Highway Work Zone Traffic Incident Management

A Guide For First Responders, Transportation Agencies and Contractors

May 2016

Tractor-trailer crash in a work zone on I-75 near Perrysburg, Ohio. Photo: Julia Nagy, *Toledo Blade* (retouched)

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16. Abstract
Dealing with a motor vehicle crash or similar incident in a highway construction zone requires the combined skills of many people including police, fire, emergency medical services (EMS), highway agency, and contractor personnel. Work Zone Traffic Incident Management (WZ-TIM) is more complicated than ordinary TIM because access to the incident site is often difficult, there is limited space for response operations, and there are more organizations to coordinate. Response can be hampered by the combined effect of incident traffic backups and construction closures.

First responders, highway agencies and contractors need to work together to help prevent work zone traffic incidents and to be prepared to respond quickly when incidents occur. Responses should be matched to site conditions including terrain, available road space, and incident severity. Intensive pre-planning could be required for projects affecting tunnels, long bridges, freeway-to-freeway interchanges, and other challenging sites. Administrative procedures should be reviewed to assure effective coordination of major decisions, such forced diversion of traffic to a secondary route.

Traffic mitigation measures and work zone emergency access should be considered during project design. During construction, first responders should be updated regularly about work status and available access points. For projects on congested high-speed roadways, Queue Warning Vehicles should be considered to reduce the risk of secondary crashes. Training and tabletop exercises can help responders, highway agency, and construction personnel understand their roles and responsibilities and prepare for efficient, well-coordinated response and recovery. Post-incident review can help assure that good practices are perpetuated.

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Truck crash near Waterloo, Iowa (May 2013).
Photo: Iowa DOT

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Introduction

Dealing with a crash or other traffic incident that occurs in a work zone requires the combined skills of many people. This guide was developed to help first responders (police, fire, and Emergency Medical Services [EMS] personnel), transportation agency employees, field engineers[1], construction management consultants, highway maintenance personnel, and contractors coordinate and improve work zone incident prevention and response.

If you are a first responder, agency employee, maintenance worker, consultant, or contractor it is very likely that you also experience the roadway system as a driver, passenger, and pedestrian. At times, you might also be a bicyclist, transit passenger, or heavy truck operator. For all of these types of road users, ROAD WORK AHEAD signs are a familiar sight—but one that can also bring a moment of apprehension:

- Will there be congestion and delays?
- Will it be a difficult or uncomfortable driving experience?
- Will the roadway be safe?
- Will other people behave in a safe and predictable way?

The impacts of highway construction are as diverse as work zones themselves. Sometimes a project is simple, perhaps one or two workers replacing signs, with no lane closures. Sometimes the project is complicated, with many workers and an ongoing series of lane closures and roadway changes lasting months, or even years.

Figure 1. Traffic bottleneck from a work zone incident.
Photo: Iowa DOT

To provide space for work operations it is often necessary to relax the usual roadway design standards temporarily. For example, one or more lanes might be closed, and the remaining lanes might be narrower than usual. Sometimes it is necessary to shift lanes sideways to get around partially-completed work or other obstacles. The pavement surface might be rougher than usual. Visibility is often reduced. Construction also introduces new risks, such as collisions between fast-moving traffic and slow-moving work vehicles. The cognitive workload for drivers increases: orange drums and other temporary traffic control devices increase the number of objects that drivers need to observe and mentally process as they try to identify traffic hazards. In addition, drivers sometimes get distracted looking at the roadwork when they should be paying attention to the road. The combined result of all of these factors is that the number of crashes per distance travelled is higher in work zones than it is under non-construction conditions.[2]

First responders, contractors, designers, construction engineers, and other highway agency personnel have a shared responsibility to prepare for potential work zone crashes. This includes

[1] For simplicity, the term "field engineer" is used in this document to refer to the highway agency's on-site representative. In some States this person is called the "resident engineer" and in some cases this person is a consultant rather than an agency employee.

[2] References: Hayes, M. R., P. J. Taylor, and H.C.R. Bowman. "A study of the safety performance of major motorway roadwork layouts." TRL Project Report PR 81 (1994) and Hayes, M. R., and P. J. Taylor. "A review of the accident risk associated with major roadworks on all-purpose dual carriageway roads." TRL Project Report PR 37 (1993).

three overlapping tasks: arranging the work zone to minimize the chances of a crash, making efforts to assure that crash severity and crash consequences are minimized, and being ready to respond quickly and efficiently if a crash occurs.

Work zones often reduce the traffic-handling capacity of the roadway. If the traffic volume is relatively high, backups and delays can occur. Incidents that occur within a work zone can compound these delays (Figure 1).

POOR PRACTICE

Figure 2. Abrupt pavement edge drops create the potential for serious crashes.
Photo: Wisconsin DOT

It is desirable to avoid all crashes, but if we are forced to make difficult choices it is better to tolerate a few minor property damage crashes than to have even one crash that results in a serious injury or fatality. For example, removal of old pavement often leaves abrupt edge drops (Figure 2). If the edge drops are close to live traffic, momentary driver inattention can result in a roll-over crash. Installing barriers to protect edge drops can reduce the risk of serious injury. The barriers are often very close to traffic, which can increase the number of minor vehicle damage incidents, but an overall improvement in road user safety can usually be expected.

As the pace of rebuilding the American highway system accelerated in the mid-2000s, the Federal Highway Administration (FHWA) became increasingly concerned about work zone safety and the impacts of work zone traffic delays. FHWA established the Work Zone Safety & Mobility Rule to help manage traffic and safety issues on projects that receive federal funding. Since 2007 the Rule has required each State Department of Transportation (DOT) to establish a work zone planning process. This is called a Transportation Management Plan (TMP) in some States and a Maintenance of Traffic (MOT) plan in others (for simplicity this guide uses the term TMP). Typically, the TMP includes administrative, procedural, and operational strategies for managing and mitigating work zone impacts. Several issues are considered in the document such as work zone traffic impacts, traffic management, incident management, and public outreach. The TMP process has been successful in improving travel conditions and reducing complaints from the public. It is now considered "best practice" for significant construction projects, regardless of the way they are funded. Although not all projects are large enough to require a formal TMP, being prepared to handle work zone incidents can be helpful even on small jobs, so this guide provides a review of basic concepts and state-of-the-art approaches for managing incidents in work zones.

Many regions of the United States have well-established Traffic Incident Management (TIM) programs designed to improve coordination between highway agencies, law enforcement, and other first responders. Construction projects can serve as a catalyst for strengthening existing TIM programs or starting a program in a location that does not already have one. The run-up to a project can also be a good time to train agency personnel, test inter-agency procedures, and update mutual aid agreements.

There are important differences between TIM on ordinary roadways and Work Zone Traffic Incident Management (WZ-TIM). WZ-TIM is often more complicated for the following reasons:

- **Difficult Access.** As shown in Figure 3, many work zones utilize temporary barriers that funnel traffic into a narrow channel. Lack of shoulders, missing pavement, temporary barriers, fences, stockpiles, and other obstacles can make it difficult to reach the incident site from the main travel direction, and they sometimes cut off access from other directions.
- **Limited Space.** Lane closures and reduced lane width often make it difficult to find enough space to deal with the incident and also keep traffic moving. Emergency response vehicles sometimes have difficulty maneuvering at the site, making it all the more important to assure effective coordination in life-critical situations. Lack of space can also affect the physical safety of people involved in incident response.

Figure 3. Work zones with barrier on both sides can be difficult to access in the event of an incident.
Photo: Pam Panchak *Pittsburg Post-Gazette*

- **Traffic Congestion.** The reduced traffic-handling capacity associated with most work zones combined with backups caused by the incident can make it doubly difficult for emergency vehicles to reach the site in a timely manner. Bottlenecks and traffic queues (back-ups) can be especially problematic if the incident turns out to be more serious than initially expected and a second wave of responders is required. Queues can grow rapidly, creating an elevated risk of secondary collisions as high-speed traffic approaches stopped or slowed vehicles at the back-of-queue.
- **More Organizations to Coordinate.** Contractors, subcontractors, and construction managers are usually present in the work zone, in addition to the first responders and transportation agency personnel who ordinarily deal with incidents. Consequently, there are more people and organizations that play a role in incident prevention and incident management. Some of these personnel could be inexperienced with their roles in managing an incident or unfamiliar with how to work together under a unified command structure.

Making the Work Zone a "Safe System"

The Safe System approach is a new way of thinking about the interaction of roads, road user behavior, vehicles, and speeds.[3] Traffic crashes usually involve a chain of events that includes mistakes, mishaps, and sometimes misbehavior (Figure 4). The goal is to break the chain before a mistake turns into a serious incident, or at least to reduce the severity of the incident.

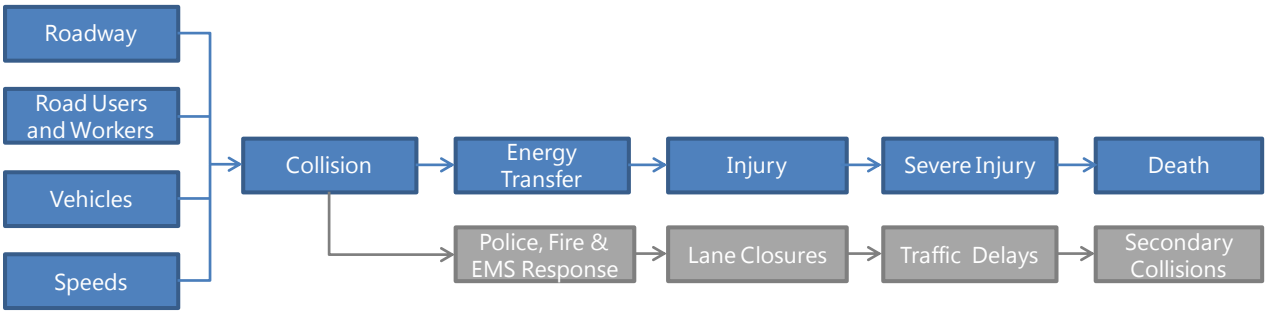

Figure 4. Causal chain for a fatal work zone collision.

[3] The Safe System approach was published in 2008 as the result of a three-year cooperative effort by an international group of safety experts representing 22 countries. The United States was represented in this effort by high-ranking officials from the Federal Highway Administration (FHWA), the Federal Motor Carrier Safety Administration (FMCSA), and the National Highway Traffic Safety Administration (NHTSA). For more information see the International Transport Forum report *Towards Zero: Ambitious Road Safety Targets and the Safe System Approach*.

A Safe System has four elements: safe roads, safe vehicles, safe speeds, and safe road users. If one part of a Safe System fails, then other parts of the system help minimize the consequences of the failure.

Protecting human health is the core of the Safe System approach. First, the approach recognizes that humans have very limited ability to absorb the forces of blunt trauma that occur during a crash. Instead of trying to eliminate all crashes (which is not realistic), the focus is on preventing crashes from resulting in death or serious injury. To minimize work zone crash severity, this means making the work zone environment as forgiving as possible to errors or misjudgments made by workers, first responders, drivers, or other road users. If a crash does occur, emergency response personnel—and people who are already on scene—need to respond quickly and correctly to assure that victims receive appropriate treatment as promptly as possible.

Creating a Safe System in a work zone is a shared responsibility that requires coordination between organizations. This includes assuring temporary traffic control is properly implemented and maintained, traffic proceeds at safe speeds, work vehicles are properly maintained and safely operated, and there is safe driver behavior throughout the entire work zone. Achieving these goals in work zones can be challenging because law enforcement and emergency response are often hampered by lack of space and limited site access.

Work Zone Traffic Incident Management (WZ-TIM) Elements & Concepts

Traffic incident management and work zone management are two sets of tools for reducing traffic congestion:

- *Incident management* involves developing procedures, implementing policies, and deploying technologies to identify incidents more quickly, improve response times, and manage the incident scene more effectively and efficiently.
- *Work zone management* aims to reduce the amount of time work zones are needed and deploy strategies for moving traffic more effectively in and around the work zone, particularly during peak travel times.

What Constitutes a Work Zone?

The Manual on Uniform Traffic Control Devices (MUTCD) and the federal Work Zone Safety & Mobility Rule provide the same formal definition for a work zone: *"an area of a highway with construction, maintenance, or utility work activities…typically marked by signs, channelizing devices, barriers, pavement markings, and/or work vehicles. It extends from the first warning sign…or strobe lights on a vehicle to the END ROAD WORK sign or the last temporary traffic control (TTC) device."*[4]

Work zone incidents often extend beyond the boundaries of the work zone itself. This is recognized in the Safety & Mobility Rule's definition of a work zone crash: *"a traffic crash in which the first harmful event occurs within the boundaries of a work zone or on an approach to or exit from a work zone, resulting from an activity, behavior, or control related to the movement of the traffic units through the work zone. This includes crashes occurring on approach to, exiting from or adjacent to work zones that are related to the work zone."*[5]

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[4] Reference: Manual on Uniform Traffic Control Devices for Streets and Highways (2009 Edition). U.S. Department of Transportation - Federal Highway Administration: Washington, DC.

[5] Reference: 23 CFR 630 *Work Zone Safety and Mobility: Final Rule*, In *Federal Register* Vol 69, No. 174 p. 54562-54572 (2004), Federal Highway Administration: Washington, DC.

The National Highway Traffic Safety Administration (NHTSA) and the Governors Highway Safety Association (GHSA) jointly developed the Model Minimum Uniform Crash Criteria (MMUCC) to standardize crash reporting throughout the United States. The MMUCC reinforces these definitions by describing a work-zone-related crash as: *"A crash that occurs in or related to a construction, maintenance, or utility work zone, whether or not workers were actually present at the time of the crash. 'Work-zone-related' crashes may also include those involving motor vehicles slowed or stopped because of the work zone, even if the first harmful event occurred before the first warning sign."*[6]

What Constitutes an Incident?

A wide range of situations can cause a spike in traffic demand or an abrupt reduction in roadway capacity. Some examples include traffic crashes, special events, adverse weather, and natural disasters. Some of these are planned long in advance (a rock concert, festival, professional baseball game, etc.). Others are not very predictable (a rockslide, tornado, tsunami, etc.). *For the purposes of this guide, the focus is on preparedness and response for traffic crashes and similar problems (such as disabled vehicles and cargo spills) that occur in work zones.* In other words, we are considering the combination of a planned event (highway construction or maintenance) and a second situation whose exact timing, location, and severity are relatively unpredictable.

Types of Work Zone Incidents

Broadly speaking, there are three types of work zone incidents:

- Traffic crashes that occur within a work zone or in a traffic queue leading into a work zone.
- Occupational injuries involving workers in or near the right-of-way.
- Construction-related mishaps such as an equipment tip-over, embankment collapse, or fire at the construction site (Figure 5).

This guide addresses occupational injuries and similar incidents only to the extent that they affect traffic management in the work zone—for example if it is necessary to close a lane to rescue an injured worker or provide emergency access to the work area.

Figure 5. In August 2015 an excavating machine struck an electrical tower while working on a freeway interchange in Burlingame, California. The incident dropped live high voltage lines onto the freeway, leaving some drivers stranded for hours.
Photo: sfgate.com

Secondary Crashes

The term "secondary crash" refers to a second (or subsequent) crash that occurs at the incident scene or in a queue resulting from the original incident. Secondary crashes are a significant problem in terms of both frequency and severity. According to one estimate, they cause 18% of all fatalities on freeways.[7] The most common type of secondary crash occurs when traffic is backed up and a high-speed vehicle strikes a slowed or stopped vehicle at the back of the queue. Crashes involving gawkers travelling in the opposite direction are also considered secondary crashes.

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[6] Reference: Model Minimum Uniform Crash Criteria (MMUCC) Guideline - Fourth Edition (2012). U.S. Department of Transportation and Governors Highway Safety Association, Washington, DC.

[7] Reference: *Improving Traffic Incident Management Together* (2004), National Traffic Incident Management Coalition, pp 1.

Work Zone Safety: Not Just for Drivers

Police officers, firefighters, and construction workers face significant hazards while working on roadways. Although not specific to work zones, Figure 6 shows the leading causes of occupational death for these three groups based on data collected by the U.S. Department of Labor. Notably, more police officers are killed on the job in traffic crashes than by perpetrators of crime. Similarly, the number of firefighters who are struck and killed by motor vehicles exceeds the number killed by fires and explosions. For highway maintenance workers, transportation incidents are by far the most common cause of on-the-job death. Tow truck operators are also at high risk of being struck by motor vehicles.

Work zone situations present particular safety challenges for people involved in incident management. Drivers already impatient from construction-related traffic delays are likely to be even more so when the delay is compounded by an incident. As a result, drivers are sometimes tempted to take risks they would ordinarily avoid, such as unauthorized driving on shoulders or trying to squeeze through narrow spaces. In addition, based on the assumption that law enforcement is preoccupied with incident response, drivers can be tempted to make illegal maneuvers that put everyone on scene at risk.

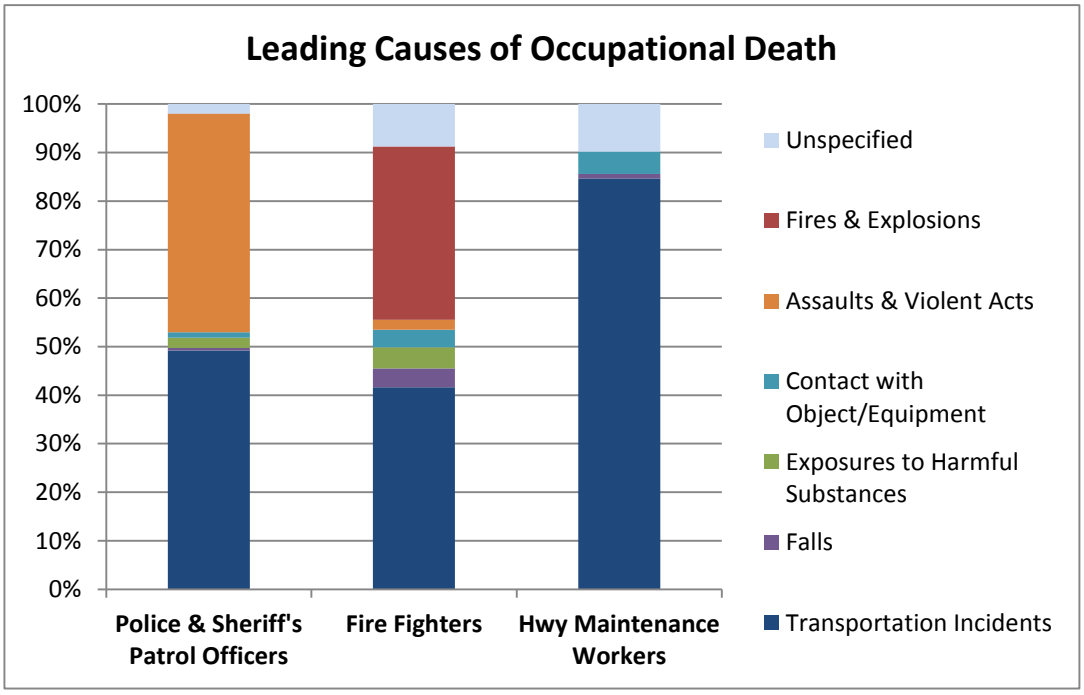


Figure 6. Leading causes of occupational death for selected occupations 2002-2013.
Source: Bureau of Labor Statistics

Regulations, Standards, and Protocols

Several documents establish essential requirements for traffic management and incident management in the U.S.:

- **Pre-Planning.** The federal Work Zone Safety & Mobility Rule (23 CFR 630, Subpart J) requires all highway construction projects that use federal funds to plan for anticipated safety and mobility issues during project design and manage traffic problems during construction. Each project is required to develop an appropriate Transportation Management Plan (TMP) in consultation with stakeholders such as police, fire, and EMS providers.

- **Traffic Control.** The Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (MUTCD) establishes U.S. national standards for traffic control devices such as signs, lights, and traffic cones. Chapter 6 includes several "Typical Application" drawings that illustrate recommended layouts for work zone traffic control and incident management. This large document can be downloaded free of charge at http://mutcd.fhwa.dot.gov/ . Printed copies are available from online booksellers.
- **Emergency Vehicle Lights.** Flashing lights help alert drivers to an unusual situation while emergency vehicles (and possibly contractor vehicles) are travelling toward an incident scene. As vehicles start to congregate at the scene, the accumulation of lights can become dazzling. To minimize the risk of driver distraction, Section 6I.05 of the MUTCD recommends that flashing lights be reduced to the essential few after the vehicles arrive at the site, and this is particularly important at night. In addition, drivers (especially elderly drivers) can be temporarily blinded by glare from floodlights used for incident response or construction (Figure 7). As a result, it is important to assure that work lights and vehicle headlights are aimed so that they do not shine into the eyes of oncoming drivers.

Figure 7. Glare from emergency vehicle lighting can temporarily blind oncoming drivers.
Photo: Jantman/WikiMedia Commons

- **Apparel.** High-visibility vests and garments help assure that first responders, incident command personnel, and construction workers are readily seen by drivers (Figure 8). These items must meet standards set by the American National Standards Institute (ANSI) in collaboration with the International Safety Equipment Association (ISEA), specifically standards 107-2010 and 207-2011. Many States require the use of both vests and high-visibility pants at night. The standards allow the use of both orange and yellow-green; in general, the color that provides the best contrast with the surroundings should be used.
- **National Unified Goal (NUG).** In 2007 the National Traffic Incident Management Coalition established the National Unified Goal for Traffic Incident Management with goals, objectives and strategies for assuring responder safety, quickly and safely clearing incidents, and assuring prompt, reliable, interoperable communications between emergency response agencies.

Figure 8. Officers wearing high-visibility apparel respond to an incident near Holton, Kansas.
Photo: David Powls, Holton Recorder

- **Hazardous Materials.** Several categories of hazardous materials or "hazmat" are established by Federal regulations. Broadly speaking, hazmat includes any substance that could harm humans, animals, plants, or the environment. Examples include toxic, flammable, explosive, corrosive, radioactive, and chemically reactive substances (reacting with air, water, acids, or bases), along with biological hazards such as medical waste. A wide range of hazardous materials are routinely transported on the highway system as cargo. Motor vehicle fuels (gasoline and diesel) are inherently hazardous. Compressed gasses, solvents, chemicals, and explosives required for work operations could also be present at construction sites. Due to the proximity of workers and limited space for clean-up operations, work zone incidents involving hazmat can potentially have more serious consequences than a similar situation occurring during normal highway operations. Response procedures vary by jurisdiction, and should be discussed as part of incident management pre-planning. Although the party responsible for the spill is usually legally liable to arrange cleanup, others might need to step into this role if the responsible party is injured or neglects this duty. Hazmat response crews should be contacted promptly, since they might need to travel a considerable distance to reach the site.

National Incident Management System (NIMS) and Incident Command System (ICS)

The National Incident Management System (NIMS) was established in 2004 by the Federal Emergency Management Administration (FEMA) to be a "systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work together seamlessly and manage incidents involving all threats and hazards—regardless of cause, size, location, or complexity—in order to reduce loss of life, property and harm to the environment." The NIMS serves as the template for management of all incidents and related support operations.

A key feature of NIMS is the Incident Command System (ICS), a systematic tool for command, control and coordination of an emergency response. ICS is a set of procedures for making effective and efficient use of personnel, facilities, equipment and communications by integrating them within a common organizational structure. It is designed to be used or applied from the time an incident occurs until the need for management and operations no longer exists. The ICS structure should be used for every traffic incident in a work zone, regardless of complexity or duration. Although a full description of ICS is beyond the scope of this document, the key concepts include:

- **Modular Organization:** The first arriving unit establishes command over the incident. The chain of command follows a top-down hierarchy. The overall organization expands and contracts as needed based on the conditions. As the response progresses, command is handed over to the agency or group that is best able to handle the overall coordination of that phase of the incident. For example, if law enforcement officers are the first to arrive at the scene but the most serious hazard is a fire, command is handed over to the fire services as soon as they arrive and are ready to take control.
- **Unity of Command:** Each individual participating in the operation reports to one (and only one) supervisor.
- **Span of Control:** Each supervisor oversees no less than 3 and no more than 7 individuals. Supervisors coordinate with one another, but do not get directly involved in front-line operations. Instead, supervisors allocate tasks to individuals based on their training and expertise.
- **Management by Objective:** Incidents are managed by aiming towards specific objectives. These objectives are ranked by priority, should be as specific as possible, must be attainable, and if possible given a working time-frame. Objectives are accomplished by first outlining strategies (general plans of action), then determining appropriate tactics (how the strategy will be executed) for the chosen strategy.

The *Simplified Guide to the Incident Command System for Transportation Professionals* provides additional information about ICS and its application during highway incidents. It is available on the FHWA website.

Incident Complexity Levels

Traffic incident and response levels can be organized into three categories based on expected duration and complexity:

- **Minor**. Expected duration of less than 30 minutes. These incidents typically involve only a few on-scene responders (e.g. law enforcement, towing/recovery vehicle, or freeway service patrol). Examples include disabled vehicles in a travel lane or on the shoulder, minor crashes, and minor roadway debris.

- **Intermediate**. Expected duration of 30 minutes to two hours. These incidents typically require on-scene traffic control to direct road users around the blockage. Full roadway closures might be needed for short periods during traffic incident clearance to allow incident responders to accomplish their tasks. Examples include large roadway debris, truck-trailer crashes, rollover crashes, and multi-vehicle crashes.

- **Major.** Expected duration of more than two hours. These crashes often involve fatalities, hazardous materials, or numerous vehicles. Major incidents can also include natural or man-made disasters. In many cases traffic control will be required to direct road users around the blockage or divert traffic to alternate routes. Examples include:
  - Chain reaction crashes with multiple vehicles and/or injuries.
  - Crashes that require a significant medical response, a site visit by the coroner or medical examiner, or investigation by a crash reconstruction specialist (e.g., fatalities or suspected impaired drivers).
  - Incidents involving advanced, prolonged environmental clean-up (e.g., hazardous material spills).
  - Overturned tractor-trailer.
  - Structural damage (e.g., bridge strike).

Matching Response to Site Conditions

The response to work zone incidents must be tailored to the characteristics of the work zone and the nature of the incident itself. Some factors that affect the ease or difficulty of incident response include the type of roadway (such as a freeway, arterial, or local street), the setting (urban, suburban or rural), the type of work that is being done, the work duration (long term, short term, or mobile), and the season(s) of the year when work operations occur.

Access is an important consideration for incident planning and management. This includes (most fundamentally) the roadway type, such as a divided highway that has access only at interchanges or a conventional road with intersections and driveways. Another consideration is loss of access caused by the project itself—for example, freeway ramp closures can impede access to incident sites.

Access to water for fire-fighting is another consideration: response will be more difficult if the site has no fire hydrants or if the water has been turned off because of construction. A related consideration is the ability to turn off electricity—especially high-voltage power—in case of a fire or other major incident. The availability of highway lighting can be helpful for incident management at night, but sometimes introduces electrical risks for responders.

Terrain also influences incident management. For example, many highway crashes result in fuel spills, which can cause significant environmental concerns if the site adjoins a waterway or other sensitive area. Man-made features also need to be considered. For example, if there is a railroad line adjacent to the highway work zone, a highway incident could affect the railway, perhaps requiring rail service to be suspended (or a reduction of

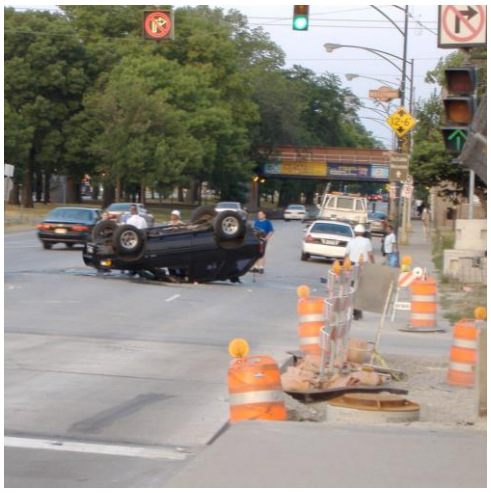


Figure 9. Single-vehicle rollover crash on an urban arterial adjacent to a work zone in Chicago, Illinois.
Photo: Kim Scarborough/Wikimedia Commons

train speeds). Similarly, a serious incident on a highway bridge that passes over a shipping channel might require temporarily closing the waterway.

The intensity of incidents varies. For example, some incidents block only the roadway shoulder, while others affect one or more travel lanes. Incident traffic impacts are also influenced by lighting and weather conditions and the traffic volume (also called the traffic demand). In nearly all locations, demand varies depending on the time of day and day of week. As a result, incident response plans should be as flexible as possible so that they can be scaled up or down based on actual conditions and the resources available when the incident occurs.

Construction activities usually reduce the traffic-handling capacity of roadway lanes, and incidents can compound these capacity reductions. The resulting traffic impacts sometimes extend a considerable distance upstream of the construction closure or incident site.

- Being prepared to resolve the incident as quickly as possible can help reduce traffic delays and the risk of secondary collisions.
- If the bridges, pavement, lane markings, and signs are still intact, it is sometimes possible to reduce traffic impacts by restoring traffic on lanes or shoulders that were closed for roadwork.
- In other cases, it might be appropriate to redirect traffic to alternate routes by using signs, entrance ramp closures, or uniformed law enforcement officers.
- Many agencies use their relationships with radio and television stations or other media outlets to notify the public about incidents, which can help reduce the number of drivers attempting to pass through the incident scene.

Figure 10. Pre-planned alternate route for construction project near Cape May, New Jersey.
Photo: Dough4872/WikiMedia Commons

Pre-planned detours or alternate routes can be helpful in managing incidents (Figure 10). Sometimes these routes double as construction detours during off-peak hours (for example, if an overnight full closure of the roadway is required to set bridge girders). If the traffic stream includes a large proportion of heavy trucks, it might be desirable to mark separate routes for automobiles and heavy vehicles. This can avoid excessively long routes for car traffic, while also minimizing maneuverability issues (and pavement impacts) for large vehicles. Alternate routes for pedestrians and bicycle traffic might also need to be considered, especially in urban areas.

A particularly important administrative issue is to establish in advance who has the authority to make the decision to divert traffic to the alternate routes, who is authorized to discontinue their use when the situation improves, and the criteria that will be used to make these decisions. If the site is complicated, it might also be necessary to prepare step-by-step deployment instructions in advance.

As a result of the wide range of possible sites and situations, it is usually preferable to develop site-specific incident management plans (especially for larger construction projects). Although it might not be possible to cover every potential situation, the plan should consider a set of reasonably likely scenarios. For example, if the project involves night construction, the possibility of an incident that occurs at night should be considered. Similarly, if the project will involve winter construction in a cold climate, the additional challenges of responding to incidents during periods of heavy snowfall or unusually cold temperatures should be evaluated.

Unusual Sites

Most roadway construction projects occur at relatively routine sites on urban streets, two-lane rural highways, and freeways. Occasionally the site conditions are more complicated.

It can be particularly challenging to manage work zone incidents if there is a combination of difficult terrain and restricted or confined access. Detailed pre-planning should be considered for projects involving long or high bridges, freeway-to-freeway interchanges, tunnels and other underground structures, and sites in remote or mountainous areas. Special coordination is also important to assure continuous access to hospitals, ambulance stations, police and fire stations, military facilities, etc.

In a few cases, there is a reasonable chance that a highway work zone incident could disrupt another mode of transportation. An example would be an incident that blocks access to a major passenger airport. In preparation, it would be appropriate to develop a communication plan to assure that the airport operating authority, airlines, and Transportation Security Administration are informed promptly in case of an incident affecting the access road. Other situations where extra planning and coordination might be required include sites near major railroads, pipelines, or maritime facilities (at minimum, contact numbers for railroad, pipeline, and maritime control centers should be pre-identified).

In several U.S. cities, mass transit rail lines, commuter rail lines, or bus rapid transit systems have been built in freeway medians or immediately adjacent to a major road (Figure 11 and Figure 12). This can pose special challenges in case of a work zone incident:

- Many urban trains operate on high-voltage "traction power" supplied by overhead wires or an electrified third rail. This electricity will need to be switched off if first responders need to access the track, or want to use water for fire suppression.
- For the physical safety of first responders, it might be necessary to stop traffic on the rail line or busway. If possible, this should be done in an orderly manner: in past incidents, anxious passengers stranded between stations have taken actions that put themselves, first responders, and the public at risk of serious injury. Therefore, whenever it is safe to do so, trains or busses should stop and off-load at a station (or other regular stopping place), not between stations. Off-loading at stations also reduces the likelihood that passengers with disabilities will require rescue assistance from first responders.

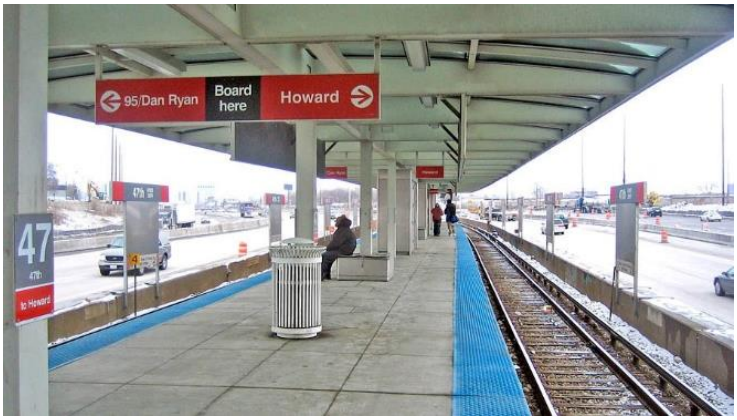


Figure 11. The Chicago Transit Authority's Red Line is one of several U.S. mass transit facilities located in freeway medians. An electrified third-rail is visible at the lower right. Photo: Graham Garfield/WikiMedia Commons

Figure 12. New Mexico Rail Runner, a commuter train connecting Belen, Albuquerque and Santa Fe, operates partly in the median of I-25. Photo: Aaron Friedman/YouTube

Measuring Success

There are three generally accepted performance measures for gauging TIM effectiveness:

- ***Roadway* Clearance Time:** the interval between the first awareness of an incident by a responding agency (detection, notification, or verification) and first confirmation that all lanes are available for traffic flow.
- ***Incident* Clearance Time:** the interval between the first awareness of the incident and the time at which the last responder has left the scene.
- **Secondary Incidents:** the number of additional unplanned incidents that occurs at the scene (or in the traffic queue approaching the scene) after the original incident is reported.

Another useful metric is road user delay, which is often available from agencies' traffic speed detectors or from data vendors that have access to GPS data from cell phones and navigation devices.

Implementing the WZ-TIM Process

Incident Prevention

Unsafe conditions often exist for a long time before someone actually gets hurt. Some of these "latent failures" or "problems waiting to happen" could be physical, such as an open manhole, an unprotected drop-off, a splattered and unreadable traffic sign, or traffic speeds that are routinely too fast for conditions. Others are organizational, such as communication problems or ambiguous procedures. People and groups with exceptional safety performance are constantly on the lookout for such problems and find ways to solve them promptly and systematically. Recognizing that even the best people make mistakes, they avoid scapegoating and stay focused on finding timely solutions. In a proactive or "generative" safety culture, people freely share what they have learned so that the best practices can spread rapidly.

Law enforcement, fire, EMS, transportation agency, and contractor personnel are as important to incident prevention as they are to incident response. For example, first responders often pass through work zones as part of their ordinary duties. They are an authoritative source of information to alert the roadway agency when they notice defects in the work zone, such as missing or damaged traffic control devices, unnecessary driving distractions, or unsafe working practices (such as a contractor swinging an excavator bucket out over live traffic). Generative organizations have a clear and easily understood safety message: *if you see an unsafe situation, tell someone who can fix it.*

Law enforcement, fire service, EMS, transportation agency, and contractor personnel can also serve as role models for safe work zone driving and compliance with work zone speed limits. This includes not only uniformed officers and frontline staff, but also management and administrative personnel, both on- and off-duty.

Preparedness

As shown in Table 1, there are a number of steps that first responders, transportation agencies, construction managers, and contractors can take to reduce the risk of incidents, limit the severity of casualties, expedite incident response, and reduce incident-related traffic impacts. Some of the issues and opportunities to be considered during work zone design and incident pre-planning are discussed below. Table 2 provides examples of questions to consider during the pre-planning process and some potential strategies for mitigating work zone incidents. Many agencies also have detailed information about pre-construction incident management planning and the TMP process in their official roadway design manuals.

Table 1. Examples of WZ-TIM preparedness actions.

Pre-Construction	During Construction
☐ Determine which jurisdictions and agencies are affected by the project. ☐ Identify access locations and plan alternate routes. ☐ Evaluate project impacts on existing traffic monitoring and communications equipment. ☐ Develop physical accommodations for incident management such as emergency pullouts, enforcement pads, triage areas, and emergency traffic control device storage areas. ☐ Discuss and agree upon project expectations and objectives. ☐ Clarify incident management roles and responsibilities of agencies, construction managers, contractors, and subcontractors. ☐ Review and update communication protocols, coordination procedures, inter-agency memos, mutual aid agreements, contracts, etc. ☐ Prepare contact lists (including contractor point of contact) for both routine updates and emergencies. ☐ Distribute anticipated project timeline. ☐ Agree to periodic evaluations of work zone effectiveness. ☐ Conduct training and tabletop exercises to practice and clarify incident management procedures.	☐ Provide regular updates to people on the contact list and law enforcement communication centers regarding changes in work schedules, open/closed lanes, and other aspects of the work zone traffic configuration. ☐ Conduct periodic or as-needed briefings on significant pending changes to traffic configurations. ☐ Develop and maintain access/egress signing into work areas for emergency responders (Figure 13). ☐ Install and maintain supplemental access point signing for fire hydrants, sound wall access points, etc. ☐ Provide detailed, up-to-date information to the public concerning roadway closures, traffic congestion, and recommended alternate routes. ☐ Use construction press releases to remind the public about quick-clearance laws ("clear it if you can steer it"), crash investigation sites, and other relevant rules, regulations, and facilities.

Table 2. Response planning questions and potential strategies.

Questions to Consider in Response Pre-Planning	Incident Mitigation Strategy Examples
☐ Will the project impact emergency response in this segment of highway? ☐ How easily can first responders reach incidents that occur in the work zone? ☐ If an incident closes the highway in one or more directions, how will traffic be re-routed? ☐ Are there strategies to minimize project impacts on response agencies or the public? ☐ Are there procedures that would enhance traffic incident clearance and safety? ☐ What equipment would improve emergency response and management during construction? Is it available? Where is it located? ☐ How will project personnel coordinate with and assist emergency responders? ☐ Are existing systems for coordination among first-responders sufficient?	☐ Physical features such as crash investigation sites, emergency parking, enforcement staging areas, triage areas, and landing areas. ☐ Pre-staging of incident management traffic control devices and other emergency apparatus. ☐ Pre-installation of wayfinding signs along alternate routes to guide drivers in case of a closure or backup. ☐ Electronic signage to detect and notify drivers about work zone queues. ☐ Roving towing patrols. ☐ Equipment for rapid incident detection (e.g. video monitoring and traffic speed sensors). ☐ Electronic signs and other technologies for disseminating information to travelers. ☐ Notification and redirection of oversize/overweight trucks. ☐ Administrative procedures to expedite incident response and clearance. ☐ Real-time public information to alert drivers to unfavorable traffic conditions and suggest realistic alternate routes before they reach the congested area.

Access. If an incident occurs in the work zone, well-planned temporary access contributes to timely response. For example, law enforcement, fire, and EMS personnel should be kept aware of any haul roads or closed-but-passable ramps that could be used to access the site and bypass queued traffic.

Figure 13. Signs identifying work area access points can make it easier to reach an injured worker.

On complex projects a system for identifying work areas and their corresponding access points should be established so that fire and EMS can readily locate and respond to problems such as worker injuries (Figure 13). Each access point should be given a unique identifier which should be distinct from exit numbers or mile markers (for example letters could be used instead of numbers). To facilitate communication in noisy work areas, consider using letter sequences that do not sound alike (for example Q, R, S, T instead of B, C, D, E).

Emergency Management Spaces. Physical features of the work zone can contribute to the safety of workers, responders, and the public. Some examples include:

- **Emergency parking.** Due to limited space, many freeway work zones do not have full shoulders. As shown in Figure 14, emergency parking areas (also called crash investigation sites, lay-bys, pull-offs, pull-outs, refuges, or turnouts) provide spaces where damaged or disabled vehicles can be temporarily parked without blocking the traffic stream. If their length is sufficient, these areas also provide a relatively safe place for police to intercept work zone violators. (Although agencies refer to these locations using a variety of terms, the MUTCD R8-4 signage phrase EMERGENCY PARKING is probably the most readily recognized by drivers).


Figure 14. Emergency Parking pull-out with storage shed for emergency traffic control devices (permanent site).
Photo: Steve Fareham/Geograph (retouched)

- **Enforcement pads.** Enforcement pads are similar to emergency parking areas, but are generally shorter. They serve primarily as places where a tow truck or enforcement vehicle can be parked.
- **Traffic control caches.** A cache (pronounced "cash") is a location where useful items are stored. Establishing a cache of traffic cones, drums, or barricades in or near the work zone can be helpful in speeding up deployment of temporary traffic control for managing the incident (Figure 14). To expedite deployment some agencies pre-load this equipment in a dedicated trailer.
- **Triage and Landing areas.** If an incident involves more than one casualty, EMS personnel may need to establish a triage area to assess the condition of injury victims. People with less severe injuries sometimes remain in the triage area while those with more urgent problems are treated (or sent to a hospital for more advanced treatment). Pre-establishing triage locations can help expedite response and assure that medical resources are allocated in accordance with the degree of injury. Having a pre-established triage site can also help manage ambulance traffic. If possible, the triage area should be accessible from more than one direction so that ambulances can avoid traffic back-ups. In some cases it could also be desirable to pre-designate a medical helicopter landing zone (this is particularly relevant for bridge projects and remote sites).

Back of Queue Protection. As noted previously, secondary crashes are a significant concern during incidents, especially if the roadway capacity is already reduced as a result of construction. Therefore, determining how best to protect the back-of-queue is a key preparedness decision.

Figure 15. MUTCD W3-4 Sign.

Secondary crashes can also be reduced by providing advance warning of the slowed traffic ahead. If the roadway has remotely-controlled changeable message signs, they can sometimes be used for this purpose. More often, a police vehicle or suitably-marked work vehicle is necessary. For non-construction incidents this is generally a police responsibility. During construction on freeways (and possibly other high-volume roadways) some jurisdictions require the contractor to provide one or more specially-marked work vehicles that can be deployed upstream of incident queues to warn approaching drivers. If this is done, the marking requirements for the Queue Warning Vehicle (QWV) and the process for notifying the contractor should be established prior to the start of construction.

The advance warning needs to be positioned far enough upstream to give drivers sufficient distance to comprehend the situation and begin braking before they reach the stopped/slowed traffic, but not so far upstream that drivers forget the warning. Although stopping distance depends on several factors such as traffic speed and pavement moisture, NCHRP Report 746 recommended that (for freeways) the warning should be positioned approximately ¼ mile (400 meters) upstream of the back-of-queue to allow ample stopping distance. This means the warning will need to move upstream (against the direction of traffic) as the queue grows. The QWV or sign must also be positioned so that it is not hidden by curves, hills, etc.

a. Quick response vehicle (with traffic flow) (Photo simulation)

b. Extended duration vehicle with truck-mounted attenuator (with traffic flow) Source: Tennessee DOT

c. Quick response vehicle (for contraflow operation) (Photo simulation)

Figure 16. Queue Warning Vehicles (QWVs)

At least two types of contractor-supplied vehicles have been used in queue protection applications. Figure 16a is a simulated photo of a van that can be used to respond quickly to a rapidly-developing queue (Tennesse DOT uses pick-up trucks for this application). Figure 16b illustrates a heavy-duty vehicle used by Tennesse DOT for longer-duration queue protection; the impact attenuator attached to this vehicle helps protect the operator, but can make the vehicle difficult to maneuver in congested situations. Figure 16c is a sketch of a specially-marked vehicle that could be driven contraflow (facing

traffic) along the shoulder to make it easier for the operator to remain an appropriate distance upstream of the hazard.

Tactical Planning. Pre-planning of incident response tactics helps avoid secondary incidents. For example, a plan can be established for closing upstream ramps to limit traffic volume. There should also be up-front consideration of how the tactics will change depending on traffic conditions. For example, if a law enforcement officer will be used to manage traffic speeds and traffic is flowing freely, it may be appropriate to position that vehicle near the incident location (to encourage speed reduction where it is needed most). If traffic becomes congested it might be appropriate to position the officer upstream to encourage drivers to slow down as they approach the back-up.

Use of the Contractor's Traffic Control Drums and Other Assets. Preparing for work zone incidents includes determining which (if any) of the contractor's assets can be used for incident management. For example, a large number of orange traffic control drums might already be present on site, and it could be expedient for first responders to use them to channelize traffic around an incident. If this will be done, lines of communication need to be pre-established so that the contractor (or traffic control subcontractor) can move the drums to appropriate locations after the incident is cleared. A contractor's portable work lights could be useful during an incident that occurs at night. Occasionally, other contractor equipment might be useful, such as an all-terrain forklift to lift a damaged vehicle that blocks traffic or interferes with incident response. Contractor vehicles that are equipped with truck-mounted attenuators (TMAs or "crash cushions") could potentially be used to help manage traffic, but construction equipment such as bulldozers, backhoes, and excavators is not crashworthy and should be kept away from high-speed traffic.

Incident Management Training. Transportation agencies, first responders, contractors, and others involved in managing traffic incident response can benefit greatly from incident management training. The FHWA and National Highway Institute (NHI) websites provide information about online and instructor-led programs. To encourage people from different occupations to train together and build mutual understanding, train-the-trainer programs that can be implemented locally are also available. Ironically, the individuals and organizations that are in greatest need of training are often the least aware of their knowledge gaps. As a result, it is important for those who recognize the benefits of training to encourage decision makers to arrange learning sessions regularly.

Tabletop Exercises. Tabletop exercises are moderated discussions that allow stakeholders to meet in an informal setting and rehearse their duties using a realistic traffic incident scenario (perhaps a composite based on significant incidents that have previously occurred in the area). A well-designed tabletop exercise can help participants evaluate their ability to implement ICS protocols and blend into a single management hierarchy if an incident occurs. In some cases, these exercises can also help the group discover hidden weaknesses so that appropriate corrective actions can be taken prior to any actual incident.

Figure 17. First responders and agency staff participate in an incident management tabletop exercise.
Photo: Iowa DOT

Staying Calm and Focused. Numerous comedy skits have been written around the idea of a person who becomes flustered by an urgent situation and then makes bad decisions. In real emergencies, such behavior is far from humorous. Research shows that when people in stressful situations remain

relatively calm, they tend to respond to new information more effectively, consider their options more carefully, remember more details, and are less likely to make blunders.[8] While a little bit of stress might encourage people to sharpen their focus, people generally make better decisions if they are not excessively stressed. High-performing individuals and teams also anticipate the questions that others involved in managing the situation are likely to have, and share that information readily and rapidly—often before they are asked.

Preparation efforts such as training exercises and pre-planning can help responders remain calm and focused in the event of an actual incident. Self-calming techniques such as deep breathing are helpful for many individuals. An un-panicked response by contractor, agency, and emergency services personnel can help set the tone for thoughtful actions by road users and the general public.

In long-duration incidents, the combination of stress and fatigue can contribute to poor decisions. To avoid this, it is important to assure that the people involved in handling the incident regularly have opportunities for breaks, meals, snacks, and re-hydration.

Coordinating Incident Response

When an incident occurs in a work zone, everyone on site needs to work together to keep the public safe, assist crash victims quickly, and restore traffic flow promptly. This joint effort includes law enforcement, fire services and EMS, along with the contractor, the field engineer, and the agency responsible for the roadway (including the agency's traffic management center, if applicable).

Some incidents also require specialized resources. For example, a truck crash that results in a diesel fuel or hazardous material spill will require specialized expertise for stabilization and clean-up. An animal control officer might be required if the crash results in the release of livestock that were being transported. Highway maintenance or contractor employees might need to make minor repairs before the roadway can be re-opened. In case of a fatal crash, some jurisdictions require a medical examiner or coroner to examine the victim before the body is removed from the scene.

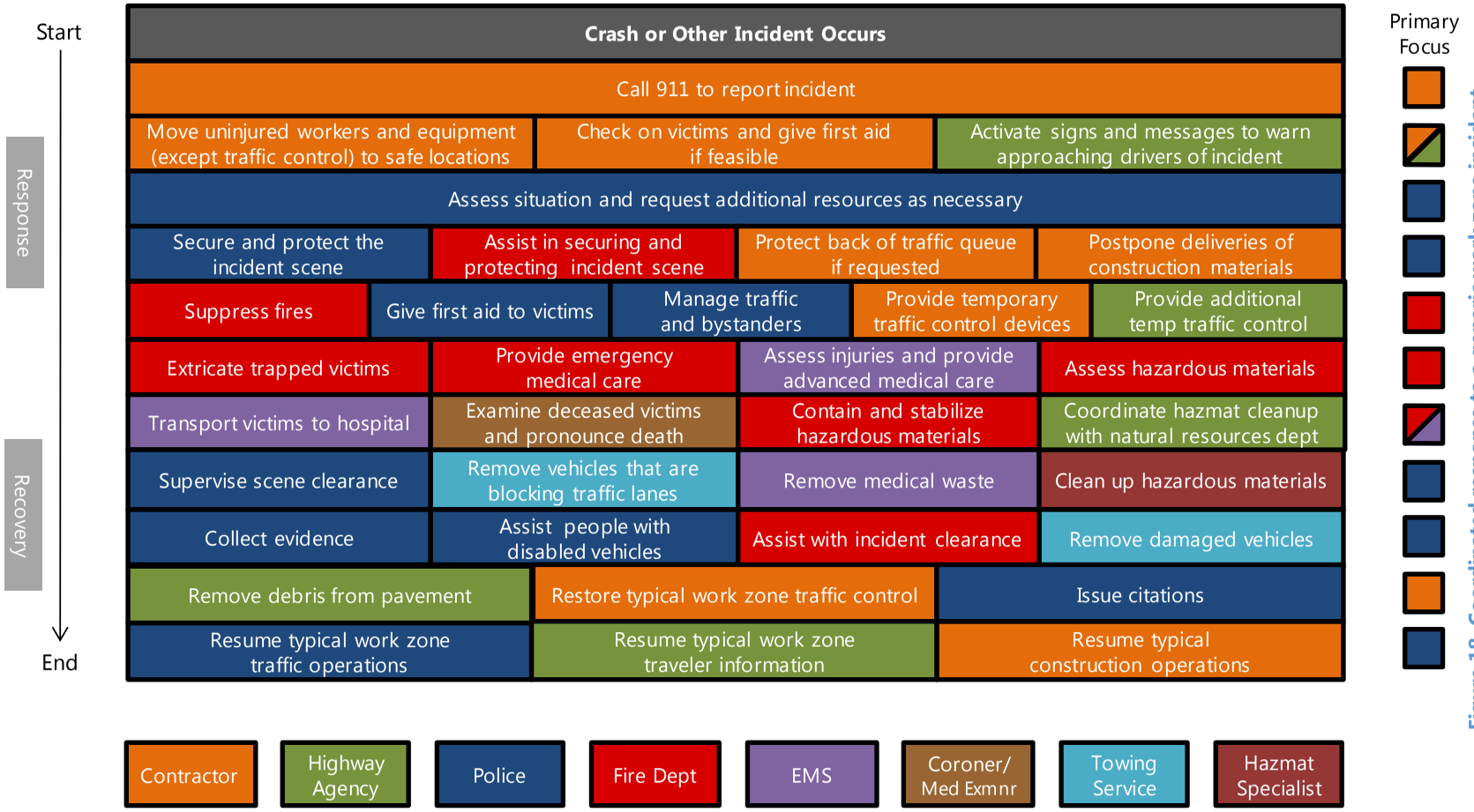
Figure 18 provides a general overview of the tasks involved in responding to a work zone incident, including the organizations active in each phase of the response and recovery. Some work zone incident management tasks can be done at the same time, while others need to be done sequentially. This means that at times, some of the people involved in managing the incident will be incredibly busy, while others are simply waiting for the moment when their skills, knowledge, and tools are required.

Although each actual incident will differ in its details, let's consider how a typical situation unfolds. Because of their proximity to the site, contractors are often the first to become aware of the incident. They should respond by calling 911 and following any other reporting protocol that was established in advance.

In general, the first task involved in incident management is to secure the scene. This includes moving uninjured workers and other bystanders safely away from the crash, and establishing traffic control to minimize the risk of secondary crashes. If the incident occurs on a freeway, upstream entrance ramps might need to be closed to minimize traffic backups and limit the amount of traffic attempting to pass the incident scene. Similarly, if the incident is on a street or highway that has intersections,

[8] Reference: Kowalski-Trakofler, Vaught & Scharf (2003), *Judgment and Decision Making Under Stress: An Overview for Emergency Managers*, International Journal of Emergency Management, 1(3), 278-289.

Working Together: Coordinated Response to a Generic Work Zone Incident



Note: Roles and responsibilities shown in this chart are generalized, and could vary based on State and local laws, agreements, and contracts.

Figure 18. Coordinated response to a generic work zone incident.

some nearby access points might need to be closed temporarily. The contractor might be asked to assist with this effort by repositioning drums or other temporary traffic control devices that are already on site. In some jurisdictions, contractors might be tasked to position a Queue Warning Vehicle (Figure 16) upstream of the incident to alert drivers as they approach the backup caused by the incident. Another likely task for the contractor is postponing any scheduled material deliveries to reduce the number of work vehicles in the traffic stream and avoid wasting materials that require prompt delivery, such as fresh concrete or hot asphalt.

Almost concurrent with the deployment of traffic control devices, first responders will most likely try to determine whether there are any special circumstances, such as fire or chemical spills, that represent imminent danger to responders, crash victims or the public. Efforts to extinguish fires and contain spills will begin (Figure 19). As soon as it is safe to do so, attempts to rescue victims will begin. Depending on the severity of the incident, this could be as simple as helping a victim exit their vehicle, or as complicated as cutting open a vehicle to extricate someone who is trapped or unable to exit the vehicle on their own.

Figure 19. Spreading absorbent material to soak up spilled diesel fuel. Photo: Pennsylvania DOT

Contractor personnel may provide first aid to crash victims if they have the appropriate training. Treatment efforts should be handed off to EMS personnel as soon as they arrive on scene and can attend to the victims.

If there are multiple casualties, EMS or fire personnel might set up a triage process to determine the extent of injuries, the type of treatment each person is likely to be require, and each victim's chances of survival. Although "triage" means "three groups," current U.S. protocols generally classify victims into five groups, and medical transport is allocated accordingly. For example, a person with life-threatening injuries will probably be rushed to the nearest trauma center that is able to accept the victim, perhaps by helicopter. A person with less urgent injuries will have a lower treatment priority and might need to wait for a road ambulance to arrive. People with only minor injuries and those who are already deceased receive the lowest treatment priority.

After medical issues are addressed, the incident response moves into the recovery phase. Law enforcement will begin investigating the incident (such as taking witness statements, photographs and measurements) to gather evidence that might be needed in civil or criminal litigation. Citations will be issued if necessary. Damaged vehicles will be removed and spills/debris will be cleaned up. Transportation will be arranged for uninjured people whose vehicles are not driveable.

The roadway will be prepared for re-opening. At this stage the contractor will need to verify that any work zone traffic control devices that were temporarily repositioned for incident management have been returned to their desired locations. In some cases, the traffic control might need to be positioned differently than it was prior to the incident; for example, if vehicles involved in the crash drove through unhardened concrete it could be necessary to alter traffic control so that damaged material can be removed. When it is safe to do so, the roadway will be fully reopened to traffic and work operations can resume.

Table 3. Typical Incident Management Roles and Responsibilities

Law Enforcement
- Secure the scene.
- Assume command and control or unified command of the scene.
- Provide emergency medical aid until help arrives.
- Direct traffic/establish temporary alternate routes.
- Safeguard personal property.
- Remove alcohol/drug-impaired drivers from scene.
- Collect witness statements, photos, measurements, and other evidence for crash reconstruction and investigation.
- Assist motorists in disabled vehicles; push disabled vehicles out of traffic lanes.
- Supervise scene clearance.

Dispatch/Communications
- Detection/notification of incident.
- Gather detailed preliminary information to facilitate more effective emergency response.
- Provide "Steer it, Clear it" or "Move It" direction to motorists, if appropriate.
- Disseminate incident information to the Traffic Operations Center.
- Maintain project contact information including contractors and traffic control subcontractors.

Fire Services
- Protect the incident scene.
- Assume command and control or unified command of the scene.
- Suppress fires/minimize fire risk.
- Rescue crash victims.
- Provide emergency medical care/coordinate with medical service providers.
- Provide initial hazmat response and containment.
- Provide traffic control until law enforcement or highway maintenance personnel arrive.
- Assist in incident clearance.

Emergency Medical Services (EMS)
- Provide basic/intermediate/advanced emergency medical care.
- Perform triage if there are multiple victims.
- Determine destination/treatment options for injured people.
- Coordinate with fire, police, ambulance, and air-ambulance.
- Serve as incident commander for medical emergencies.
- Determine approximate cause and nature of injuries and provide information to the hospital or trauma center.
- Remove medical waste from the incident scene.

Traffic Operations Center (TOC)
- Assist in incident detection and verification.
- Initiate traffic management strategies on incident impacted facilities.
- Provide motorist information through changeable message signs, mass media, social media, 511, etc.
- Coordinate clearance and repair resources/highway helper patrols.
- Monitor system cameras to update situational awareness.
- Disseminate highway information to commercial motor carriers.
- Notify specialized personnel (bridge inspectors, electricians, etc.).
- Notify TOCs in adjoining jurisdictions if appropriate.

Contractor and Subcontractors
- Call 911 in case of a crash, or call a pre-designated non-emergency number for a minor issue such as a disabled vehicle.
- Provide first aid until EMS arrives (if qualified and if it is safe to do so).
- Move any personnel or equipment that interferes with incident response, as directed by the incident commander.
- Cancel/postpone materials deliveries.
- Repair/reset traffic control devices (e.g. damaged barrier sections) as directed by agency engineering staff.
- Assist in removal of damaged/disabled vehicles if appropriate equipment is available and requested to do so.
- Stabilize/repair roadway infrastructure in coordination with incident commander and field engineer.

Field Engineer
- Identify any personnel or equipment that impedes incident response and direct contractor to reposition equipment and personnel (except equipment involved in the incident).
- Identify situations which require contractors to stop work, e.g. work operations that interfere with incident response or make backups worse.
- Coordinate with first responders to identify need and timing for repair and reset of traffic control.
- Coordinate temporary repairs with contractor and agency maintenance forces.
- Assure that any repair/recovery vehicles that remain on-scene after the incident has been cleared are using appropriate temporary traffic control.

Towing and Recovery Operator / Freeway Service Patrol
- Recover and remove vehicles from incident scene, under the direction of law enforcement.
- Protect victims' property and vehicles.
- Remove debris from the roadway.
- Provide other services (such as traffic control or assisting crash reconstructionist), as directed by incident commander or as per contract.

Highway Maintenance
- Provide first aid until EMS arrives (if qualified and if it is safe to do so).
- Initiate traffic management strategies on incident impacted facilities.
- Protect the incident scene.
- Provide traffic control.
- Assist motorists with disabled vehicles.
- Provide motorist information.
- Provide absorbent material for small fuel/coolant spills.
- Provide special equipment to assist in clearing incident scenes.
- Determine incident clearance, roadway repair needs and any other safety needs.
- Implement and maintain alternate routes.
- Coordinate clearance and repair resources.
- Serve as incident commander for clearance and repair functions.
- Stabilize/repair transportation infrastructure.

Post-Incident Review

Safe, effective, efficient WZ-TIM includes proper preparation, accurate and timely communication, coordinated response, and post-event evaluation. These factors can be reviewed on a continuous basis to improve work zone design, incident management techniques, and related training. Many States have formalized these efforts by developing TIM action plans that include after-action reviews and work zone process reviews.

Post-incident information sharing contributes to long-term improvement in roadway safety. This means going beyond issuing a traffic citation to the most-at-fault driver. It also means informing the roadway agency about work zone conditions that potentially contributed to the incident. For example, if improperly aimed work lights made it difficult for drivers to see, this information needs to get back to the contractor so the problem can be remedied for future nighttime work.

Each incident that occurs can be seen as an opportunity to review how effectively the response was handled and consider what could be done to achieve higher levels of safety and efficiency in the future. A well-known professional football coach once said, "*Perfection is not attainable, but if we chase perfection we can catch excellence*." Accomplishing TIM objectives in work zones can be especially challenging, but when accomplished safely, effectively and efficiently, the value-added to the traveling public can be tremendous.

Notable Examples of Work Zone Incident Management Practices

Tennessee DOT: Protect the Queue

Tennessee DOT recognized a need to protect innocent motorists from secondary crashes by actively alerting drivers approaching slow-moving traffic. This effort goes above and beyond longstanding efforts to clear incidents quickly. In June 2013 the agency launched its "Protect the Queue" campaign. The initiative encourages Tennessee DOT employees and partner agencies to emphasize the importance of protecting drivers caught in a traffic queue. A training program on the most effective queue management techniques was deployed, including the use of contractor-supplied Queue Warning Vehicles in work zones (Figure 16b). Data from the first six months of the campaign indicated a 19% reduction in secondary incidents compared to the same six month period in 2012, equating to 20 fewer secondary incidents and a possible savings of four lives. More information is available on the Tennessee DOT and FHWA websites.

Iowa DOT: Traffic Critical Projects

Iowa DOT identifies upcoming highway construction projects likely to create the most mobility and safety issues and categorizes them as Traffic Critical Projects (TCP). In any given construction year, there are approximately 60 designated TCP projects statewide, which feature a variety of systematically applied strategies, such as:

- Development of traffic incident management plans, including meetings with key project stakeholders to solicit input and work toward consensus on solutions.
- Statewide on-call service contractor, responsible for deploying Intelligent Work Zone (IWZ) devices (e.g. detectors, cameras, portable changeable message signs) at about half of the TCP locations.
- Seamless integration of IWZ devices into the agency's statewide Advanced Traffic Management System Software, allowing TOC operators to see portable devices on the same platform as fixed devices to manage available resources better.
- Queue warning alerts generated from vehicle probe data and sent to the department's statewide Traffic Operations Center.

Maryland DOT: Work Zone Performance Monitoring System

In collaboration with the University of Maryland, the Maryland DOT developed a Work Zone Performance Monitoring (WZPM) tool that provides real-time information about traffic delays associated with Maryland work zones (Figure 20). The data is also archived to facilitate evaluation of the effectiveness of work zone incident management efforts and other after-action reviews.

Figure 20. Maryland's Work Zone Performance Monitoring system provides detailed information about the traffic impacts of freeway work zone incidents. Image: University of Maryland

Multiple States: Interagency Cooperation Agreements

To improve the coordination of emergency planning and response, a number of groups have established interagency agreements based on the principles of cooperation, training together, and maximizing efficacy. These formal and informal agreements cover a variety of situations such as interagency coordination at the State level (e.g. State highway department and State police), State-local cooperation, mutual support across State lines, and relationships between publicly-funded agencies and self-funded toll road or toll bridge organizations. Notable examples include:

- Delaware Valley Regional Planning Commission (DVRPC) Incident Management Task Force Policies
- Washington State Patrol and Washington DOT's Joint Operations Policy
- Florida Open Roads Policy
- The I-95 Corridor Coalition, comprising State and local agencies, tollway operators, and other organizations from 16 East Coast States and the District of Columbia.

These agreements typically address issues such as clarifying roles and responsibilities, methods for sharing personnel and equipment during major incidents, unifying command and control procedures, and resolving technical issues such as the interoperability of two-way radios. In principle, similar collaborative agreements could be put in place with contractors (or contractors' associations) to clarify operational relationships during WZ-TIM situations.

Case Studies

Wisconsin: U.S. 12/18 Madison Beltline Work Zone Crash

U.S. 12/18 is an urban freeway bypass of Wisconsin's second-largest city. The roadway has three lanes in each direction carrying approximately 123,000 vehicles per day and includes a long series of bridges across a river and adjoining wetlands. As shown in Figure 21, due to width constraints a unique lane configuration was provided during bridge re-decking work: one lane on what is ordinarily the eastbound roadway (Lane 1) and two lanes on what is ordinarily the westbound side (Lanes 2 & 3). Two sets of temporary barriers separated the relocated travel lanes from eastbound traffic and the work activity area.

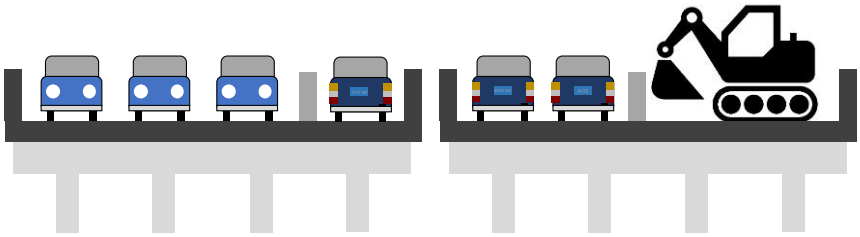


Figure 21. Bridge configuration during construction.

On Friday, June 14, 2013 at approximately 7:00 am, a crash occurred in the operational work zone on westbound U.S. 12/18. The incident was a one-car collision involving a driver who struck the construction barrier, resulting in lane blockage and slowed traffic in all westbound lanes. The crash was reported to State and local dispatch centers and the State Traffic Operations Center (STOC).

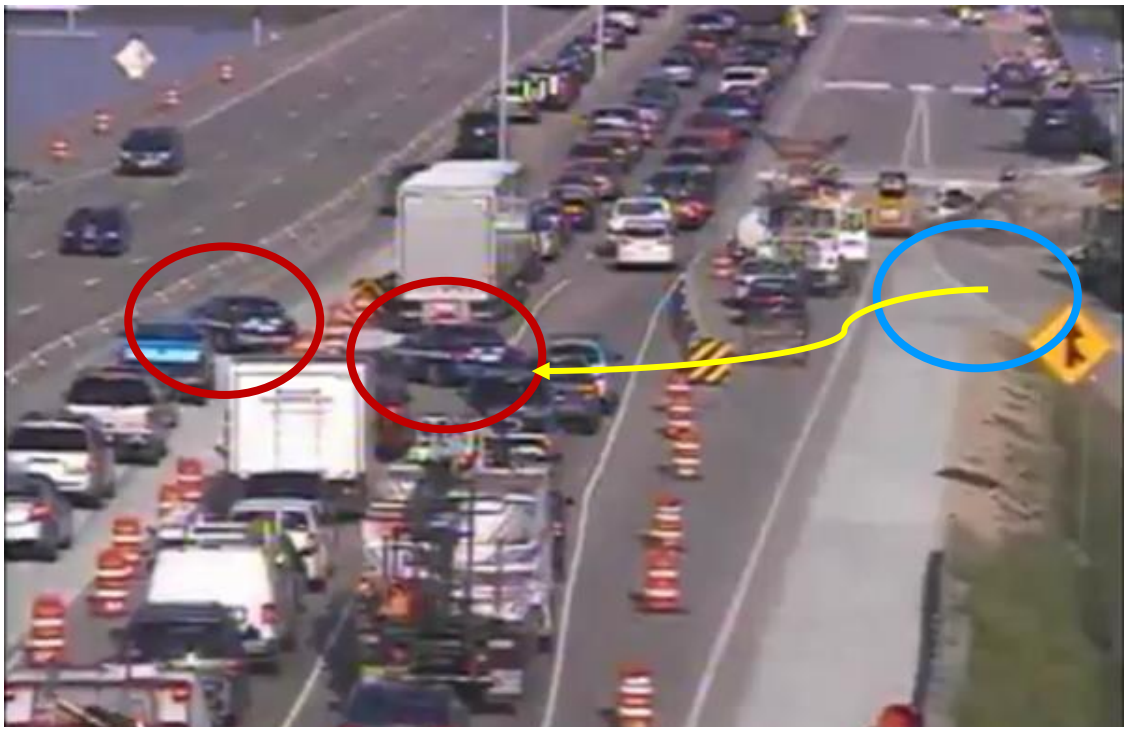


Figure 22. During the Madison (WI) Beltline work zone crash responders took advantage of the split lane configuration. Originally both police vehicles were staged at the closed entrance ramp identified by the blue oval. One responder used each side to assure that at least one squad would reach the incident site in a timely manner (red ovals). Photo: Wisconsin DOT

The law enforcement officers assigned to the work zone were staged on a closed ramp south of the incident location, just upstream of the location where the roadway split into the 1+2 lane configuration (Figure 22). The officers took full advantage of the unusual work zone configuration, making the pre-planned decision to have one squad car utilize the single-lane side (Lane 1) and the other squad car utilize the double lanes (Lanes 2 and 3) to assure that at least one of the two squads could reach the crash site in a timely manner. The service patrol truck, EMS, and tow company were also dispatched to the crash.

The responders' detailed knowledge of the site contributed to rapid clearance of the incident. Efficient TIM quick clearance techniques were used to quickly transport the injured driver. The tow truck operator used a winch to quickly snag the disabled vehicle and stage it temporarily in a closed portion of the westbound roadway. With the damaged vehicle no longer blocking traffic, the tow operator could take the time needed to load it onto a flatbed tow truck. This combination of techniques allowed the incident to be cleared in approximately one hour.

In terms of the four Safe System elements (roads, road users, vehicles, and speeds), this incident was primarily a road user problem, specifically driver inattention and substance abuse. The roadway was a contributing factor: narrow lanes constrained by concrete barriers left the driver with little space to recover from his errant maneuver. Although they made incident response more challenging, the concrete barriers reduced the severity of the incident, possibly preventing a fatal collision.

Iowa: I-35 West Des Moines Work Zone Crash

I-35 near West Des Moines, Iowa is a rural freeway that carries approximately 25,800 vehicles per day. On Tuesday, September 30, 2014 at approximately 9:14 am, a crash occurred on I-35 in an operational work zone. A northbound semi-truck/trailer (Unit 1) struck and shattered the concrete construction barrier and continued into the southbound lane where it struck a southbound semi-truck/trailer (Unit 2). Unit 1 rolled onto its right side. Two southbound passenger vehicles (Units 3 and 4) then struck Unit 1 and concrete debris from the damaged barrier wall.

State and local law enforcement, local fire/EMS, the Iowa Department of Transportation, two tow operators, the State natural resources agency, and a hazardous materials contractor responded to the crash scene. These responders were dispatched to the scene by the DOT Traffic Operations Center (TOC), State law enforcement dispatch and local dispatch centers. Both the northbound and southbound lanes were blocked due to the crash. The southbound lanes that had already been closed for construction were used for staging first responders and clean-up crews. An alternate route for both northbound and southbound traffic was established on a combination of State and local highways located east of I-35.

The contractor made significant contributions to the incident response. The crash ruptured Unit 1's fuel tank, spilling diesel fuel onto the pavement. Fuel flowed through a stormwater drainage inlet and into a small waterway adjacent to the freeway. As shown in Figure 23, the contractor suggested placing soil around the inlet to block the inflow of fuel, and then provided materials, equipment and personnel to accomplish this. During later stages of the response, contractor personnel removed debris and then replaced and repositioned the concrete barriers to expedite freeway reopening.

Video monitoring installed at the work zone assisted TOC staff in identifying the crash rapidly, the northbound and southbound queues were cleared safely and efficiently, and the contractor's

assistance contributed to containment of the fuel spill and incident recovery. Nevertheless, the freeway was closed for an extended duration, primarily because of the time required for the hazardous materials cleanup contractor to reach the site and complete cleanup work.

This incident was evaluated in an After Action Review (AAR). The AAR identified opportunities to improve incident management through better communication between agencies and incident command, updating alternate route plans, and revising hazmat response procedures to improve quick clearance times. In terms of the Safe System approach, the incident suggests that truck-resistant temporary barriers deserve consideration on roadways with high truck volumes.

Figure 23. I-35 crash site near West Des Moines, Iowa, viewed through the fence from an overpass. The concrete barrier was heavily damaged. Responders used the lanes that were closed for construction to reach the site. This view also illustrates contractor personnel and equipment placing soil to block spilled diesel fuel from entering the storm drain (red circle). Photo: West Des Moines Police Department

Further Reading

Work Zone Traffic Incident Management

- **Guidebook on Incident Management Planning in Work Zones.** This 2005 document developed for the Smart Work Zone Deployment Initiative provides engineers and construction managers with guidance on developing work zone incident management plans.

- **Guidelines for Developing Traffic Incident Management Plans for Work Zones.** This 2008 Colorado DOT report discusses best practices, existing TIM programs, and considerations and key components for developing and implementing work zone TIM programs.

Traffic Incident Management—General Publications

- **Best Practices for Emergency Vehicle and Roadway Operations Safety in the Emergency Services.** This publication from the International Association of Fire Fighters discusses a number of issues related to emergency management practices. Notably, Section 7 titled Roadway Scene Incident Management provides practical recommendations on emergency site management and interagency coordination procedures.

- **Simplified Guide to the Incident Command System for Transportation Professionals**. This 2006 FHWA publication discusses the principles of the Incident Command System (ICS) and associated concepts such as unified command.

- **Traffic Incident Management Handbook**. This FHWA handbook defines key TIM concepts, defines TIM objectives, and provides examples of good practices. It was revised in 2010.

- **Traffic Incident Management Systems.** This 2008 publication from the U.S. Fire Administration discusses the characteristics of traffic incidents, on-the-job safety for firefighters, incident command, techniques for minimizing the risk of secondary collisions, and many other aspects of traffic incident management.

Agency Guideline Examples

- **Minnesota: Traffic Incident Management – Recommended Operational Guidelines**. This 2002 publication was developed by the Minnesota Incident Management Coordination Team, incorporating practices agreed upon by the Minnesota DOT, Minnesota State Patrol, Minnesota Metro Fire Chiefs, and Minnesota Professional Towing Association.

- **Wisconsin: Emergency Traffic Control and Scene Management Guidelines**. These guidelines were established to provide incident responders with a uniform approach to emergency traffic control and scene management, maximize responder safety, and minimize the risk of secondary crashes.

Other Specialized Information

- **Hazardous Materials.** The *Emergency Response Guidebook* (ERG) provides first responders with a go-to manual to help deal with hazmat transportation incidents during the critical first 30 minutes. Published jointly by national transportation agencies from the U.S., Canada, and Mexico,

it is available online in English, French, and Spanish and as a mobile app for Android and iPhone. FHWA's 2009 booklet *Traffic Incident Management In Hazardous Materials Spills In Incident Clearance* discusses hazmat issues in the context of incident management.

- **TIM Training.** In recent years, considerable effort has been devoted to developing Traffic Incident Management training materials that can be used by first responders, contractors, and agency personnel. These include instructor-led and web-based courses. Details are available on the FHWA and National Highway Institute (NHI) websites.

- **Tunnels.** The 2011 NCHRP report *Best Practices for Roadway Tunnel Design, Construction, Maintenance, Inspection, and Operations* discusses U.S. tunnel incident management practices. In Europe, tunnel incident management received considerable attention after a series of serious tunnel fires in the 1990s and 2000s resulted in numerous casualties and disruptive structural damage. Some relevant European references include Appendix A of *Operational Guidance: Incidents in Tunnels and Underground Structures* published by the British Fire and Rescue Service in 2005 and *Fire and Rescue Operations During Construction of Tunnels*, an English-language report by Swedish researchers Kumm and Bergqvist circa 2007.

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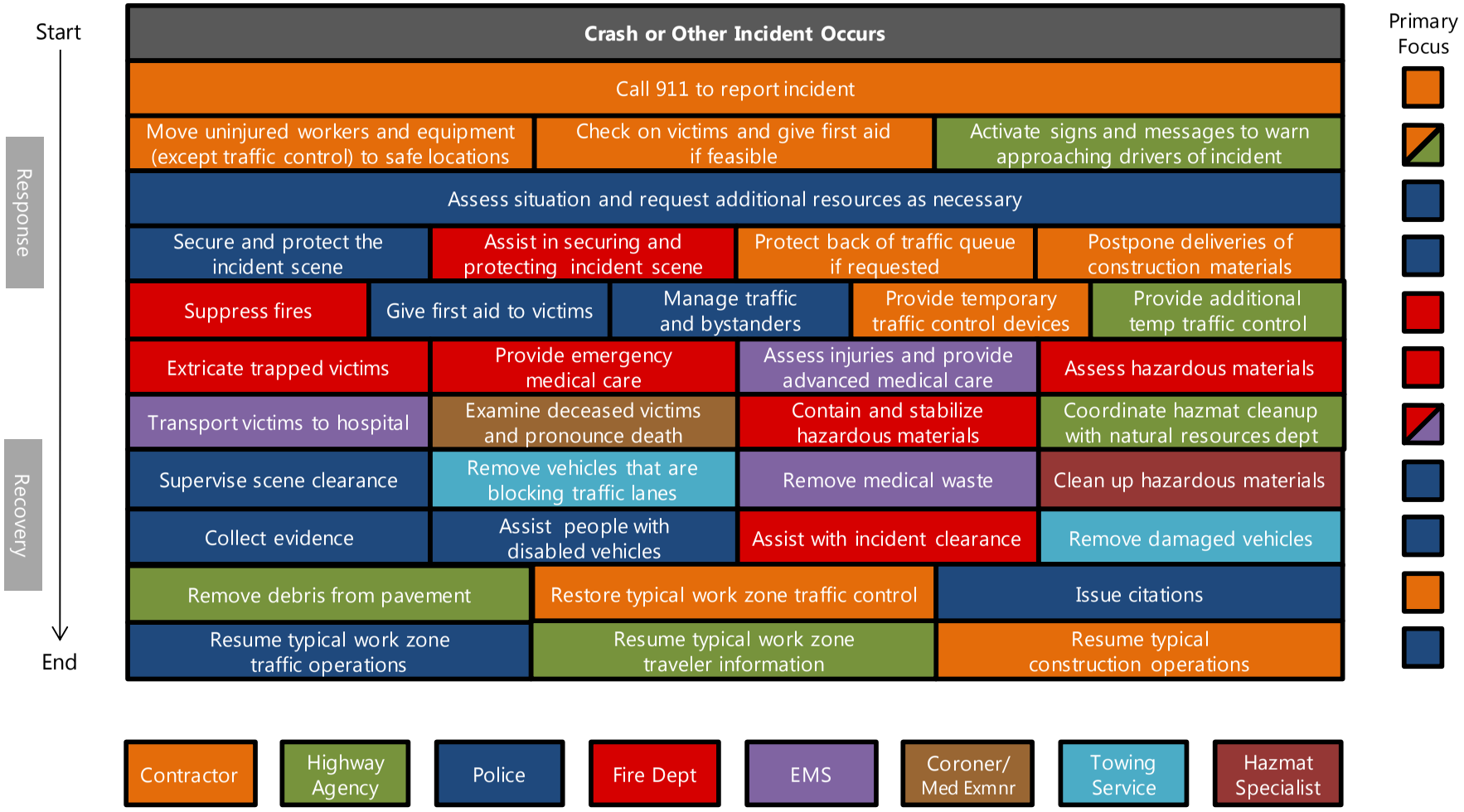
(Inside Back Cover)

Working Together: Coordinated Response to a Generic Work Zone Incident



Note: Roles and responsibilities shown in this chart are generalized, and could vary based on State and local laws, agreements, and contracts.