 minutes and clear the roadway to traffic within 90 minutes of the Florida Highway Patrol's notice to proceed. If the contractor fails to open the roadway within 3 hours, the contractor is penalized $10 for each minute over. In the first 9 months of operation, the average time to respond to an incident was 41 minutes (well under the required response time of 60 minutes), and the average clearance time was 55 minutes (well under the required 90 minutes to receive bonus incentives) (Florida Department of Transportation 2005). Georgia and Washington recently initiated similar programs (the Towing and Recovery Incentive Program and the Blockage Buster Tow Incentive Program, respectively) aimed at clearing commercial and other vehicle incidents within 90 minutes. In Georgia, average incident duration decreased from 314 minutes in 2007 to 131 minutes in 2008 (Smith 2008). All three programs include explicit equipment, training, and performance requirements for participating towing and recovery companies.

- Towing and Recovery Training/Equipment Standards. Towing and recovery services represent an important component in the incident management process. Their quick response to the incident (upon notification) and their efficient conduct of the removal activity can be a key step in minimizing incident clearance time and the re-opening of a blocked roadway or portion of the roadway to the motoring public. Most commonly, towing and recovery services are provided through rotation lists, contractual agreements, or a combination of both. Poor or unresponsive service may result in a tower being removed from the rotational list, but this practice alone does not encourage improvement in the level of competency and operating standards in the towing and recovery industry. Carefully crafted contractual agreements with the towing and recovery industry that specify the use of standards, training and equipment requirements, and other measures to assure the quality and competency of towing service providers can better serve quick clearance efforts. Pre-qualification procedures can identify towing and recovery companies that have the appropriate equipment, education, certifications, and level of competency to serve as TIM responders.

TRAA has developed a three-level National Driver Certification Program that incorporates TIM training. An increasing number of law enforcement agencies that contract with towers are now requiring TRAA certification as a qualification for participation. In Virginia, adequate towing and recovery standards, training, and equipment requirements are encouraged through State law:

> §46.2-2826. Public safety towing and recovery services. The Board shall establish regulations required of Class A and Class B operators to provide public safety towing and recovery services. For the purposes of this section, "public safety towing and recovery services" shall be those towing and recovery and related services requested by a state or local law-enforcement agency. Such regulations shall establish minimum requirements, including qualifications, standards, necessary equipment, and public safety concerns necessary and appropriate to permit a Class A or Class B operator to provide public safety towing and recovery services. No operator shall provide public safety towing and recovery services unless they meet such criteria established by Board regulation applicable to public safety towing and recovery services. Upon submitting evidence to the Board of meeting such criteria, the Board shall maintain, on a timely basis, a list to be readily available to state and local law-enforcement agencies of Class A and Class B operators who meet the Board's criteria for providing public safety towing and recovery services.

Incident management personnel in Salt Lake City, UT, reported utilizing towing and recovery training and equipment standards in their locale and rated their effectiveness in enhancing the quick clearance of major incidents as "moderate."

- **Fatality Certification/Removal Protocol**. When responding to fatality traffic incidents, it is important to balance the need for thorough investigations into the cause of death, with the need to minimize responder exposure to danger, minimize risk of secondary incidents involving the motoring public, respect the dignity and privacy of the decedent and the decedent's family, and restore the flow of traffic. In many cases, local policy or State law requires that death be certified by a coroner or medical examiner and that the victim not be moved until the coroner has done so. The result may be significant delays to traffic while the arrival of a coroner is awaited; because the coroner is not facing a life or death situation, he or she may not feel an urgent need to respond. In addition, the number of coroners available is generally limited in comparison to their geographic area of coverage. Alternative policies include allowing a designated EMS unit to certify death. Accordingly, EMS units are typically among the first to arrive at an incident that may involve an injury or a fatality. Vital signs of fatalities can be telemetrically relayed to an off-site coroner for verification, eliminating the need for the coroner to travel to the site. Once death is certified, fatalities can be relocated to a better, safer refuge in the interest of public safety.

  In select States (Pennsylvania, Tennessee, and Texas), *Fatality Certification* laws permit the removal of the victim before the arrival of the coroner when the incident poses a safety hazard. To expedite clearing the roadway and to prevent additional incidents, law enforcement marks the locations and removes the victims immediately, without waiting for the arrival of the coroner. In the absence of or in addition to such legislation, interagency agreements can explicitly define or detail responder operations during fatality incidents. In Texas, for example, the Austin Police Department, Austin Fire Department, Austin-Travis County Emergency Medical Services, and Travis County Office of the Medical Examiner (TCME) recently developed an agreement that outlines mutual operating procedures to expedite the removal of deceased persons from the scene of an incident when the incident restricts the free movement of traffic on the State and National Highway Systems. The agreement also addresses operating procedures related to the dispatch of and communications with TCME investigative personnel, the expedited transport of deceased person(s), the relocation/removal of deceased persons in the absence of TCME investigative personnel, and the maintenance/capture of evidentiary information. Similar agreements are in place between the Washington State Patrol, the Washington State Department of Transportation, and various county medical examiners throughout the State.

Incident management personnel in Redding, CA, Stockton, CA, and Baltimore, MD, consistently rated fatality certification/removal protocol as "moderate" in effectively enhancing the quick clearance of major incidents.

Liability Concerns. Perhaps the most common issue that arises when attempts are made to speed incident clearance is the fear of liability resulting from additional damage to a vehicle or its cargo because of clearance actions taken. Important points to realize, however, are that (1) the vehicle and cargo are already damaged as a result of the incident and are already, in many instances, unusable; (2) damage costs are most often covered by insurers, not the party involved; and (3) liability costs attributable to extra damage are negligible in comparison to the liability costs associated with an unnecessary fatality or serious injury as a result of a secondary incident. This reasoning alone does little to overcome the reluctance of responders to take action.

- ***Hold Harmless* Laws**. Often, liability concerns are raised by responding agency personnel when they clear an incident because of additional damage the vehicle or cargo may incur during clearance procedures. Recent sensitivity to liability has resulted in hesitation regarding clearance actions, even though the resulting additional vehicle damage is often minimal and covered by the causing party's insurer. Concurrent legislation or language that protects responders from liability resulting from their actions (in the absence of gross negligence) is often included with *Authority Removal* laws to encourage responders to expeditiously move damaged or disabled vehicles and/or spilled cargo from the roadway. The same pre-designated agencies authorized to remove damaged or disabled vehicles and/or spilled cargo from the roadway, as well as any qualified responder working under the direction of these agencies, are generally protected under *Hold Harmless* laws. Approximately half of all States that have *Authority Removal* laws in place have concurrent *Hold Harmless* provisions. Select States (Texas and Virginia) also include *Hold Harmless* clauses that protect against liability for responder actions not taken; authorities are not held responsible for any damages or claims that may result from the failure to exercise any authority granted, provided they are acting in good faith.

  Similar concurrent legislation or language is often included with *Driver Removal* laws to protect drivers from liability resulting from their actions (in the absence of gross negligence) or waive at-fault determination regarding the cause of the incident as a result of moving their vehicle. Such language is intended to encourage drivers to expeditiously move their vehicle.

  In 2004, the ITS Deployment Survey reported at least 37 major metropolitan areas in the United States operating under associated *Hold Harmless* laws (ITS Deployment Survey Website 2008). Incident management personnel in Redding, CA, and Austin, TX, rated *Hold Harmless* laws as "moderate" and "high," respectively, in effectively alleviating liability concerns among incident responders.

CROSS-CUTTING CHALLENGES AND STRATEGIES

Efforts to develop or improve TIM are often challenged by issues of an institutional rather than operational nature. Common impediments frequently relate to:

1. agency relations,
2. training,
3. communications,
4. technology,
5. performance measurement, and
6. program resources and funding.

Institutional challenges are more difficult than operational challenges to characterize and address. As such, the effectiveness of various tools and strategies designed to overcome the most common impediments and improve overall TIM efforts is difficult to accurately determine. Many of these tools and strategies offer potential benefit across multiple institutional areas, with wide-ranging reported effectiveness.

The remainder of this chapter describes common institutional challenges and potential strategies for improvement for each of the six areas identified above. The relative effectiveness reported for each strategy is based upon input from TIM personnel directly participating in this investigation.

Agency Relations

Strong agency relations are a basic underlying principle of effective TIM. Key relationships should exist among transportation, law enforcement, fire and rescue, and EMS agencies and the towing and recovery industry. Additional partners that should not be overlooked include the trucking industry, traffic control industry, insurance industry, and emergency management agencies (National Traffic Incident Management Coalition 2006c). Positive agency relations can be encouraged and sustained through joint TIM operating policies, procedures, communications networks, and training.

Common challenges to effective agency relations relate to:

- differing agency priorities and cultures—especially between emergency and support agencies, and
- efforts to institutionalize TIM practices.

Table 7 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Table 7. Agency Relations Challenges, Strategies, and Reported Effectiveness

AGENCY RELATIONS STRATEGIES	Different Priorities/Cultures	Institutionalizing TIM	REPORTED EFFECTIVENESS
Administrative Traffic Management Teams	●		Moderate-Very High
Routine, Periodic TIM Meetings	●		Low-High
Joint Agency/Jurisdictional Protocols	●		Low-High
Viable Agency Career Path in TIM		●	Very High
Joint Traffic/Emergency Management Center		●	Low-Very High
Interagency Agreements		●	Low-High

Different Agency Priorities and Cultures. Although each traffic incident responder performs a valuable function at the scene of an incident, differing priorities and agency cultures often complicate and may delay the TIM process. For example, lengthy law enforcement investigation duties sometimes conflict with the objective of quickly restoring traffic flow under a multidisciplinary TIM approach. Fire and rescue personnel, with the intent of protecting the incident scene, may use fire equipment that can unnecessarily block traffic lanes and may not respond individually to requests from other response agencies unless their commanding officer directs them to do so. Transportation agencies are rarely connected directly to public safety emergency communications and dispatch systems, and not all operate 24 hours a day, resulting in sometimes lengthy after-hours response. Compared to other TIM participants, towing and recovery service providers are unique because they are not public agencies; they must remain profitable to retain a skilled work force and purchase and maintain expensive and complex equipment (Federal Highway Administration Traffic Incident Management Program Website 2008). Understanding these differences in priorities and operating protocols helps each participant appreciate another's expertise and helps agencies coordinate overall incident management efforts more effectively.

- **Administrative Traffic Management Teams.** An administrative traffic management team provides a formal, continuing mechanism for TIM program planning, oversight, support, and evaluation. Ideally, administrative traffic management teams are comprised of members from all incident management agencies or companies, and may evolve from an early working group or partnership into a permanent institutional entity. Their primary objectives—through improved interdisciplinary contact, communications, and awareness—are to secure resources and to implement procedures that benefit overall TIM operations. Specific tasks and functions may include selecting equipment or recommending compatible standards across jurisdictions, providing for personnel training, creating standard response plans for most incidents, defining responsibilities, facilitating agency coordination, or guiding overall program design and direction.

  Incident management personnel in Austin, TX, and Stockton, CA, reported utilizing administrative traffic management teams in their respective locales and rated their effectiveness in enhancing

agency relations as "moderate" and "very high," respectively. Incident management personnel in Austin, TX, indicated that a higher level of effectiveness could be achieved if the team had greater authority.

- **Routine, Periodic TIM Meetings.** To encourage ongoing dialogue among TIM responders, monthly or quarterly meetings may be held to bring forward and discuss TIM challenges, typically related to operations or safety. These meetings are commonly organized and facilitated by a champion within one of the participating agencies but may also be arranged through an external contractor. Successful meetings include regular participants from law enforcement, fire and rescue, emergency medical services, transportation departments, towing and recovery agencies, and others.

  Incident management personnel rated the effectiveness of periodic TIM meetings in enhancing agency relations as "low" in Bishop, CA, and Chattanooga, TN; "moderate" in Austin, TX, and Salt Lake City, UT; and "high" in Stockton, CA, and Baltimore, MD. The range in reported effectiveness is likely explained by differences in meeting frequency, participation, and content. For example, incident management personnel in Bishop, CA, reported holding only two to three meetings per year.

- **Joint Agency/Jurisdictional Protocols.** Agencies or jurisdictions can develop joint operating protocols intended to recognize the shared responsibility for roadway safety between public safety and transportation agencies.

  For example, the Washington State Department of Transportation (WSDOT) and the Washington State Patrol (WSP) signed the first *Joint Operations Policy Statement* (JOPS) in the Nation to better coordinate efforts to clear traffic incidents. In addition to describing how each of the various TIM program components function under a multi-agency agreement, this document formalized the 90-minute clearance goal for major traffic incidents that was initiated in 1997. The agreement also addresses broader issues related to data sharing, communication, enforcement, work zone safety, commercial vehicle operations, safety rest areas, and more (Washington State Patrol and Washington State Department of Transportation 2002).

  Incident management personnel in Redding, CA, Stockton, CA, and Austin, TX, rated joint agency/jurisdictional protocols as "moderate" to "high" in effectively enhancing agency relations. Comparatively, incident management personnel in Bishop, CA, rated the effectiveness of this same strategy in enhancing agency relations as "low."

Institutionalizing TIM. Traffic incident management efforts, as stand-alone activities, may be beneficial but are vulnerable to administrative personnel changes and annual budgetary fluctuations. Institutionalizing TIM efforts into formalized TIM programs can help to encourage sustainability. Sustainable TIM programs may require legislative or administrative authorization, strategic missions and goals, written operational policies, and formal organizational structure. The latter can include trained and dedicated staff, assigned responsibilities, defined reporting channels, and steady dedicated funding. Most TIM programs at the State and regional levels have some of these institutional support elements in place, but none seem to have them all (National Traffic Incident Management Coalition 2006c).

- **Viable Agency Career Path in TIM.** Frequently, within transportation agencies, personnel assigned to TIM duties have other full-time responsibilities in maintenance, traffic engineering, intelligent transportation systems (ITS), or emergency management. Field operations are often conducted by maintenance personnel as a secondary function. Intelligent transportation systems and traffic control personnel typically handle communications functions at separate traffic management center facilities. Most States treat transportation emergency and disaster management as a different activity from major TIM in organizational and reporting terms, although these activities are most

often carried out by the same people at the field operational level (National Traffic Incident Management Coalition 2006c). Over time, TIM may evolve into a professional sub-specialty within the transportation profession, practiced by full-time personnel who have clear responsibilities and accountability through reporting and performance measurement for stable and funded TIM programs. This evolution in TIM will provide a viable career path for incident response personnel, leading to enhanced retention of personnel and associated knowledge and skill sets and more effective, long-term working relationships with other incident responders.

Incident management personnel in Baltimore, MD, rated a viable career path in TIM as "very high" in effectively institutionalizing TIM, citing the ability to retain qualified personnel as a significant benefit.

- **Joint Traffic/Emergency Management Center.** Traffic management centers can be staffed by a single agency or multiple agencies. Facilities that house multiple agencies, including associated dispatch centers, under a single roof have the potential to enhance agency relations, as well as reduce overall facility development and operating costs (i.e., costs are shared across multiple agencies). Effective joint TMCs require a high level of information sharing and cooperation from all agency participants.

  Incident management personnel in Baltimore, MD, Austin, TX, and Salt Lake City, UT, rated joint traffic/emergency management centers as "high" to "very high" in effectively institutionalizing TIM. Conversely, incident management personnel in Redding, CA, rated the effectiveness of this same strategy in institutionalizing TIM as "low."

- **Interagency Agreements.** In the absence of legislation explicitly addressing some aspect of TIM, interagency agreements or memoranda of understanding may be used to effectively establish good TIM policies and practices. Open Roads policies that bind agencies to quick clearance by setting implied or explicit goals for clearing traffic incidents from the roadway have been described previously. Other important types of interagency agreements include:

  1. mutual-aid agreements that commit jurisdictions to assist partners in the event of need;
  2. joint operating agreements that define the roles and responsibilities of dissimilar agencies in handling incidents and emergencies; and
  3. memoranda of understanding between (a) various agencies to share data and information; (b) the medical examiner, public safety, and transportation agencies to allow for fatality certification by an on-site response agency and/or immediate removal of the deceased from the roadway (under clearly stated conditions); and (c) transportation and law enforcement agencies that establish an agreement for transportation agency support in exchange for increased traffic enforcement services on designated facilities (I-95 Corridor Coalition 2007).

  Interagency agreements and memoranda of understanding can be an effective near-term approach to formalizing TIM strategies and can provide a basis for pursuing future related legislation.

  Incident management personnel in Redding, CA, and Baltimore, MD, rated the effectiveness of interagency agreements in institutionalizing TIM as "low" and "high," respectively. The reported effectiveness is dependent upon the interagency agreement's original intended purpose and the level of adherence by TIM responders to the agreement's terms. Incident response personnel in Baltimore, MD, noted that the integrity of interagency agreements is sometimes challenged by changes in agency leadership.

Training

Traffic incident management training efforts may focus on three general areas:

1. training specific to TIM within one's own agency or company,
2. training aimed at increasing awareness of other responders' roles or existence, and/or
3. training aimed at improving specific procedural operations.

Efforts to improve TIM should consider training activities in each of these areas. Training efforts focused on a single agency or company's procedures or on procedural operations can be tailored based on specific needs. Training aimed at increasing awareness of other responders' roles or existence should involve response personnel from law enforcement, fire and rescue, EMS, transportation, towing and recovery, and other disciplines.

Common challenges to effective training stem from:

- inadequate joint training among emergency and support responders,
- inconsistent standards for responder competency, and
- variable traffic control training among responders—particularly emergency responders.

Table 8 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Table 8. Training Challenges, Strategies, and Reported Effectiveness

TRAINING STRATEGIES	Inadequate Joint Training	Responder Competency/Standards	Variable Traffic Control Training	REPORTED EFFECTIVENESS
Local TIM Training	●			Very High
Virtual Training	●			High-Very High
Public Safety Academy TIM Training	●			Moderate-Very High
National TIM Training	●			Moderate-High
Tabletop Exercises/Scenarios	●			Low-High
Incident Response Manual	●			Low-High
Post-incident Debriefings	●			Very Low-Very High
Requirements for Ongoing, Periodic Training		●		Moderate-Very High
TIM Personnel Certifications		●		Low-Very High
Towing and Recovery Training and Equipment Certifications/Standards		●		Moderate
Active Enforcement of Certifications/Standards		●		Low
Minimum Traffic Control Training Certifications/Standards			●	Moderate-High

Inadequate Joint Training among Responders. Traffic incident management personnel receive extensive discipline-specific training but have fewer opportunities to train with responders from other disciplines. As noted previously, the NTIMC Training Task Force has identified essential TIM functions that can be commonly performed by various agency personnel in their document *Multidisciplinary Core Competencies* (National Traffic Incident Management Coalition 2008). For example, NTIMC recommends that all responders, regardless of discipline, be trained to position vehicles to support scene safety and expeditious exit of EMS vehicles, establish temporary traffic control, provide basic first aid to victims until EMS arrives, and assume incident command until replaced. NTIMC recommends cooperative roles for law enforcement and transportation personnel when establishing advanced traffic control and detour routes, with fire and rescue personnel providing assistance as needed. Similarly, law enforcement personnel are primarily tasked with vehicle and debris removal, but transportation and fire and rescue personnel are urged to take an assistive role. Both fire and rescue and transportation personnel are presumed to competently perform functions associated with the cleanup of minor spills. Interdisciplinary training, particularly in these common functional areas, will encourage more efficient and effective TIM.

- **Local TIM Training.** Traffic incident management training can be tailored to meet local conditions, policies, procedures, and needs. The *Quick Clearance Toolkit*, developed by the I-95 Corridor Coalition (2007), serves as a significant resource to support local TIM training efforts. The toolkit is designed for use by multiple disciplines, including law enforcement, fire and rescue, emergency communications, transportation, towing and recovery, traffic-reporting media, and other agencies or companies and provides policy makers and TIM practitioners with handy and ready-to-use tools to assist them in providing more effective TIM practices, with a primary emphasis on quick clearance. Information that is available electronically for download includes presentations, videos, and incident management scenarios as well as supporting information such as sample policies, laws, memoranda of understanding, and incident management plans. NTIMC's Traffic Incident Management Training Resources website (http://timcoalition.org/?siteid=41&pageid=2768) also provides electronic access to a variety of training resources, focused on multidisciplinary training and directed training for law enforcement, fire and rescue, transportation (including service patrols), and towing and recovery personnel (National Traffic Incident Management Coalition 2008).

  Incident management personnel in Baltimore, MD, rated local TIM training as "very high" in effectively enhancing the adequacy of joint training among responders, citing relationship building as a significant benefit.

- **Virtual Training.** Incident Commander™, developed by the National Institute of Justice, is one example of a virtual training tool. Using three-dimensional, multi-player computer gaming simulation technology, Incident Commander™ allows incident management personnel to enhance response performance for a variety of large-scale incidents including severe storms and natural disasters; chemical, biological, radiological, or nuclear events; terrorist bombings and insurgencies; explosions and fires; and floods. With a focus on smaller scale, traffic-related incidents, the I-95 Corridor Coalition is sponsoring development of the Virtual Incident Management Training Program, designed to educate and validate incident management techniques and quick clearance practices. It promotes communication, coordination, and cooperation using practical, interactive incident scenarios for up to 500 responders representing law enforcement, fire and rescue, emergency communications, transportation, towing and recovery, traffic-reporting media, and other agencies or companies simultaneously. The program incorporates realistic time delays and resource limitations.

  Incident management personnel in Redding, CA, and Baltimore, MD, reported using virtual training and rated its effectiveness in enhancing the adequacy of joint training among responders as "high" to "very high." The reported effectiveness of virtual training in Baltimore, MD, is based on

experiences with the Virtual Incident Management Training Program prototype currently available to I-95 Corridor Coalition members.

- **Public Safety Academy TIM Training.** It is often difficult for multiple disciplines to commit to formal training on a frequent basis. A more feasible training method is to involve representatives from outside a discipline to speak about their role in incident management at regular agency or company training sessions.

  For example, a representative from the Washington State Department of Transportation's major incident response team speaks regularly to cadets at the Washington State Patrol's training academy. Similarly, the Oregon Department of Transportation has a local outreach program focused on responder safety that offers TIM training to local fire and law enforcement responders (National Traffic Incident Management Coalition 2006c). Incident management personnel in Redding, CA, and Baltimore, MD, rated public safety academy training as "moderate" and "very high," respectively, in effectively enhancing the adequacy of joint training among responders. The reported effectiveness by incident management personnel in Baltimore, MD, is high even though exposure to public safety personnel is limited; transportation personnel report having a single hour to address State Police trainees and access to a single fire academy.

- **National TIM Training.** The National Highway Institute offers a suite of courses that provides awareness-level training for personnel from law enforcement, fire and rescue, emergency communications, transportation, towing and recovery, traffic-reporting media, and other agencies or companies involved in responding to unplanned traffic incidents or planning special events. *Managing Traffic Incident and Roadway Emergencies* (FHWA-NHI-133048) addresses institutional and technical aspects of resolving traffic incidents and roadway emergencies safely and efficiently. *Managing Travel for Planned Special Events* (FHWA-NHI-133099) guides practitioners through all phases of managing travel for planned events using a local event scenario. And *Using the Incident Command System (ICS) at Highway Incidents* (FHWA-NHI-133101) presents an overview of ICS, its structure, and how it expands and contracts to meet the demands of an incident while maintaining a manageable span of control for on-scene personnel. These courses may be taken in succession or individually.

  Incident management personnel in Austin, TX, and Baltimore, MD, rated national TIM training as "moderate" and "high," respectively, in effectively enhancing the adequacy of joint training among responders. Incident management personnel in Austin, TX, noted that not all agencies practice the national incident management principles learned, reducing the overall effectiveness of this strategy.

- **Tabletop Exercises/Scenarios.** For TIM training focused on operations, staged incidents provide the best forum for learning, particularly if the time and place of the staged incident are covert. Complex logistics prevent this form of training from occurring frequently, however. A training alternative includes tabletop exercises and scenarios in which representatives from law enforcement, fire and rescue, EMS, transportation, and private industry act out what they would do in a sample emergency using a two- or three-dimensional representation of a locale and toy cars. The benefit of such formal training over on-the-job training is that participants can stop at any time and question other responders about their actions. At an actual incident scene, the urgency of performing actions does not allow this type of insightful discussion.

  Incident management personnel in Redding, CA, Stockton, CA, and Baltimore, MD, reported using tabletop exercises and scenarios, rating their effectiveness in enhancing the adequacy of joint training among responders as "moderate" to "high" in their respective locales. Comparatively, incident management personnel in Bishop, CA, rated this same strategy as "low," based on a single experience.

- **Incident Response Manual.** To ensure that TIM training efforts are effective, operations are efficient, and the program has longevity, it is important to develop textual material to support recommended actions. An incident response manual generally includes the policies and responsibilities for each participating agency or company, response personnel capabilities and training, and resources (i.e., equipment, supplies) and their availability. Any interagency agreements developed to facilitate efficient incident management operations should be included. The most successful incident response manuals are cooperatively developed. Responder policies and responsibilities can be fairly general to allow them to be adapted to different incidents but specific enough so that each responder's responsibility within the context of incident management is clear.

  Arizona's *Statewide Incident Management Plan*—which includes statewide alternate route plans and traffic operations center (TOC) incident management operations guidelines—was developed with input obtained from legislative, transportation, law enforcement, fire and rescue, and EMS agencies; the towing industry; and others. The plan includes related traffic control agreements with the towing industry (O'Laughlin 2000). The Twin Cities Metro Incident Management Steering Committee's *Incident Management Recommended Operations Guidelines* defines the roles and responsibilities of different agencies at incident scenes, and provides guidelines for incident response and clearance. This regional plan is the model for a Minnesota statewide plan under development. Idaho provides secure electronic access to a complete collection of guidance documents including an incident management plan, hazardous materials plan, State emergency operations plan, national response plan, emergency response manual, internal policies and procedures, and an employee phone list (National Traffic Incident Management Coalition 2006c). Incident management personnel in Salt Lake City, UT, reported using an incident response manual to support operations in their locale but rated its effectiveness in enhancing the adequacy of joint training among responders as "low." Comparatively, incident management personnel in Baltimore, MD, are currently finalizing an incident response manual for their locale and anticipate a "high" level of effectiveness in enhancing the adequacy of joint training among responders.

- **Post-incident Debriefings.** It is important to have follow-up reviews or assessments of incidents (i.e., debriefings) to discuss what went well and what actions could be improved upon. Ideally, post-incident debriefing should occur immediately after the incident has been cleared (to ensure that details and procedures of the response effort are not forgotten) but following the necessary data collection. The main goals of these meetings are to constructively critique the procedures used and any decisions made and to determine whether future management could be improved in any way (e.g., by restructuring the procedures, adding extra resources, etc.). Personnel in attendance should include each of the responders who participated in the management effort.

  Incident management personnel in Redding, CA, Chattanooga, TN, and Salt Lake City, UT, rated post-incident debriefings as "very low" to "low" in effectively enhancing the adequacy of joint training among responders. Comparatively, incident response personnel in Stockton, CA, and Baltimore, MD, rated this same strategy as "high" to "very high." Incident response personnel in Bishop, CA, and Austin, TX, rated post-incident debriefings as "moderate" in effectively enhancing the adequacy of joint training among responders. The wide range of reported effectiveness may be explained, in part, by the frequency with which debriefings are held and the tone of the meetings when they are held. Post-incident debriefings that are too infrequent or too cordial (i.e., no one is willing to raise any criticism) may not effectively identify opportunities for improvement in TIM operations. Incident management personnel in Austin, TX, and Stockton, CA,—who reported "moderate" and "high" effectiveness ratings, respectively—noted the potential for good information sharing and expressed a desire for more frequent debriefings.

Responder Competency/Standardization. Too often, TIM is learned on the job, with training deficiencies most commonly identified for transportation and towing and recovery personnel. Transportation agencies, in a formal capacity, are relatively new to TIM and, therefore, lack substantive training materials. Unlike public safety agencies, whose personnel devote much of their time to training for emergency or life-threatening situations, transportation personnel are typically not trained in such areas. One reason may be that the role of transportation agencies at an incident scene may be clear in the most general terms (i.e., to provide traffic control) but quickly becomes vague about specific duties such as response to hazardous material incidents. In addition, the roles and involvement of transportation agencies in incident management vary nationally (i.e., some transportation agencies are very proactive and would like to assume additional incident management responsibilities, whereas others are content to perform construction and maintenance functions). Until recently, towing and recovery agencies also suffered from a lack of substantive training materials. The TRAA National Driver Certification Program was developed to enhance TIM training for towing and recovery operators. Not all companies subscribe to the TRAA certification program, however, resulting in inconsistent operator competency at the scene of an incident. A request to a towing and recovery company may result in response by a well-qualified professional with years of expertise or a new employee whose skills are not up to the job.

- **Requirements for Ongoing, Periodic Training.** Ongoing, periodic training in TIM helps to ensure that newly developed policies, tools, and strategies are effectively and consistently integrated into practice. Ongoing, periodic TIM training also helps to reaffirm successful practices and identify potentially harmful practices that have evolved over time.

  Incident management personnel in Redding, CA, and Baltimore, MD, rated requirements for ongoing, periodic training as "moderate" and "very high," respectively, in effectively enhancing responder competency and standardization.

- **TIM Personnel Certifications.** Personnel certification helps to ensure a certain level of consistency and competency in the performance of TIM tasks. Certifications can be valid indefinitely following demonstration of a minimum acceptable knowledge or skill base (i.e., passing an exam) or may require periodic recertification to ensure that knowledge and skills remain strong. Certifications can differ by specific area of expertise or with increasing complexity. Traditionally focused on improving consistency and competency among towing and recovery operators, personnel certification has more recently been applied to and is being considered for a broader range of TIM responders.

  For example, the Georgia Department of Transportation provides a 208-hour certification program for members of its Highway Emergency Response Operators (HERO) incident management patrol unit. Research is currently underway that considers the potential for certification of responders to achieve the National Unified Goal for Traffic Incident Management, with a focus on the common set of core competencies that promote a shared understanding of the requirements for achieving the safety of responders and motorists, quick response, and effective communications at traffic incident scenes. Based on current experience, incident management personnel in Salt Lake City, UT, and Baltimore, MD, rated personnel certifications as "low" and "very high," respectively, in effectively enhancing responder competency and standardization. The reported effectiveness by incident management personnel in Baltimore, MD, is based on certification of transportation personnel only.

- **Towing and Recovery Training and Equipment Certifications/Standards.** Towing and recovery services represent an important component in the incident management process. Their quick response to the incident and their efficient conduct of the removal activity can be a key step in minimizing incident duration. In an effort to improve the quality and consistency of response industry-wide, TRAA developed a three-level National Driver Certification Program that incorporates TIM training.

An increasing number of law enforcement agencies that contract with towers are now requiring TRAA certification as a qualification for participation. In Virginia, TIM partners worked together to pass State legislation requiring certification of towers. Pre-qualification procedures can identify towing and recovery companies that have the appropriate equipment, education, certifications, and level of competency to serve as TIM responders. Incident management personnel in Salt Lake City, UT, rated towing and recovery training and equipment standards as "moderate" in effectively enhancing responder competency and standardization.

- **Active Enforcement of Certifications/Standards.** Traffic incident management certifications and standards are ineffective without active enforcement. Law enforcement or transportation agencies responsible for ensuring compliance may have limited resources to allocate to this activity. As such, it is important when implementing TIM certifications and standards that a companion strategy for efficiently enforcing the requirements be developed. Pre-qualification procedures for participating in TIM activities can determine initial eligibility; periodic checks can be performed to determine ongoing eligibility. Suitable "punishments" are also required for not meeting the certification/standards requirements.

  Incident management personnel in Redding, CA, rated active enforcement of certifications and standards as "low" in effectively enhancing responder competency and standardization. This low effectiveness ranking may be reflective of poorly crafted original certifications and standards that—even when enforced according to their terms—do not provide a high enough assurance of personnel competency or may suggest a high level of compliance with existing certifications and standards such that active enforcement is not needed.

Variable Traffic Control Training among Responders. The use of traffic control standards meets driver expectations and reduces a public agency's potential for liability. Non-transportation personnel are often ill equipped and untrained to provide extensive traffic control at the scene of an incident. Because they are often first on the scene, however, enhancements to scene management could result if they are trained in MUTCD-compliant procedures, despite limitations in available traffic control devices.

- **Minimum Traffic Control Training Certifications/Standards.** While transportation personnel receive extensive training in proper traffic control procedures, non-transportation personnel are often ill equipped and untrained to provide extensive traffic control at the scene of an incident. Because they are often first on the scene, however, requiring a minimum level of competency in proper traffic control procedures could enhance scene management. Existing training courses that already target non-transportation personnel—such as ATSSA's *Emergency Traffic Control for Emergency Responders (ETC)* course—provide opportunities for achieving certification in the event such certification is required. This 4-hour course covers principles and concepts of temporary traffic control presented in the *Manual on Uniform Traffic Control Devices*.

  Incident management personnel in Redding, CA, and Austin, TX, consistently rated minimum traffic control training standards as "moderate" in effectively encouraging consistency in traffic control training among responders. Incident management personnel in Baltimore, MD, rated this same strategy as "high" but noted again that this minimum training requirement applies to transportation personnel only.

Communications

Traffic incident management communications includes the exchange of information both on- and off-scene, and within and between participating agencies and companies. Critical communication links include an agency's dispatch with agency responders in the field, an agency's field responders with another agency's field responders, and an agency's dispatch with another agency's dispatch.

Common challenges to effective communication include:

- limited en-route/on-scene communications and
- inefficient communications.

Table 9 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Table 9. Communications Challenges, Strategies, and Reported Effectiveness

COMMUNICATONS STRATEGIES	Limited Communications	Inefficient Communications	REPORTED EFFECTIVENESS
Common Mutual-Aid Frequency/Channel	●		High
Wireless Information Networks	●		High
Alternative Communications Devices	●		Moderate-Very High
Common Radio Systems	●		Moderate
Cross Installation of Radios	●		Low-High
Console Patch	●		Very Low-Moderate
Standardized Communications Protocol		●	Low-Moderate

Limited En-Route and On-Scene Communications. Limited communications capabilities compromise both en-route and on-scene operations. En route to the incident, speed and convenience could be improved if response personnel from different agencies were able to communicate directly with one another. For example, law enforcement personnel already at the scene of an incident may want to inform the dispatched towing and recovery operator to take an alternate, more time-efficient route. Instead, the towing and recovery operator may lose 15 minutes or more weaving through the traffic backup. When agencies from different or multiple jurisdictions need to coordinate response actions on-scene, personnel often rely upon other, inefficient means of communication (such as relaying messages through multiple dispatchers or using runners to hand-carry messages). For example, law enforcement personnel may want to inform transportation personnel of the need to close a lane temporarily to remove the wreckage from the scene. The transportation personnel may be performing traffic control a significant distance upstream of the incident. Limited communications capabilities among responders prevent the request from being made directly.

- **Common Mutual-Aid Frequency/Channel.** Emergency radio systems that allow everyone at the incident scene to communicate on a common mutual-aid frequency or channel for the duration of the incident may also be useful in improving communications capabilities among responders. Certain designated mutual-aid or interoperability frequencies can be programmed into radios for all agencies. As long as all radios are in the same frequency band, responders can select the designated channel to communicate with personnel from other agencies. In the event of a major incident, the single interoperability radio frequency can become congested (National Law Enforcement and Corrections Technology Center 2003).

  Incident management personnel in Salt Lake City, UT, reported utilizing a common mutual-aid radio frequency/channel in their locale and rated its effectiveness in enhancing en-route and on-scene communications as "high."

- **Wireless Information Networks.** Wireless technology can be used to improve communications capabilities among TIM responders.

  To demonstrate, the States of Maryland and Virginia and the District of Columbia operate a multi-State, multidiscipline interoperable public safety and transportation wireless data system—the Capital Wireless Information Net (CapWIN)—intended to allow law enforcement, transportation, and fire and rescue personnel to communicate across jurisdictions and disciplines, and access operational information. CapWIN allows secure one-to-one and group public and private discussions, provides a searchable directory of individual first responders, and provides access to regional transportation data and multiple State/Federal law enforcement criminal databases to support operations. Similar systems are currently in use or under development in other States including Arkansas, Illinois, and Mississippi. Incident management personnel in Baltimore, MD, rated wireless information networks as "high" in effectively enhancing en-route and on-scene communications.

- **Alternative Communications Devices.** The use of alternative communications devices—such as cellular telephones or alphanumeric pagers—has proven somewhat promising in mitigating interagency communications challenges. These alternative devices are relatively inexpensive to purchase, operate, and maintain. In some instances, strict guidelines describing when to use such devices and for what purposes may be required. To be most effective, a list of cellular telephone numbers or pager numbers should be compiled and distributed to appropriate response personnel. If the contact list is not maintained and updated, alternative communications devices will quickly lose their effectiveness.

  Incident management personnel in Redding, CA, Stockton, CA, and Baltimore, MD, rated the use of alternative communications devices as "high" to "very high" in effectively enhancing en-route and on-scene communications. Incident management personnel in Bishop, CA, and Austin, TX, rated this same strategy as "moderate," noting the need to keep associated contact lists up to date.

- **Common Radio Systems.** A permanent communications solution can be achieved by building a single radio system that serves multiple TIM agencies. Multiple agencies typically share in the system costs, ensuring that their collective performance requirements are met. In particular, trunked systems can be configured to allow agencies to have their own talk groups (i.e., allowing them to communicate as if they had a system dedicated to their agency when appropriate), and allow interagency talk groups to be utilized when interoperability is required. Traffic incident management agencies are heavily invested in existing radio systems; it may be extremely difficult to persuade agencies to abandon these investments for new systems.

  Incident management personnel in Bishop, CA, and Austin, TX, rated common radio systems as "moderate" in effectively enhancing en-route and on-scene communications. Incident management

personnel in Austin, TX, reported limitations in the availability of common radio systems among all responders (i.e., public safety agencies may utilize common radio systems, but transportation and other support agencies may not).

- **Cross Installation of Radios.** Cross installation of conventional radios in response vehicles is one approach to improving communication among TIM responders from different agencies (i.e., a transportation radio is installed in a police vehicle in addition to the police radio and vice versa). Resources can usually be made available to allow for the installation of one agency's radio in another agency's vehicle; both agencies benefit if the swap of radios is equal. The cross installation of radios is only effective at improving communication between a few agencies; cross installation of radios is limited by physical space in the vehicle and the ability to simultaneously monitor and operate several different radio systems. Hence, to be most effective, cross installation of radios requires the identification of the most critical communication links.

  Incident management personnel in Redding, CA, and Austin, TX, rated the cross installation of radios as "low" to "moderate" in effectively enhancing en-route and on-scene communications, noting that not all TIM responders were sufficiently trained in the use of outside agency radios. Comparatively, incident management personnel in Stockton, CA, and Baltimore, MD, consistently rated the cross installation of radios as "high" in effectively enhancing en-route and on-scene communications in their respective locales.

- **Console Patch.** An alternative to the more limited cross installation of radios or the more costly common radio system accessible to all TIM responders is to deploy a gateway interface device that receives a transmission from one radio system and rebroadcasts it on another radio system. One disadvantage of this approach is that it ties up a frequency (channel) for each different radio system when in use. However, given the relatively low cost of retransmission devices and the achievable deployment with little or no changes required to existing radio systems, this approach has significant potential, particularly as a near-term solution or as part of a transitional strategy toward more complete communications capabilities (National Law Enforcement and Corrections Technology Center 2003).

  Incident management personnel in Redding, CA, and Salt Lake City, UT, rated the use of radio console patches as "very low" to "low" in effectively enhancing en-route and on-scene communications. Comparatively, incident management personnel in Baltimore, MD, rated the effectiveness of this same strategy in enhancing en-route and on-scene communications as "moderate," but noted that this effectiveness rating was based on its infrequent use.

Inefficient Communications. Both dispatchers and field personnel have been faced with not knowing whom to call, not calling the appropriate person, and not having accurate numbers for contacting the appropriate person. As a result, multiple calls are often made to reach the appropriate personnel, wasting time and heightening frustration. It is important to know not only whom to call but under what circumstances. For example, during normal operating hours, transportation department supervisors may want incident response requests routed through them, but this chain of command is likely to change during after-hours operations. Locating specialty equipment may also require several calls before the equipment can be successfully dispatched. The use of specialized codes or acronyms that are not understood by all responders on-scene further challenges efficient communications.

- **Use of Common Terminology.** Common terms (i.e., common definitions, lingo) for personnel, equipment, and facilities are essential to effective communication among TIM responders. The use of specialized codes or acronyms that are not understood by all responders on-scene should be avoided.

As a related note, the use of common terminology is also essential when exchanging information automatically using various technologies. The Institute of Electrical and Electronics Engineers, Inc., (IEEE) has developed a suite of standards intended to establish common traffic incident management message sets that reduce the duplication of messages among public safety and traffic management centers and help responders interact more effectively and efficiently. Five separate but related standards have been developed:

- IEEE Std 1512™-2006: IEEE Standard for Common Incident Management Message Sets for Use by Emergency Management Centers includes general introductory material about IEEE Std 1512 and a message set that focuses on the exchange of information about traffic incidents.
- IEEE Std 1512.1™-2003: Traffic Incident Management Message Sets for Use by Emergency Management Centers focuses on the exchange of information about traffic and public safety agency resources used during traffic incident response. It specifically addresses the assignment of multi-jurisdictional resources and covers how to request a traffic management center to perform functions with their roadside devices.
- IEEE Std 1512.2™-2004: Public Safety Incident Management Message Sets for Use by Emergency Management Centers covers the exchange of information necessary to support traffic incident response across public safety agencies, including law enforcement, emergency medical services, and fire and rescue.
- IEEE Std 1512.3™-2006: Hazardous Material (HAZMAT) Incident Management Message Sets for Use by Emergency Management Centers covers the exchange of information where hazardous materials have been released on or near a roadway. It deals specifically with the information content necessary to describe the type of cargo and placards.
- IEEE P1512.4™ (Draft): Common Traffic Incident Management Sets for Use in Entities External to Centers specifies message sets that support the exchange of information between a mobile asset and the center (Klotz Associates, Inc., et al. 2008).

Incident management personnel in Bishop, CA, Redding, CA, and Austin, TX, rated common terminology among incident responders as "moderate" to "high" in effectively enhancing efficient communication among the various response agencies.

- **Standardized Communications Protocol.** Many challenges to effective incident-related communications are procedural in nature. Typically, these challenges relate to a lack of awareness regarding whom to call or how to call them. Standardized communications protocols can be developed to formalize and increase awareness of each agency's call-out procedures and contact points, 24 hours day, 7 days a week. On-scene Incident Command System principles and use of a command post can facilitate effective communications. Personnel from each responding agency are staged at a command post; information and directions are disseminated from the command post to each agency's respective personnel.

  Incident management personnel in Bishop, CA, and Redding, CA, rated the standardized communications protocols used in their respective locales as "low" to "moderate" in effectively enhancing efficient communications.

Technology

Technology plays an important role in every aspect of TIM. In a number of instances, the use of technology can be demonstrated to directly increase the efficiency and, in some cases, the effectiveness of responders performing their duties. For example, access to CCTV images of an incident prior to arriving on-scene

supports both the dispatch of appropriate equipment (i.e., a heavy-duty wrecker) and quicker dispatch of resources (i.e., instant tow dispatch). Use of automatic vehicle location and geographic information system technologies can identify and mobilize resources that are closest in proximity to the incident scene, reducing overall travel times. Traffic signal priority systems can reduce delay for emergency vehicles along signalized arterials en route to the incident scene. On-scene, portable intrusion alarm systems—consisting of a sensing mechanism that forms a partial perimeter around the incident scene and an audible alarm that warns incident responders if an approaching vehicle inappropriately enters the scene—provide a technology-based alternative to the use of response vehicles for responder protection. To maintain traffic flow along the alternate route, use of responsive traffic signal control plans to manage traffic around the incident scene relieves law enforcement personnel from this duty and allows them to perform other tasks for which they are trained (i.e., crash investigation). When an incident requires investigation by law enforcement personnel, the use of total station surveying equipment and photogrammetry can dramatically reduce investigation time while increasing the quality and quantity of measurements captured. The smooth integration of technology into TIM policies and practices can help to support widespread implementation and use.

Common challenges to the effective use of technology include:

- a lack of standards,
- limited integration and interoperability among system components,
- limited data sharing and accessibility, and
- inadequate life-cycle costing.

Table 10 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Lack of Standards. Technology standards, typically developed by industry consensus, define how system components operate within a consistent framework. Equipment-related standards generally describe design, material, processing, safety aspects, or performance characteristics of equipment used for controlling, directing, or informing users of transportation facilities. They may include specific testing procedures and guidance for evaluating the test results based on the equipment's intended use. Software or protocol standards generally define software or communications procedures used in transportation facilities, systems, communications, or equipment. These standards may include message sets, object definitions, data dictionaries, and other components of application software, operating systems, and communications protocols.

Standards can be mandatory or less restrictive, including only recommended or optional specifications. Agencies that deploy technologies without consideration for standards, however, may be locked into proprietary specifications, custom interfaces, higher long-term operating and maintenance costs, reduced options for vendor competition and price stability, a need for unique training and specialized skills, and early obsolescence. To expand such a system, agencies must either buy the same brand of equipment or redesign/rebuild the existing system at significant cost. For intelligent transportation system development, agencies are being asked to incorporate standards into upgrades of existing systems and into new systems to promote interoperability and reduce life-cycle costs. As an added incentive, FHWA currently requires that all ITS projects funded from the Highway Trust Fund be in conformance with the National ITS Architecture and officially adopted standards. Despite the noted benefits of and incentives for incorporating standards into upgrades and enhancements of existing systems or into new systems, TIM agency personnel may be inadequately prepared to do so.

Table 10. Technology Challenges, Strategies, and Reported Effectiveness

TECHNOLOGY STRATEGIES	Lack of Standards	Limited Integration/Interoperability	Limited Data Sharing/Accessibility	Inadequate Life-Cycle Costing	REPORTED EFFECTIVENESS
Expedited Standards Development Process	●				Moderate-High
Standards Development and Maintenance Process	●				Low-Very High
Regional ITS Architecture		●			Low-Very High
Minimum Interoperability Requirements		●			Moderate
Standards Requirements for State Procurement		●			Low-High
Legacy System Integration Plans		●			Very Low-Very High
Web Access/Shared Networks			●		Low-Very High
Multi-agency Data Use Concept of Operations			●		Very Low-Very High
Common Data Dictionary			●		Very Low-High
Interagency Agreements for Data Exchange/Privacy			●		Low
Life-Cycle Cost Requirements for State Procurement				●	Low

- **Expedited Standards Development Process.** The development of robust standards to support technology deployment is a lengthy process. At the national level, draft standards for ITS deployments must be developed, balloted and amended as appropriate, approved, and published, which can take several years. Once published, time is needed for manufacturers to incorporate the standards into the devices and systems and make the technology available.

  While this process is necessary for the development of high-quality technical and functional standards, agencies may become impatient with the timeline if they are seeking to deploy technologies in response to a contemporary challenge or may forfeit near-term funding opportunities that may no longer be available when the technology standards mature. While little can be done to speed the national standards development process, agencies can expedite local technology deployment by fully utilizing existing national standards. If no related standards apply, agencies can consult draft national standards currently under development to help guide appropriate content and considerations for newly developed standards at the State level. Some risk exists in basing State-level standards on draft national standards; changes in content or requirements may cause inconsistencies. Agencies must then weigh the benefits of expedited technology deployment with the potential added costs of system modifications to support interoperability.

  Incident management personnel in Redding, CA, and Baltimore, MD, reported using expedited standards development processes in their respective locales, rating their effectiveness in encouraging the use of standards as “moderate” to “high.”

- **Standards Development and Maintenance Process.** Once developed, the existence of a standard must be made known, and an ongoing process for maintaining and updating the standard is required. Standards can be reviewed on a periodic cycle to ensure currency, validity, and applicability based on current knowledge, trends, and developments.

Incident management personnel in Redding, CA, and Baltimore, MD, rated standards development and maintenance processes used in their respective locales as "low" and "very high," respectively, in effectively encouraging the use of standards. The range in reported effectiveness may be explained, in part, by the variable nature of standards and the length of time between review cycles.

Limited Technology Integration/Interoperability. The use of standards in upgrades to existing systems and in new systems promotes integration and interoperability among systems and system components by supporting data sharing between components manufactured by different vendors at different times, across different applications, and among agencies located in different jurisdictions. Technological challenges arise when trying to integrate new systems with existing or legacy systems. These challenges are compounded when system integration or interoperability is required across multiple agencies or multiple jurisdictions. Coordination among Federal, State, and local agencies or agencies representing public safety and transportation disciplines has typically lacked cohesion. Public and private sectors must also cooperate. The technical expertise needed to deploy, operate, and maintain many technologies may be beyond the current capability of many State and local agencies; the private sector's expertise may be essential to the system's success.

- **Regional ITS Architecture.** The National ITS Architecture provides a common framework for planning, defining, and integrating technology-based systems and components. The architecture defines the system functions that are required, the locations where these functions reside (e.g., the field or the vehicle), and the information and data flows that connect these functions and physical subsystems together into an integrated system. The National ITS Architecture can be used to develop a regional ITS architecture, tailored to address local conditions and investment needs. Subsequent technology-based project requests are then compared for adherence to the regional ITS architecture.

  Incident management personnel in Bishop, CA, and Austin, TX, rated a regional ITS architecture as "low" to "moderate" in effectively encouraging technology integration and interoperability in their respective locales. Comparatively, incident management personnel in Baltimore, MD, rated the effectiveness of this same strategy as "very high," noting resulting benefits related to information and resource sharing. The range in effectiveness may be further explained by the timeliness of its development (i.e., older architectures may not adequately reflect local conditions that have changed over time) and the level of input originally obtained from diverse TIM response agencies.

- **Minimum Interoperability Requirements.** Minimum interoperability requirements for new technologies can be developed as long as consensus can be reached on the degree of interoperability that is required. Higher levels of interoperability can generally be achieved technically, but with potentially higher associated development costs and limited enhancements to functionality. Defining minimum interoperability requirements will help to ensure that key system components can function cooperatively at some level to enhance current TIM operations, and that the system can support future expansion or enhancement.

  Incident management personnel in Redding, CA, and Austin, TX, rated minimum interoperability requirements as "moderate" in effectively encouraging technology integration and interoperability. Incident management personnel in Austin, TX, cited a need for better enforcement and oversight to help maximize the effectiveness of this strategy.

- **Standards Requirements for State Procurement.** FHWA currently requires that all ITS projects funded from the Highway Trust Fund be in conformance with the National ITS Architecture and officially adopted standards. Similar requirements could be integrated into the State-level procurement process to ensure that minimum levels of system and component interoperability are obtained and life-cycle costs for the agency are minimized.

Incident management personnel in Bishop, CA, and Austin, TX, rated standards compliance requirements for State procurement as "low" to "moderate" in effectively encouraging the use of standards, again citing a need for better enforcement and oversight. Comparatively, incident management personnel in Redding, CA, and Baltimore, MD, consistently rated this same strategy as "high" in effectively encouraging technology integration and interoperability.

- **Legacy System Integration Plans.** Integrating new systems with existing or legacy systems can prove challenging. In some cases, it may be more cost-effective to abandon a legacy system in favor of a newly developed system rather than try to integrate the two. For agencies involved in TIM, this is not often the case. Public safety or transportation agency legacy systems may have been deployed on a regional or statewide level and at a significant cost. Integration of new applications with existing systems often proves to be more cost-effective.

  Different system integration methods can be used, with varying levels of cost. Real-time integration, which changes and upgrades information throughout integrated systems the instant a change is made, is the most complex and the most costly. Other integration methods are less costly but may be more disruptive to operations (i.e., requiring system downtime for integration changes to be made). A legacy system integration plan can define the intended method for integration, as well as address issues related to inconsistencies in data definitions between the new and legacy systems, functional redundancies between the two systems, and continued opportunities for expansion.

  Incident management personnel in Bishop, CA, Redding, CA, Austin, TX, and Baltimore, MD, rated legacy system integration plans as "very low," "moderate," "high," and "very high," respectively, in effectively encouraging technology integration and interoperability. The range in reported effectiveness may in fact reflect the wide range of services offered by private-sector system integrators in terms of both functionality outputs and timeliness. Complex integrations have a high associated risk of compromised functionality and time delays.

Limited Data Sharing and Accessibility. Traffic incident management relies heavily upon the collection, assimilation, and distribution of data among response personnel and to the motoring public. Most of this information is required in real time. Numerous technical challenges exist in the provision of real-time information including the capture and integration of dynamic information from multiple sources; database maintenance to include only current, accurate, and reliable information; the selection of desired information for transmission to on-scene responders as compared to motorists; and the presentation of information via numerous user interfaces (i.e., DMS, website, etc.).

The participation of multiple agencies and multiple jurisdictions in TIM complicates the data exchange process. Certain sensitivities inevitably arise regarding data confidentiality and system security. For example, law enforcement agencies may have concerns about releasing certain incident-related information recorded in the computer-aided dispatch (CAD) system for fear of compromising investigations or other personal or proprietary information related to law enforcement activities. Conversely, transportation agencies may be reluctant to release taped video from CCTV cameras. Concerns involve what the cameras monitor and how operators and others, including law enforcement personnel, use the traffic information. The legitimate data security concerns of law enforcement and homeland security organizations complicate the already difficult problems in data sharing. Security issues increase costs and can impact the timeliness of data sharing.

- **Web Access/Shared Networks.** When agencies are not co-located, the sharing of information can be challenging. Web access and Internet communications techniques offer opportunities for enhancing the sharing of information among TIM agencies. Web access can be provided through establishment of a common password-protected site for sharing of relevant information. Participating agencies can

be granted access to the site to receive or enter information of interest to the partner agencies. Shared networks provide a second alternative. With a shared network, participating agencies are able to exchange traffic and video data or other information. Once a communications backbone is in place (i.e., fiber-optic network), additional agencies can connect to the network, paying only for the marginal cost of the expansion.

Incident management personnel in Bishop, CA, and Baltimore, MD, rated the effectiveness of web access and shared networks among TIM response agencies in enhancing data sharing and accessibility as "low" and "very high," respectively. The range in reported effectiveness may reflect the level of participation from TIM agencies and the unique limitations or capabilities for information sharing for each approach.

- **Multi-agency Data Use Concept of Operations.** Effective TIM can benefit from the sharing of information—sometimes large quantities of information—among numerous agencies. To avoid inefficiencies in the exchange of such information, the information-sharing process and each agency's role in that process can be clearly defined in a multi-agency data use concept of operations document. This document should address specific data to be exchanged, methods for addressing data differences among multiple agencies, filtering requirements that consider both incident type and data elements, methods to reduce duplicate data entry, and opportunities for a redundant communications path (i.e., a fiber-optics system may provide the primary communications medium, while the Internet may be used as a back-up communications mechanism to link agencies).

  Incident management personnel in Bishop, CA, and Baltimore, MD, rated a multi-agency data use concept of operations as "very low" and "very high," respectively, in effectively enhancing data sharing and accessibility. The range in reported effectiveness may again be explained, in part, by the timeliness of its development and the level of input originally obtained from TIM response agencies.

- **Common Data Dictionary**. A data dictionary is a centralized repository of information about data—its meaning, relationships to other data, origin, usage, and format. Traffic incident management agencies can benefit from a common data dictionary that catalogs the organization, contents, and conventions of one or more databases owned and maintained by the various TIM agencies. Enhanced knowledge about each agency's databases can identify and encourage data-sharing opportunities, not only encouraging the effective use of technology but also encouraging ongoing TIM program performance measurement that may require data originating from multiple agencies.

  Incident management personnel in Bishop, CA, rated a common data dictionary as "very low" in effectively enhancing data sharing and accessibility. Comparatively, incident management personnel in Austin, TX, rated the effectiveness of this same strategy as "high." Despite the high rating, incident management personnel in Austin, TX, noted implementation challenges associated with common data dictionaries that may preclude their effectiveness.

- **Interagency Agreements for Data Exchange/Privacy.** To address sensitivities regarding data confidentiality and system security, agencies can develop written agreements that delimit the use and distribution of data. Specifically, agencies should consider: (1) who owns the data generated, (2) how this information will be shared among partners and to whom this information should be released, (3) how to protect confidential information, and (4) what the proper use of and retention timeframe for data are. Depending on the agreements and processes in place, sensitive data may be completely unavailable, may have operational restrictions placed on them, or may require additional system development to implement filters to extract data that can be shared. Some data security issues cannot be overcome without enabling legislative action.

In Washington, the Washington State Patrol had concerns about releasing all incident-related information recorded in the CAD system to the Washington State Department of Transportation, citing concerns over the integrity of investigations and the personal and proprietary nature of some of the information. The two agencies successfully established a protocol describing the nature and extent of information provided to WSDOT (SAIC 2006). Incident management personnel in Bishop, CA, and Redding, CA, rated interagency agreements for data exchange and privacy as "low" to "moderate" in effectively enhancing data sharing and accessibility in their respective locales.

Inadequate Life-Cycle Costing. Life-cycle costing involves the analysis of the costs of a system or a component over its entire life span. Typical costs for a system may include: (1) design, development, and acquisition costs; (2) operating and maintenance costs; and (3) disposal costs. A complete life-cycle cost analysis may also adjust for discount rates, interest rates, depreciation, present value of money, etc. With respect to the cost inputs for such an analysis, design, development, acquisition, and disposal costs are generally deterministic. Operation and maintenance costs can vary significantly based on the complexity of the system and the random nature of system failures. The novelty of many of the technologies utilized for TIM challenges the accurate prediction of system costs over its lifetime. As such, these types of analyses may be performed infrequently.

- **Life-Cycle Cost Requirements for State Procurement.** Typical costs for a system over its life span may include: (1) design, development, and acquisition costs; (2) operating and maintenance costs; and (3) disposal costs. Design, development, acquisition, and disposal costs are generally deterministic, but operating and maintenance costs can vary significantly based on the complexity of the system and the random nature of system failures. As such, agencies may be surprised by the magnitude of operating and maintenance costs associated with technology deployment and be ill prepared to cover these costs without sacrificing some other aspect of service. By requiring life-cycle costing as part of the State procurement process, agencies can better anticipate and plan for comprehensive technology costs at the time of procurement.

  Incident management personnel in Redding, CA, and Chattanooga, TN, consistently rated life-cycle costing requirements for State procurement as "low" in effectively enhancing the use of technology. This low rating may suggest a sufficient level of technology deployment experience by TIM program administrators to successfully anticipate life-cycle costs without State procurement requirements. It may also suggest a lack of confidence in life-cycle cost estimates, particularly related to the operation and maintenance of technology-based systems.

Performance Measurement

Performance measurement provides the necessary feedback to TIM responders to allow them to improve performance. Equally important, performance measurement provides decision makers with the data to demonstrate the value of TIM activities and justify their related expenditures.

Common challenges to effective performance measurement stem from:

- a lack of consensus among TIM agencies and available supporting data,
- inconsistent data definitions, and
- concerns over data confidentiality and system security.

Table 11 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Table 11. Performance Measurement Challenges, Strategies, and Reported Effectiveness

PERFORMANCE MEASUREMENT STRATEGIES	Lack of Concensus/Data	Inconsistent Definitions	Data Confidentiality/Security	REPORTED EFFECTIVENESS
Strong Funding and Performance Link	●			Very High
Periodic TIM Self-Assessment	●			High
Performance Targets/Goals	●			Moderate-Very High
National Performance Measurement Guidance	●			Moderate-High
Data Capture/Performance-Monitoring Methods	●			Very Low-Very High
State Traffic Records Coordinating Committee Partnerships	●			Low
Use of Common Terminology		●		Moderate
Interagency Agreements for Data Exchange/Privacy			●	Moderate

Lack of Consensus and Supporting Data. Where officials fear public controversy over failure to meet stated goals, or unfair comparisons to results from other jurisdictions, there can be resistance to setting performance goals and defining associated measures. One example of potential conflict is if a law enforcement agency has established a priority to improve response times to high-priority incidents (i.e., lane-blocking, injury incidents) while admittedly sacrificing response times to lower priority incidents. The proposed TIM performance measure may include all incident types, ranging from lane-blocking, injury incidents to minor vehicle disablements, and hence may reflect a higher incident response time and duration than that currently reported by law enforcement. Resistance from just a single TIM agency can preclude consensus and limit progress in developing associated performance measurement methods.

Even if consensus is reached on intended performance goals and measures, the ability to capture the information needed to support these measures may be limited. Many agencies currently collect and analyze data to measure their performance toward meeting the goals and objectives specific to their agencies. Measuring performance for TIM requires collecting program performance data that may be different from agency-specific performance data. Oftentimes, limited documentation of incidents and their management exists. Incident occurrence may be regularly recorded, but more detailed information relative to the type of incident, response times and procedures, and traffic management activities is typically not documented. For example, consider the data captured through a typical CAD system. The time at which the first recordable awareness of an incident occurs is automatically captured from the 9-1-1 call time tag for the majority of incidents. The time at which all travel lanes are available for traffic flow (i.e., towing and recovery personnel have physically cleared the travel lanes) may be recorded in an open field entry on the incident report, but this information is probably not comprehensive or consistent. Access to historic information entered in open fields is not supported by query methods and requires manual review of individual CAD records. Certain CAD records, such as incidents involving criminal activity, would be limited to review by law enforcement personnel, further preventing access to necessary supporting data.

- **Strong Funding and Performance Link.** Similar to performance-based incentive programs instituted at the employee level, TIM can be evaluated at the program level with performance tied to continued or increased program support. Performance measures defined explicitly for TIM should also reflect broader agency-wide or statewide goals related to increased productivity, cost-efficiency, and improved quality in the delivery of State services. Incorporating performance measures into formal long-range plans can help to ensure that TIM programs receive adequate attention in prioritization of projects for funding.

  Incident management personnel in Baltimore, MD, rated a strong funding and performance link as "very high" in effectively reaching consensus and developing supporting performance data. This rating suggests a high level of confidence in the benefits provided by TIM programs and an agency's ability to adequately capture and report these benefits to decision makers.

- **Periodic TIM Self-Assessment.** In 2003, FHWA facilitated initial assessments of TIM programs in the largest 75 urban areas of the United States and in each of three areas: program and institutional issues, operational issues, and communications and technology issues. Participants were asked to respond to 34 questions related to program and institutional (30 percent), operational (40 percent), and communications and technology (30 percent) issues using a five-point relative scale ranging from 0=no progress in this area to 4= efforts in this area are outstanding. Subsequent annual assessments have enabled State and local program managers and practitioners to evaluate their TIM programs and identify strengths and weaknesses in their programs in order to prioritize program activities and initiatives. At a national level the assessments enable FHWA to evaluate progress in TIM and to identify national TIM program initiatives.

  Incident management personnel in Baltimore, MD, rated periodic TIM self-assessment as "high" in effectively reaching consensus and developing supporting performance data, but reported a desire for greater feedback on performance from FHWA.

- **Performance Targets/Goals.** Explicit performance targets or goals for TIM have most commonly been defined for average or maximum incident clearance time, defined as the time between the first recordable awareness and the time at which the last responder has left the scene. Such goals can be highly controversial and even political. It is important to understand that these goals are not meant to encourage reckless actions. The purpose of these goals is to encourage multi-agency reviews of operational processes to determine where procedural changes or coordination of activities at the incident can reduce incident duration.

  As noted previously, California, Washington, and Florida have statewide 90-minute incident clearance targets. Utah's state performance goals are based on incident severity: 20 minutes for fender benders, 60 minutes for injury crashes, and 90 minutes for fatalities. Idaho takes a similar approach, with a statewide program for 30-, 60-, or 120-minute maximum clearance times, based on incident severity (National Traffic Incident Management Coalition 2006b). Incident management personnel in Austin, TX, and Salt Lake City, UT, consistently rated performance targets or goals as "moderate" in effectively reaching consensus and developing supporting performance data. Comparatively, incident management personnel in Baltimore, MD, rate the effectiveness of this same strategy in effectively reaching consensus and developing supporting performance data as "very high."

- **National Performance Measurement Guidance.** At the national level, the recently developed National Unified Goal for Traffic Incident Management recommends setting goals for performance and progress as a primary strategy. Recent developments from FHWA's Traffic Incident Management Focus State Initiative for Performance Measurement identified a list of 10 candidate incident management objectives and 30 related performance measures, developed through

consensus of transportation and law enforcement practitioners in 11 states. Nine of the 10 candidate incident management objectives and related performance measures identified collectively are being implemented for testing in one or more of the 11 participating states. Two of the objectives and related performance measures are slated for implementation and testing in each of the 11 participating states:

Objective 1: Reduce roadway clearance time—the time between the first recordable awareness of an incident by a responsible agency and confirmation that all lanes are available for traffic flow.

Performance Measure 1: Time between the first recordable awareness of an incident by a responsible agency and the first confirmation that all travel lanes are available for traffic flow (i.e., towing and recovery personnel have physically cleared the travel lanes).

Objective 2: Reduce incident clearance time—the time between the first recordable awareness and the time at which the last responder has left the scene.

Performance Measure 2: Time between the first recordable awareness of an incident by a responsible agency and the time at which the last responder leaves the incident scene.

Incident management personnel in Baltimore, MD, Chattanooga, TN, and Austin, TX, rated national performance measurement guidance as "moderate" to "high" in effectively reaching consensus and developing supporting performance data. Incident response personnel in Austin, TX, noted implementation challenges that may preclude the effectiveness of this strategy in the near term.

- **Data Capture/Performance-Monitoring Methods.** After measures of program performance are defined, it is necessary to specify what data will be used to measure each objective, how they will be collected and analyzed, and who will be responsible for the data. Specific considerations may include methods for reconciling inconsistencies in performance measure definitions; filtering unnecessary data; efficiently assimilating data from disparate agency databases developed under different data standards; and performing analysis, evaluation, and reporting with varying levels of aggregation to target different audiences.

  Incident management personnel in Redding, CA, and Salt Lake City, UT, rated the development of data capture and performance-monitoring methods as "very low" to "low" in effectively reaching consensus and developing supporting performance data. Conversely, incident management personnel in Baltimore, MD, rated the effectiveness of data capture and performance-monitoring methods in their locale as "very high," noting that this strategy continues to secure additional funding and personnel for their TIM program. Hence, the range in reported effectiveness for data capture and performance-monitoring methods may be more indicative of how successfully the resulting data are used to market TIM program potential and subsequent needs.

- **State Traffic Records Coordinating Committee Partnerships.** At the State level, traffic records coordinating committees represent multiple agencies involved in traffic records initiation, storage, transmission, and dissemination with the intent of formulating mutually beneficial projects for improving the accessibility, timeliness, accuracy, and completeness of statewide traffic-related information. State traffic records coordinating committees strive to maximize utilization; improve functionality; improve data accuracy, timeliness, and linkages; advance electronic data collection; protect privacy; and minimize redundancies in traffic records systems, allowing agencies to better accomplish individual goals. Although State traffic records coordinating committees involve additional agencies beyond public safety and transportation agencies, participation in or partnerships with these forums may enhance TIM efforts.

Incident management personnel in Bishop, CA, reported utilizing partnerships with State traffic records coordinating committees but rated their effectiveness in reaching consensus and developing supporting performance data as "low."

Inconsistent Definitions. While many agencies currently measure performance related to TIM in a single-agency context, the definitions of these measures are often inconsistent between transportation and public safety disciplines. For example, both transportation and public safety agencies use "response time" as a critical performance measure; however, the operational definition of this measure varies significantly. Transportation agencies generally define "response time" as the time differential between when an incident was reported to their agency and when the first responder from any official response agency arrived on-scene. Emergency service providers generally define "response time" as the time differential between when a call was received by their dispatcher and when their first response vehicle arrived on-scene (Balke et al. 2002). The operational definition of "clearance time" also varies considerably between transportation and public safety agencies. Transportation agencies typically define "clearance time" as the time differential between when the first responders arrived on the scene and when the capacity of the facility was fully restored (i.e., when the incident was removed from the travel lanes) (Balke et al. 2002). Law enforcement agencies typically record their time "back in service," but this often includes enforcement or investigatory duties that take place off-site with no impact to the primary incident roadway (i.e., if a law enforcement officer pushes an involved vehicle to a nearby parking lot and gathers victim and witness information).

Performance measure definitions used by public safety agencies are fairly standard across the industry. National reporting databases—such as the National Fire Incident Reporting System—have encouraged agencies to adopt common terminology and collect data in a consistent manner. For transportation agencies, performance measure definitions are generally local decisions and, hence, are more variable.

- **Use of Common Terminology.** Just as the use of common terms (i.e., common definitions, lingo) for personnel, equipment, and facilities are essential to effective en-route and on-scene communications among TIM responders, the use of common terminology is also essential for effective performance measurement. Performance measurement for TIM often requires the use of data from multiple response agencies; common terms and definitions help to ensure accurate and efficient data processing and reporting.

  Incident management personnel in Bishop, CA, Redding, CA, and Austin, TX, consistently rated common terminology as "moderate" in effectively encouraging consistent data definitions for performance measurement.

Data Confidentiality/System Security. Measuring performance for TIM may require the assimilation of data originating from multiple agencies. Certain sensitivities inevitably arise regarding data confidentiality and system security. For example, law enforcement agencies may have concerns about releasing certain incident-related information recorded in the CAD system for fear of compromising investigations or other personal or proprietary information related to law enforcement activities. Conversely, transportation agencies may be reluctant to release taped video from CCTV cameras. Concerns involve what the cameras monitor and how operators and others, including law enforcement personnel, use the traffic information. The legitimate data security concerns of law enforcement and homeland security organizations complicate the already difficult problems in data sharing. Security issues increase costs and can impact the timeliness of data sharing.

- **Interagency Agreements for Data Exchange/Privacy.** As described previously in the context of technology use, agencies can develop written agreements that delimit the use and distribution of

data to address sensitivities regarding data confidentiality and system security. Depending on the agreements and processes in place, sensitive data may be completely unavailable, may have operational restrictions placed on them, or may require additional system development to implement filters to extract data that can be shared. Some data security issues cannot be overcome without enabling legislative action. Such agreements can be beneficial for TIM performance measurement that often requires the use of data from multiple response agencies.

Incident management personnel in Bishop, CA, and Redding, CA, rated interagency agreements for data exchange and privacy as "moderate" in effectively addressing concerns related to data confidentiality and system security.

Program Resources and Funding

To establish, maintain, and improve TIM programs, adequate and ongoing resources to support operation must be available. Program administrators must not only understand the funding process at Federal, State, and local levels but must also be able to identify specific sources of monetary support appropriate for TIM, and must successfully compete for it. Additional funding cannot be viewed in isolation as a panacea to address TIM challenges. However, adequate funding can help to support incremental improvements in TIM efforts by providing program equipment, personnel, or further research.

Common challenges related to TIM program resources and funding include:

- limited resources and funding, and
- inadequate outreach to decision makers regarding the importance of TIM.

Table 12 identifies the various tools and strategies that have been developed and implemented in an effort to overcome these challenges and describes their relative reported effectiveness based upon input from TIM practitioners directly participating in this investigation.

Limited Resources and Funding. Traffic incident management is just one among many competing claims for limited transportation resources. Transportation funding from Federal and State levels pits TIM needs against more traditional, better-understood activities such as interstate construction, pavement rehabilitation, and transit improvements. Securing TIM resources within transportation departments is especially difficult. Frequently, within transportation agencies, personnel assigned to TIM duties have other full-time responsibilities in maintenance, traffic engineering, ITS, or emergency management. Field operations are often conducted by maintenance personnel as a secondary function. ITS and traffic control personnel typically handle communications functions at separate traffic management center facilities. Most States treat transportation emergency and disaster management as a different activity from major TIM in organizational and reporting terms, although these activities are most often carried out by the same people at the field operational level (National Traffic Incident Management Coalition 2006c). As a result, it can be very difficult to isolate how much money is currently being spent on TIM personnel and equipment agency-wide, which impedes the ability to make a solid argument for spending more.

- **TIM Strategic Plan.** Unlike a TIM response plan, focused on defining the multidisciplinary actions taken in response to an incident event, a TIM strategic plan considers broader, long-term TIM program development. For a given locale, a TIM strategic plan most often establishes local program goals and objectives, response challenges and needs, potential strategies for improvement, and a short- to long-term implementation plan. Strategic plans focused on TIM should be developed through consensus of all affected agencies and companies. A TIM strategic plan can not only

Table 12. Program Resources and Funding Challenges, Strategies, and Reported Effectiveness

PROGRAM RESOURCES AND FUNDING STRATEGIES	Limited Resources/Funding	Inadequate Outreach to Executives	REPORTED EFFECTIVENESS
TIM Strategic Plan	●		Very High
Reduced Resource Redundancy	●		High
TIM Integration into Capital Planning Process	●		Moderate-Very High
Metropolitan Planning Organization Partnerships	●		Moderate
Dedicated, Ongoing Funding	●		Low-Very High
Guidelines for Federal/State Funding Sources	●		Low-High
Use of Technology	●		Very Low-Very High
Cost Recovery Mechanisms/Databases	●		Very Low-High
Use of Least Costly, Capable Personnel/Equipment	●		Very Low-Moderate
TIM Requirements in New Construction Contracts	●		Very Low-Low
Executive Outreach Materials		●	Moderate-High
Evidenced TIM Benefits to Broader Community		●	Low

provide focus for ongoing program performance monitoring but can improve agency relations and can help to garner additional program support.

For example, the Kentucky Transportation Cabinet developed a State strategic plan for TIM that includes mission, goals, objectives, and a timeline for implementation of 49 prioritized action strategies. The plan was developed with input from FHWA, State police, emergency management, and local agencies. Similarly, Tennessee developed a TIM strategic plan that represents a coordinated effort among the Tennessee Department of Transportation, Tennessee Department of Safety, Tennessee Department of Commerce and Insurance, Tennessee Emergency Management Agency, and other public and private organizations with responsibilities for TIM. The statewide plan—adopted through a four-department resolution—considers four regions, each staffed with an incident management coordinator and responsible for statewide incident and service patrol reports (National Traffic Incident Management Coalition 2006c). Florida and Wisconsin provide additional TIM strategic plan examples.

Incident management personnel in Baltimore, MD, rated the effectiveness of their TIM strategic plan as "very high" in effectively providing focus for ongoing program performance monitoring and helping to garner additional program support. As designed, the single-agency plan includes only the mission, goals, objectives, and implementation plan for the State transportation agency.

- **Reduced Resource Redundancy.** As noted previously, commonalities in responder competencies allow various TIM functions to be performed by personnel from multiple agencies, with varying degrees of efficiency and effectiveness. For example, personnel from each agency are capable of providing scene protection, initial medical care, and limited documentation. With the exception of EMS personnel, personnel from each agency are capable of providing temporary traffic control,

limited firefighting, and cleanup. Transportation and law enforcement personnel are each capable of mobilizing extra response, providing traveler information via DMS or through media contacts, modifying traffic signal timings, and removing the vehicle from the roadway. Fire and rescue and transportation personnel are each capable of mitigating minor vehicle fluid leaks. Fewer commonalities in equipment function are observed between the various TIM response agencies. Certain fire and rescue vehicles are equipped to provide advanced medical care, similar to EMS vehicles. Both law enforcement and transportation vehicles are often equipped with push bumpers for quickly removing vehicles from the travel lanes or shoulder. Additionally, law enforcement, fire and rescue, and transportation agencies commonly carry various hand tools in their vehicles to support debris removal and cleanup. The most pronounced commonality is the use of each agency's vehicles for scene protection. A concerted effort can be made to identify potential overlap in personnel competencies and equipment function and reduce potential redundancies in operations.

Incident management personnel in Baltimore, MD, rated reduced resource redundancy as "high" in effectively enhancing limited program resources and funding. As a related benefit, incident management personnel in Baltimore, MD, noted the ability to provide other agencies with resources that they may not otherwise be able to access.

- **TIM Integration into Capital Planning Process.** In recent years, metropolitan planning organizations (MPOs) have been encouraged to assume a greater and more consistent role in a broader range of activities, including TIM, and have noted that more effort needs to be made to support emergency response/management agencies in helping them achieve their goals. Despite this direction, the Association of Metropolitan Planning Organizations (AMPO) observed in a 2003 survey that, while 65.91 percent of MPOs included management and operations (M&O) programs or strategies in their long-range transportation plans (LRTPs), this inclusion was "ad hoc" in 29 percent of the cases. Similarly, 63.64 percent of MPOs reported inclusion of M&O programs or strategies in their transportation improvement programs (TIPs). When prompted to detail the nature of their M&O programs or strategies, TIM activities were reported by only 22.73 percent of MPOs, suggesting an inadequate level of priority and/or integration of TIM into the planning process. Metropolitan planning representatives have noted that the key to better integration of M&O into the transportation planning process is found in the monitoring of system performance and subsequent funding allocation based on system performance.

  Incident management personnel participating in this investigation rated guidelines for TIM integration into the capital planning process as "moderate" to "very high" in effectively enhancing program resources and funding.

- **Metropolitan Planning Organization Partnerships.** Metropolitan planning organizations may provide a unique opportunity to support TIM through their distinctive role in facilitating regional planning and programming decisions, providing a forum for cooperative decision making, working toward regional consensus, developing regional and institutional agreements, serving as a repository for comprehensive data, etc. Nearly 400 MPOs currently exist in the United States, concentrated in urban areas with populations greater than 50,000. As noted previously, MPOs have been encouraged to assume a greater and more consistent role in a broader range of system M&O, including TIM. Partnering with MPOs can help to elevate awareness of TIM as a viable transportation investment and can support long-term integration of TIM into regional planning and programming decisions.

  Incident management personnel in Baltimore, MD, and Austin, TX, consistently rated partnerships with MPOs as "moderate" in effectively enhancing limited program resources and funding.

- **Dedicated, Ongoing Funding.** Traffic incident management duties are often performed concurrently by personnel from different agencies and the private sector, as well as different divisions within single agencies (i.e., transportation personnel assigned to TIM duties have other full-time responsibilities in maintenance, traffic engineering, ITS, or emergency management). This program structure challenges the ability to accurately assess and dedicate a funding stream for ongoing operations. Service patrols—able to operate as more of a stand-alone program—provide an exception and are often included as a separate line item in State or local budgets. In California, service patrols are supported with combined Federal, State, and local funds, with local funds originating from a $1 annual vehicle registration fee in participating counties.

  Incident management personnel in Bishop, CA, and Redding, CA, rated dedicated, ongoing funding as "low" in effectively enhancing limited program resources and funding. Conversely, incident management personnel in Salt Lake City, UT, and Baltimore, MD, rated the effectiveness of this same strategy as "high" and "very high" in effectively enhancing limited program resources and funding. Incident management personnel in Baltimore, MD, noted that the availability of dedicated funding protects their TIM program from district-level budget cuts.

- **Guidelines for Federal/State Funding Sources.** An aspect of the U.S. Government that people often find confusing is the multitude of overlapping units and levels of government. Decisions are made at the Federal, State, regional, and local levels that affect TIM funding.

  By far, the largest source of Federal funding for TIM is the Federal-aid program under which Congress appropriates Federal dollars to various transportation categories (i.e., safety, congestion management, etc.) and distributes these funds to States according to a funding formula. The States, with approval from the various metropolitan MPOs, must then decide how the Federal-aid dollars are spent. The Federal Government also provides States with grants to fund their transportation programs, including TIM. From the State level, monies may then be passed on to local governments, depending on the needs and circumstances. State or local grant recipients may be required to provide matching resources and agree to various stipulations regarding what the funds may be spent on, how the program will be managed, and how the recipient will report to the sponsor. Historically, funds to support TIM have originated from the National Highway System, Interstate Maintenance, Surface Transportation, Congestion Mitigation and Air Quality (CMAQ), Research and Technology Innovation, and Highway Safety (402) programs.

  With the multitude of potential Federal and State funding sources—each having explicit conditions for eligibility and use—guidelines that address funding opportunities, requirements, and limitations in the context of TIM could provide benefit to TIM program administrators seeking to develop, expand, or enhance TIM efforts.

  Incident management personnel in Bishop, CA, Austin, TX, and Baltimore, MD, rated guidelines for Federal/State funding sources as "low," "moderate," and "high," respectively, in effectively enhancing limited program resources and funding. Low reported effectiveness ratings may reflect an already clear understanding of State and Federal funding mechanisms, existing guidelines that provide limited utility in enhancing the understanding of State and Federal funding mechanisms, or a perceived limitation to State and Federal funding sources as viable support for TIM programs (i.e., budget constraints, competition for funds, etc.).

- **Use of Technology.** Technology plays an important role in every aspect of TIM. In a number of instances, the use of technology can be demonstrated to directly increase the efficiency and, in some cases, the effectiveness of responders performing their duties. For example, access to CCTV images of an incident prior to arriving on-scene supports both the dispatch of appropriate equipment (i.e., a heavy-duty wrecker) and quicker dispatch of resources (i.e., instant tow dispatch). Use of

automatic vehicle location and geographic information system technologies can identify and mobilize resources that are closest in proximity to the incident scene, reducing overall travel times. Traffic signal priority systems can reduce delay for emergency vehicles along signalized arterials en route to the incident scene. On-scene, portable intrusion alarm systems—consisting of a sensing mechanism that forms a partial perimeter around the incident scene and an audible alarm that warns incident responders if an approaching vehicle inappropriately enters the scene—provide a technology-based alternative to the use of response vehicles for responder protection. To maintain traffic flow along the alternate route, use of responsive traffic signal control plans to manage traffic around the incident scene would relieve law enforcement personnel from this duty and allow them to perform other tasks for which they are trained (i.e., crash investigation). When an incident requires investigation by law enforcement personnel, the use of total station surveying equipment and photogrammetry can dramatically reduce investigation time while increasing the quality and quantity of measurements captured.

Incident management personnel in Bishop, CA, and Redding, CA, rated the use of technology as "very low" to "low" in effectively enhancing limited program resources and funding. Comparatively, incident management personnel in Baltimore, MD, rated this same strategy as "very high," reporting significant benefits attributable to the coordination of information from multiple agencies afforded through the use of technology.

- **Cost Recovery Mechanisms/Databases.** Select States collect and maintain various TIM data to provide historical operational performance information (i.e., changes in response or clearance times), ensure ongoing operational improvement, and justify program continuance.

  Washington collects and maintains data with a broader focus: (1) to allow review of TIM performance and direct improvements on the basis of documented examples of the techniques that have proved to be the most time- and cost-effective, (2) to allow the Washington State Department of Transportation to recover more of the costs of the incident response effort from the insurance companies of the parties at fault, and (3) to improve agency budget and planning forecasts. Incident management personnel in Stockton, CA, Baltimore, MD, and Salt Lake City, UT, rated cost recovery mechanisms/databases as "moderate" to "high" in effectively enhancing limited program resources and funding. Comparatively, incident management personnel in Redding, CA, rated the effectiveness of this same strategy in enhancing limited program resources and funding as "very low." The range of reported effectiveness may be explained, in part, by differences in the nature and extent of cost recovery and the level of effort required to maintain such a recovery system.

- **Use of Least Costly, Capable Personnel/Equipment.** Efficient and effective TIM resource management relies upon the utilization of appropriate personnel who are best qualified (i.e., capable but not overqualified) for the various tasks and equipment that can perform the function with the least cost. Uniquely trained personnel could focus on other incident management functions. For example, the use of transportation personnel to manage traffic at and around the incident scene would relieve law enforcement personnel from this duty and allow them to perform other tasks for which they are trained (i.e., crash investigation). Similarly, a higher level of efficiency and equal or higher effectiveness may be obtained by using a transportation vehicle equipped with an arrow board and additional traffic control devices to protect the scene rather than law enforcement or fire and rescue vehicles.

  Incident management personnel in Stockton, CA, and Bishop, CA, rated use of the least costly, capable personnel and equipment as "very low" and "moderate," respectively, in effectively enhancing limited program resources and funding. Incident management personnel in Stockton, CA, noted that TIM functional limitations imposed on transportation personnel in their locale (i.e.,

transportation personnel are prevented from performing certain TIM functions by agency policy) preclude a more extensive use of this strategy and a higher level of reported effectiveness.

- **TIM Requirements in New Construction Contracts.** Major construction events present an opportunity for securing additional program resources and funding to support TIM efforts. A portion of construction project funding may be required to be set aside for traffic management operations, such as TIM in construction zones, which may continue even after a project has been completed. Eligible traffic management activities may include traffic signal control, freeway surveillance, dynamic message signs, highway advisory radio, and temporary service patrols.

  Incident management personnel in Baltimore, MD, and Redding, CA, rated TIM requirements in new construction contracts as "very low" to "low," respectively, in effectively enhancing limited program resources and funding. Incident management personnel in Baltimore, MD, noted an infrequency of use of this strategy contributing to its low reported effectiveness ratings.

Inadequate Outreach to Executives. Although TIM addresses issues that are of concern to the motoring public—congestion and travel delay, public health and safety, the nation's economic health, energy savings, public safety resources, responder safety, and citizen satisfaction with government services—few decision makers at all levels of government have made TIM a priority. Decisions makers (who include elected and appointed officials) are subject to scrutiny from the public at large, who have grown more conscious of transportation issues at the same time that they have become increasingly wary of new or higher taxes in any form. To effectively encourage investment in TIM by decision makers, the associated benefits of TIM programs need to be succinctly and strongly articulated and promoted.

- **Executive Outreach Materials.** To secure program resources and funding, TIM administrators need to promote their programs among key decision makers and the public at large, to whom decision makers ultimately report. Although this group includes mayors, city and county council members, governors, members of Congress, and special district representatives, State legislators usually have the greatest ability to directly influence an agency's operation through its budget and through legislative review or oversight. State legislators review the operation of agencies and have the authority to set budget and staffing levels. Programs that are demonstrated to be in high demand fare better in the decision-making process. To support this effort, various types of outreach materials targeting State legislators can be developed to strongly yet succinctly convey the importance of TIM. Letters of thanks sent by people who have been assisted in the field can be particularly useful in this capacity.

  Atlanta's highly popular Highway Emergency Response Operators service patrol clearly illustrates the success of this approach. HERO is a highly visible arm of the TIM program. The Georgia Department of Transportation is deluged with letters of appreciation for its service. The positive responses and publicity that the Atlanta program receives put pressure on politicians and policymakers to sustain and develop the program. This provides the best protection from any threats to the entire incident management program, even the less visible operations that are most vulnerable to budget cuts (Pearce 2001). Incident management personnel in Baltimore, MD, and Austin, TX, rated executive outreach materials as "moderate" to "high" in effectively enhancing outreach to decision makers.

- **Evidenced TIM Benefits to Broader Community.** Although TIM addresses issues that are of concern to the broader community—congestion and travel delay, public health and safety, the nation's economic health, energy savings, public safety resources, responder safety, and citizen satisfaction with government services—the resulting benefits are seldom demonstrated and reported. With few exceptions, TIM programs poorly market and promote their contributions to the broader community. Difficulties in quantifying and characterizing TIM benefits—either through a one-time investigation or

through ongoing performance monitoring—often provide an initial impediment. Even when benefit-related data are available, public agencies, unlike the private sector that relies on "advertising" for its sustainability, are generally ill equipped to support even focused or targeted marketing and promotional efforts (i.e., to decision makers and elected officials).

Incident management personnel in Redding, CA, rated evidenced TIM benefits to the broader community as "low" in effectively enhancing outreach to decision makers.

CONCLUDING REMARKS

The intent of this investigation was to encourage a higher level of effectiveness in U.S. TIM efforts through the identification of current "best practices" in the United States and a synergistic partnership with NTIMC to support both the identification of U.S. best practices and the implementation of these practices by State, regional, and local TIM partners.

Best Practice TIM Tools and Strategies

In response to common task-specific and cross-cutting challenges and impediments to TIM efforts identified in the United States, a number of potential tools and strategies for improving TIM efforts were identified, each having varying levels of reported effectiveness. For many of the individual tools and strategies, a wide range of effectiveness was reported by locale, suggesting that local conditions related to the nature and extent of operation, maintenance, marketing, etc. have a significant impact on the perceived or measured success of specific TIM efforts and challenging the explicit identification of best practices. Task-specific tools and strategies generally reported to be most effective in enhancing TIM efforts include:

- field verification by on-site responders and closed-circuit television cameras to support incident detection and verification;
- media partnerships and dynamic message signs to support the provision of traveler information;
- instant tow dispatch procedures to speed response;
- on-site traffic management teams, local protocols for high-occupancy vehicle lane use during incidents, and responder injury tracking mechanisms to support scene management and traffic control; and
- service patrols, vehicle-mounted push bumpers, and major incident response teams to support quick clearance and recovery of minor to major incidents.

Tools and strategies generally reported to be most effective in addressing cross-cutting TIM challenges include:

- joint traffic/emergency management centers housing multiple agencies to enhance agency relations and institutionalize TIM,
- local and virtual TIM training to encourage joint and effective training among responders,
- a common mutual-aid radio frequency/channel and wireless information networks to enhance en-route and on-scene communications among responders from different agencies,
- expedited standards development processes and minimum interoperability requirements to encourage the cost-effective use of technology for TIM,
- a strong link between funding and performance and periodic TIM self-assessments (facilitated through FHWA's TIM self-assessment process) to encourage continued TIM program improvements, and
- development of a TIM strategic plan and the integration of TIM into local capital planning processes to ensure ongoing access to program resources and funding.

A myriad of other task-specific and cross-cutting tools and strategies identified in this document have the potential to improve TIM efforts. These tools and strategies may offer significant benefit in response to a particular challenge, may have moderate to high reported effectiveness in one or more locales, or may offer moderate benefits at little to no cost. In some cases, TIM tools and strategies must operate concurrently to fully realize the benefits to operations. For example, benefits resulting from the use of standard message

sets will only be realized if dynamic message signs are concurrently used for traveler information. Similarly, the benefits resulting from the use of electronic loop detectors and closed-circuit television cameras in combination outweigh the benefits of either used singularly. Where appropriate, opportunities for improving the effectiveness of the various TIM tools and strategies or synergistic benefit through concurrent implementation were identified. This investigation did not, however, consistently consider cost in relation to reported effectiveness. Low- or no-cost tools or strategies with moderate reported effectiveness may prove to be better implementation options than higher cost strategies with the same or potentially higher benefits.

Implementation

At a local, regional, or State level, TIM administrative or operations personnel considering implementation of a particular tool or strategy can refer to the appropriate references for published findings cited in this document or contact TIM practitioners participating in this investigation directly by telephone or email to obtain more information. Experiences that resulted in a low relative effectiveness rating may be of most interest to TIM administrative or operations personnel considering implementation of a specific tool or strategy, particularly if others have reported only positive experiences. Identification of potential pitfalls early in the implementation stage can help to ensure that the same shortcomings are not propagated and that the full effectiveness of TIM efforts can be realized.

At a national level, NTIMC provides a unique forum for disseminating the information presented here directly through its website and through participation in various outreach activities and events. Stated goals of NTIMC include promoting and supporting the successful development and conduct of local, regional, and statewide TIM programs through peer networking, mentoring, and knowledge exchange among public safety and transportation professionals, and providing leadership in the development of multidisciplinary best practices, guides, standards, and performance measures in support of sound TIM activities.

As evidenced by the wide range of reported effectiveness for singular TIM tools and strategies among the various participating locales, longer term efforts of NTIMC should focus on standardizing practices to consistently maximize the effectiveness of TIM efforts. In many cases, this may require additional research to identify the local conditions related to the nature and extent of operation, maintenance, marketing, etc. that have a significant impact on the perceived or measured success of specific TIM efforts. More consistent implementation of TIM tools and strategies will enhance not only the cost-effectiveness of program operation but also its sustainability over time.

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APPENDIX

Survey Respondents

STATE	METROPOLITAN AREA	CONTACT	
California	Bishop	Sam Esquenazi Senior Transportation Engineer Caltrans Transportation Management Team Supervisor	Lawrence Wooster, P.E. Chief, Incident Management Operations Branch Traffic Operations Division California Department of Transportation (916) 654-6104 larry_wooster@dot.ca.gov
	Los Angeles	Terry Erlwein District Traffic Operations Engineer	
	Redding	Mike Gunter Traffic Engineer Caltrans District 2 (530) 225-3206 mike_gunter@dot.ca.gov	
	Stockton	Toni Moon	
Maryland	Baltimore	Alvin Marquess Deputy Director of Operations Maryland State Highway Administration (410) 582-5677 amarquess@sha.state.md.us	
Tennessee	Chattanooga	Robert Van Horn Region 2 Incident Management Coordinator Tennessee Department of Transportation (423) 510-1168 robert.vanhorn@state.tn.us	
Texas	Austin	Brian Burk Engineer Texas Department of Transportation, Austin District (512) 974-0899 bburk@dot.state.tx.us	
Utah	Salt Lake City	David Kinnecom Traffic Management Engineer Utah Department of Transportation (801) 877-3707 dkinnecom@msn.com	

Contact Information

For additional information on this report,
contact Kimberly Vasconez, via email at
Kimberly.Vasconez@dot.gov
Federal Highway Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

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