Running head: INCIDENT SITE SAFETY: WORKING MULTILANE HIGHWAY

Executive Development

Incident Site Safety: Working Multilane Highway Incidents and Staying Alive

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June 2005

Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

ABSTRACT

The problem was that the Mesquite Fire Department's safety procedures for responding to highway incidents were not adequate. The purpose of this project was to identify best practices regarding highway operations. Descriptive research was used to answer the following: (1) What industry or governmental guidelines/procedures are applicable to highway scene safety? (2) What best practices have other departments developed to effectively and safely operate at highway scenes? (3) How will regional traffic incident clearance initiatives affect responder safety? Surveys and industry periodical reviews were used to determine best practices. The results show numerous industry best practices and applicable federal law on the subject. Recommendations include adoption of federal guidelines, regional clearance policies, and incorporation of fluorescent colors into apparatus striping.

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Incident Site Safety: Working Multilane Highway Incidents and Staying Alive

New highway construction in North Texas is not keeping up with population increases in the area. The cost of congestion on North Texas highways is estimated in the tens of billions of dollars. Statistical work done by PB Farradyne, Inc., SG Productions, Inc. and Lee Engineering, L.L.C. for the North Central Texas Council of Governments [NCTCOG] (2005) shows that by the year 2025 the area's population is estimated to increase by 75%. During the same time period the estimated vehicle miles traveled is expected to rise by 87%. The roadway capacity, as measured in lane miles, is only expected to change by 50% during this time frame. The disparity between the increase in vehicle miles traveled and the increase in roadway capacity will translate into more congestion and the greater probability of North Texas highway incidents in the future.

The Mesquite Fire Department [MFD] responds to incidents inside a 42-square-mile area within North Texas. The City of Mesquite contains 19.9 miles of limited access highways. In 2004 MFD units responded to over a thousand highway incidents. The problem is that the Department's procedures for responding to these type incidents are not adequate enough to ensure that safe operating practices are followed. The lack of sufficient highway safety procedures places MFD members at a greater risk of injury or death while working these increasingly dangerous incidents.

The purpose of this research is to identify best practices and possible issues regarding operations at highway incident scenes by the MFD.

Descriptive research methods were used to answer the following research questions:

1. What industry or governmental guidelines/procedures are applicable to highway incident scene safety?
2. What best practices have other fire departments developed to effectively and safely operate at highway incident scenes?
3. How will current NCTCOG initiatives to quickly clear traffic congestion caused by highway incidents affect highway scene safety?

BACKGROUND AND SIGNIFICANCE

MFD responds to incidents inside the 42 square miles of the City of Mesquite, Texas. The Department provides fire, emergency medical [EMS], rescue, hazardous material, and bomb response services to the community of 133,605. The City of Mesquite is located on the east border of the City of Dallas, Texas, and is considered urban/suburban in nature. MFD responded to over 14,000 calls for service in 2004. Over 70% of these calls were EMS in nature.

In 2004 MFD responded to 1,063 calls for service on the City's 19.9 miles of divided highways. Of the 1,063 calls, 823 or 77.4% were confirmed incidents. The speed limit on the City's four interstate-type highways is 60 miles per hour and is exceeded frequently during non-rush hour times. During rush hour times, in the morning and afternoon, sections of these urban highways are considered moderately congested (NCTCOG, 2005, p. 2).

Response to incidents on the City's four interstate type highways is from seven fire stations located strategically throughout the City. Highway response boxes are assigned to each station and are determined by access to highway entrance ramp locations in each direction of

travel. Apparatus response depends on the type of incident reported. Response to car fires consists of one engine. Response to EMS calls consists of one engine and one ambulance. If there is a need for patient extrication, a truck company, Deputy Chief, and EMS supervisor are also dispatched.

Firefighter fatalities as a result of being struck by passing vehicles are on the rise in the United States. The United States Fire Administration [USFA] reported in the *Firefighter Fatality Retrospective Study* (2002, p. 20) that between the years 1990 and 2000 that 3.3% of the 1,085 firefighter fatalities were a result of injuries sustained while conducting traffic control activities. It is worth noting that this number only includes firefighters whose type of duty was reported as traffic control. The National Institute for Occupational Safety and Health [NIOSH] in Hazard ID 12, titled *Traffic Hazards to Fire Fighters While Working Along Roadways* (2001, p. 01) reported that 17 firefighters were struck and killed by motor vehicles during the five-year period between 1995 and 1999. This number represented an 89% increase in this type of line-of-duty death over the previous five-year period. The USFA reported in *Firefighter Fatalities in the United States* (2003, p. 22) that in the year 2002 four firefighters were struck and killed by vehicles at emergency scenes. The National Fire Protection Association [NFPA] reported in its *Firefighter Fatalities in the United States- 2003* report (2004, p. 9) that four firefighters in 2003 were struck and killed by vehicles while working at roadway emergency scenes. For the year 2004 the USFA (2005, ¶5) reports that five firefighters were killed when they were struck by passing vehicles while working at the scene of emergencies.

The danger of being struck by passing vehicles is not isolated to just the fire service. According to Richard Ashton, in an article published in Police Chief Magazine titled *Solutions for Safer Traffic Stops* (2004, ¶2), in the 10 year period between 1993 and 2002, of the total of 681 police officers who were killed accidentally, 111 occurred after being struck by vehicles. Another 15 police officers were killed as a result of fiery rear-end collisions involving their patrol vehicles. Dallas County Deputy Sheriff Dan Plumer (personal communication, February 28, 2005) presented that being struck by passing vehicles was the fourth leading cause of line-of-duty deaths for police officers during the 20th century.

Thankfully, not all emergency responders die from the injuries they receive after being struck by passing vehicles. In the North Texas area alone there have been numerous emergency responder vehicles and responders themselves struck while working emergency scenes on the highway. Four Dallas firefighters were injured on December 16, 2004, when their ladder truck was rear-ended while blocking traffic for an incident scene on Interstate 20 in southeast Dallas. All four firefighters were released from the hospital the next day, but according to Dallas Fire Chief Steve Abraira (personal communication, February 17, 2005), it was several weeks before some of the firefighters could return to work. Passing vehicles have injured local emergency responders as recently as April 10, 2005. As reported by A. Batheja, staff writer for the Fort Worth Star Telegram (2005, p. 1b), three Forth Worth firefighters and two Forth Worth area MedStar medics were hit by a vehicle while working the scene of an accident on Interstate 820. Rain conditions at the time of the incident caused both the primary and secondary accidents.

MFD safety procedures at vehicular incidents are governed by standard operating procedure [SOP] 205.01, *Driving*. This procedure is very broad in scope and gives limited direction to firefighters and fire officers responding to vehicular incidents on highways. It is essential for the safety of the emergency responders and the motoring public that department procedures reflect up-to-date best practices in regard to highway operations. This is especially important given the NCTCOG data on the increases in the North Texas population and vehicle miles traveled for the next 20 years. NIOSH Hazard ID 12, *Traffic Hazards to Firefighters While Working Along Roadways* (2001, p. 02) recommends that fire departments develop, implement, and enforce SOPs related to roadway incidents to prevent firefighter fatalities at roadside emergency scenes. Identifying best practices is the first step in the development and implementation of sound fire department procedures to help prevent firefighter injuries and fatalities. This research supports two USFA Operational Objectives: "Reduce the loss of life from fire of firefighters" and "To respond appropriately in a timely manner to emerging issues."

The USFA National Fire Academy Executive Development course is intended to prepare fire service executives for the 21st century. Unit three of the Executive Development course covers change management and introduces management tools to effectively manage the change process. The North Texas Area is rapidly changing both from a population standpoint and from a traffic management standpoint. Identifying industry best practices for handling highway incidents will allow MFD to develop and implement sound safety procedures for handling these type incidents currently and in the future. Research on this topic supports both the intention and content of the Executive Development course.

This research project will allow MFD to review other fire departments' procedures regarding highway incident management and will identify industry and governmental guidelines as they relate to highway incident safety measures. The descriptive research method will be used in this research to identify the following:

1. Survey of other fire departments to determine how they conduct highway operations.
2. Research of Department of Transportation guidelines, industry expert findings, and NFPA recommendations.
3. Research of NCTCOG initiatives on quick clearance of highway incidents.

LITERATURE REVIEW

The literary review for this Applied Research Project [ARP] started at the National Fire Academy's Learning Research Center [LRC] in Emmitsburg, Maryland, in January 2005. The author and staff of the LRC searched on-line databases for periodicals, journals, and other published research on highway incident safety. Research continued upon the author's return home at the Mesquite Public Library in Mesquite, Texas, and the Eastfield College Library also in Mesquite, Texas. Internet searches for relevant information on highway incident safety were conducted as well as interviews with several local knowledgeable fire service members. A survey was conducted of 50 fire departments across the United States to determine how other fire departments handle emergencies on highways. Departments that were surveyed were asked to return a copy of their highway operating procedures along with the completed survey. The author attended two separate classes that were held at the NCTCOG, Arlington, Texas, on the topics of Dallas/Fort Worth freeway incident management. These classes were attended and

instructed by a mix of fire, police, towing service, and department of transportation representatives.

Information on the topic of highway incident safety is very prevalent especially in periodical form. The author studied many articles that were published in fire service periodicals as well as several from law enforcement periodicals. One Internet site is almost completely devoted to the topic of "Responder Safety," and the site has many links to electronically formatted information on the subject of roadway safety for emergency responders. Both the Federal Emergency Management Agency [FEMA] and Oklahoma State University have published fire service specific publications that contain highway incident management best practices. The towing industry also has a publication that ties the removal and recovery of vehicles and cargo into the overall highway incident management system.

The literature review for this research project will be presented in four sections, incident management, highway incident response and traffic control, emergency vehicle and firefighter conspicuity, and quick clearance.

Incident Management

Highway incidents can range from vehicle accidents, pedestrian struck incidents, hazardous material incidents, vehicle fires, and livestock loose on the freeway. The common treads to all these incidents are usually confusion and the lack of accurate initial information for emergency responders. In the white paper titled *Protecting Emergency Responders on the Highway*, Cohen (1999, p. 6) writes: "Successful operations are skillfully orchestrated efforts…Unified incident command helps restore order to chaotic situations."

While most fire departments in the United States have adopted some form of incident command system [ICS] to organized and prioritized emergency operations, the law enforcement community has not had a history of endorsing such systems. With increasing reliance on federal emergency preparedness funds by state and local governments and the upcoming requirement that all emergency responders adopt the National Incident Management System [NIMS] to remain eligible for such funds, law enforcement is starting the process of training and utilization of ICS. Sweeney (2004, ¶2) wrote in an article for The Police Chief, "This new federal requirement provides a strong incentive for states to adopt the NIMS by statute or administrative rule, and for localities to embrace it." Sweeney (2004, ¶3) went on to write in the article that the Federal Highway Administration is facilitating meetings to encourage the use of ICS by emergency responders to help it in its efforts to provide quick clearance of highway incidents which could be a lifesaver for first responders and the motoring public.

In its *2003 Traffic Incident Management Tow Operator Workplan (TIMTOW) Guide* (2003, p.1), the Towing and Recovery Association of America calls for teamwork from all emergency responders to manage five main issues in traffic incident site management operations, responder safety, secondary crash prevention, traffic control, traffic incident site management, and quick clearance. The Towing and Recovery Association of America (2003, p. 3) goes on to say, " Good site management procedures can dramatically improve safety, traffic flow, clearance times and even responder image."

The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 78) explains that the incident

management system must be implemented with the first arriving resources on the scene. If implementation is delayed, it will result in confusion and loss of a coordinated, directed, and efficient effort to mitigate the incident. The incident management system allows the incident commander to escalate and expand the organization as needed to control the highway incident. The *Model Procedures Guide for Highway Incidents* also recognizes that highway incidents are the most common situation where multiple agencies and disciplines must work together to mitigate an incident in a highly stressful environment (2004, p. 55). The most effective way to accomplish this is through the incident management system and a unified command structure. Under a unified command structure all participants with statutory authority jointly participate in the development of the overall incident strategy.

Highway Incident Response and Traffic Control

The first order of business upon the receipt of an alarm for a highway incident is to respond to the scene of the incident. Captain Tony Tricarico of the Fire Department of New York wrote in Fire Engineering (2005, p. 43):

> It is preferred that the apparatus approach the incident in the same direction of travel as the incident. On highways, we are dispatched from both directions… We try to avoid working across a divider on the highways, but this is sometimes necessary. When we encounter such a situation, we operate until the apparatus approaching from the proper direction arrive and usually release the apparatus operating across the highway.

Several standard operating procedures from fire departments surveyed for this research project called for apparatus to be dispatched to highway incidents from both directions of limited access

highways. This practice is to avoid crews working across the center median unprotected from oncoming traffic.

Michael Wilbur recommended in Firehouse Magazine (2001, p. 24) that police department personnel be dispatched for traffic control to motor vehicle incidents with fire department personnel. In the same article he recommends that firefighters responding to a highway incident must first control the oncoming vehicles before turning their attention to the emergency in the event police have not arrived.

The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 155) gives the function of traffic control at highway incidents as much importance as extrication, patient treatment, or accident investigation activities.

The Phoenix Regional Standard Operating Procedures for *Safe Parking While Operating in or Near Vehicle Traffic* (2003, p. 1) explains that all personnel should understand and appreciate the high risk of operating in or near moving vehicle traffic. The standard calls for the positioning of apparatus at the scene of emergencies to provide a protected work area for personnel. It recognizes the higher speeds associated with highway operations and provides the option of using additional companies to provide for additional blocking if needed (2003, p. 3).

In part three of a six-part article for Firehouse Magazine, Ron Moore (2003, p. 27) discussed the assignment of the apparatus driver to use the apparatus to completely block the obstructed lane or shoulder area plus one more lane. This normally is done with large vehicles, but if done with smaller vehicles, such as police cars or chief vehicles, it should always be done

to the right when possible to allow the driver to exit the vehicle downstream from oncoming traffic. Ron Moore (2003, p. 27) went on to explain, "All ambulances must be positioned in a protected location at a highway incident scene…The downstream protected activity area created by the block of a major apparatus is the first place to consider for parking the ambulance."

Stephen S. Solomon, O.D., in an article written for Firehouse Magazine titled *Apparatus Placement: Scene Safety At Highway Incidents* (2002, p. 112), cautions responders not to place apparatus on both sides of the highway and expect through traffic to pass between them. Doctor Solomon continued with, "If it is necessary to have emergency vehicles on both sides, very strong consideration must be made to shut down that route to all but emergency-related activity."

The Federal Highway Administration 2003 edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways* [MUTCD] (2003, p. 6I-1) lists traffic control that is done as part of the management of traffic incidents as "temporary traffic control" [TTC]. Traffic incidents are divided into three classes based on duration:

Major- Duration of incident is more than 2 hours

Intermediate- Duration of incident is between 30 minutes to 2 hours

Minor- Duration of the incident is less than 30 minutes

Traffic control for each class differs and becomes more stringent the longer the incident takes to clear from the highway. Traffic control for minor incidents is the on –scene responder's responsibility, and the set up of lane closure with TTC devices is often not needed. During intermediate and major classes of operations, approved TTC devices should be on hand and set

up. The MUTCD (2003, p. 6I-2, 6I-3) explains that for both intermediate and major traffic incidents, “The TTC should include the proper traffic diversions, tapered lane closures, and upstream warning devices to alert approaching traffic of the end of a queue.”

The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 159) recognizes the MUTCD recommended placement of traffic warning devices as supported by both field experience and scientific research but also recognizes that its guidance does presume a static traffic flow situation as in a construction work zone. The Guide (2003, p. 161) provides an adapted schedule of placement of advanced warning devices and taper length distances based on the fact that, “Incidental congestion is characterized by rapidly growing and slowly shrinking queues of blocked vehicles.”

Ron Moore (Firehouse, 2003, p.28) expresses that the MUTCD is adopted by reference in accordance with Federal Regulations and is the national standard for the design, application, and planning of traffic control devices. As such, anytime emergency responders respond to a traffic incident, their presence creates a temporary traffic control zone, and they are bound by the MUTCD on how that traffic control zone is set up.

Emergency Vehicle and Firefighter Conspicuity

NFPA Standard 1901 *Standard for Automotive Fire Apparatus* (2003, ¶13.8) specifies the necessary optical warning devices for fire apparatus. The standard specifies upper and lower warning levels and divides these levels into four quadrants. The number of optical warning devices should be such that failure of any one device in any level should not affect the warning

signal in that level as measured at a distance of 100ft (30 m) from the geometric center of the apparatus. Specific placement of optical warning devices is listed for both large and small apparatus. Two modes of lighting operation are called for in the standard. Calling for the right-of-way mode is used to signal drivers and pedestrians that the apparatus is responding to an emergency call. Blocking the right-of-way mode is used to signal that the apparatus is stopped and is in a blocking position. The standard also specifies permissible colors and combination of colors in each zone and for each mode. Yellow lights are not allowed on the front of apparatus except in the blocking the right-of-way mode. White lights are not allowed on the back of the apparatus in any mode of operations. Red and blue lights can be used in any zone in both blocking and calling for the right-of-way modes. NFPA does recognize certain restraints on the use of light color imposed by applicable laws and regulations (2003, ¶13.8.12.1).

Dr. Stephen Solomon (2002, chap. 5, p. 56) argues that although emergency providers think flashing lights attract attention and/or convey information, this might not be entirely true. The operation of flashing lights can also have the unwanted effect of becoming a visual stimulus that some drivers steer into.

NFPA 1901 specifies the type and amount of retro-reflective material that should be applied to fire apparatus (2003, ¶15.9.3). According to the standard the retro-reflective stripe should be at least 4 inches (100mm) in width and conform to the minimum requirements of ASTM D 4956, *Standard Specification for Retro-Reflective Sheeting for Traffic Control*, Type I, Class 1 or Class 3 (2003, ¶15.9.3.1). According to the standard at least 50% of the length of the

sides of the apparatus, 25% of the width of the front of the apparatus, and 50% of the width of the rear of the apparatus will have reflective material affixed to it (2003, ¶15.9.3.2).

Although not applicable to most fire apparatus, the National Highway Traffic Safety Administration [NHTSA] (2003, 49 CFR Chapter V, Part 571, ¶S5.7.1) requires truck tractors and trailers to be equipped with retro-reflective sheeting of specific construction, size, color, and location on the truck and tractor. As reported in FEMA's *Emergency Vehicle Safety Initiative* publication (2004, p. 17), the Phoenix Fire Department incorporated the NHTSA red and white "DOT conspicuity striping" into the base rub rails of its apparatus in the late 1980s.

The Plano, Texas, Fire Department has incorporated a retro reflective chevron design on the back of its apparatus that Fire Chief Bill Peterson brought to the department from his travels to the United Kingdom. According to Chief Peterson (personal communications, April 20, 2005) fire response equipment in the United Kingdom uses a unique chevron package of red and fluorescent yellow-green retro-reflective material on the rear of the apparatus for day and night high visibility.

NFPA 1901 does not recommend any specific apparatus color for high visibility. Dr. Stephen Solomon (2002, chap.3, p. 17) writes, "We will notice what stands out. To be detected most efficiently, that object must be contrasted to its environment." Dr Solomon goes on to explain that people have difficulty in seeing the color red in both day and night and that colors from the greenish yellow to yellow-green are the easiest to detect both day and night (2002, chap. 7, p. 71). Bob Barraclough, a member of the NFPA 1901 committee (2002, p. 23) wrote

that the NFPA 1901 committee feels that with the current reflective striping requirements and emergency lighting standards, the color of the apparatus is a “non-issue.”

The International Safety Equipment Association [ISEA] published the first American National Standard [ANSI] for high-visibility safety apparel in 1999 (2005, ¶ 1). The standard provides a uniform guide for the design and performance specifications for high-visibility worker apparel. The ANSI standard lists three classes of apparel with Class III being the highest rated and most visible (Moore, 2004, p. 31). Moore (2004, p. 31) recommends that all responders at highway incidents wear ANSI Class III vests or jackets to ensure their visibility.

NFPA 1971 *Standard on Protective Ensemble for Structural Fire Fighting* (2000, ¶4-1.12) requires that all firefighting garments have fluorescent and retro reflective trim permanently attached for worker visibility. The standard calls for trim to be at least 50 mm (2 inches) wide and to have both retro reflective and fluorescent properties. The minimum surface area for reflective trim needed to meet the standard is specified for both fire fighting coats and pants. Standard Operating Procedures for many of the fire departments surveyed for this research project allow or require structural fire fighting gear to be worn by firefighters for visibility purposes on the highway.

Moore (2004, p. 32) suggests that firefighters should be required to always wear their fire helmets when working in or near moving traffic. The helmet with its retro-reflective trim material will afford firefighters both protection and increased visibility during roadway operations.

Dr. Stephen Solomon in *Apparatus Placement: Scene Safety at Highway Incidents* (2002, p. 112) wrote, " Personal protective equipment must be worn. Working in traffic requires maximum visibility and the retro-reflective/fluorescent tape helps make the firefighter more visible night and day. The tape on helmets and cuffs is critical."

Quick Clearance Program

Sweeney, in an article for *The Police Chief* titled *Managing Highway Incidents with NIMS* (2004, ¶5) wrote:

> With traffic incidents being the historic leading cause of line-of-duty deaths for police officers and the second most frequent cause of deaths for firefighters, the quick clearance of roadways can be a lifesaver for first responders, other motorists, and onlookers.

In a Roundtable article appearing in *Fire Engineering* magazine (2005, p. 38), Battalion Chief Leigh Hollins with Cedar Hammock, Florida, Fire Rescue described a Florida Highway Patrol Policy of having local firefighters to direct drivers involved in Motor Vehicle Accidents [MVAs] to move their vehicles off the road if they are drivable. If the vehicles are not drivable, firefighters are to call a rotational wrecker service to move the vehicles. According to Chief Hollins, "This facilitates removing vehicles from the roadway and allows our crews to get out of the roadways more quickly." In the same *Fire Engineering* article (2004, p. 38) Fire Chief Rick Lasky of the Lewisville, Texas, Fire Department wrote, "Our experience and several studies have shown that the more quickly a scene is cleared and traffic lanes are opened, the less chance there is of having our personnel struck."

One of the objectives of the *Freeway Incident Management Course* provided by NCTGOG is the concept of "Quick Clear" (2005, p. 139). The concept is simple. If the accident is moved from the road as quickly as possible, the safety of responders, victims, and other motorists is increased. The roadway is restored to full capacity sooner, which minimizes delays, frustrated motorists, and secondary crashes.

Literature Review Summary

The literature review on this subject includes current information that begins to answer the questions invoked by this research project. Some information by authors, governmental agencies, and industry groups sometimes conflict on specific topics, especially traffic control practices and apparatus and responders' conspicuity. The review shows that although there are best practices, there is still some disagreement depending on the perspective.

PROCEDURES

The procedures used in this applied research project were chosen to allow MFD to review other fire departments' procedures regarding highway incident management. The procedures also allow MFD to identify industry and governmental guidelines, as they relate to highway incident safety measures. The descriptive research method was used in this research to identify the following:

1. Survey of other fire departments to determine how they conduct highway operations.
2. Research of Department of Transportation guidelines, industry expert findings, and NFPA recommendations.
3. Research of NCTCOG initiatives on quick clearance of highway incidents.

Survey of Fire Departments

The author sent out surveys to 50 fire departments by U.S. mail (Appendix A). This number was limited to 50 due to time and resource restraints on the author. The surveys were sent to fire departments (Fire Chiefs) in which a member of the department has either completed the Executive Fire Officer Program or is currently enrolled in the program. The Executive Fire Officer Program directory of graduates (2004) was used to identify graduates of the program. The survey list was further reduced to departments in which the geographic response area includes a multi-lane interstate-style highway. A United States atlas was used to make this determination and to also make an even distribution of surveys within the 48 continuous United States. All states are not represented in the survey.

The surveys were mailed on February 18, 2005, and included a cover letter (Appendix B) that explained the purpose of the survey. The letter gave March 31, 2005, as the deadline for return. Respondents were given the option of returning the survey via U.S. mail or returning via facsimile. A postage paid envelope was included in the survey pack for returning via U.S. mail.

Forty completed surveys were returned (80%). A copy of the survey is included as Appendix C. The purpose of the survey was to solicit information relating to how each department managed different aspects of highway incidents and to collect current highway incident management SOPs for review. The survey included questions regarding the following subjects:

1. Demographic information
2. Incident volume

3. Highway traffic management procedures and equipment
4. Comment section

DOT Guidelines, Industry Expert Findings, and NFPA Recommendations

Literature reviews began at the National Fire Academy LRC in January 2005 and concentrated on locating books and periodicals relating to highway incident management. The author visited the USFA Publications Center in January 2005 to obtain firefighter fatality and injury reports for statistical review for this project. The literature review continued after returning to Mesquite at the Mesquite Public Library where articles and books relating to the topic of highway incident management were requested through inter-library loans from other institutions. All literature was reviewed for relevancy to the research problem and research questions.

The Internet was used to search for on-line federal and state laws as they relate to highway incident management and traffic control. NFPA documents that are related to the research problem were obtained on-line through the Mesquite Fire Departments' on-line publication subscription. NIOSH reports regarding deaths in the line of duty and recommendations related to highway incidents were also found on-line as well as other law enforcement and fire periodical articles.

An interview was done with City of Plano Fire Chief Bill Peterson on April 20, 2005, in Plano, Texas. Chief Peterson is the current president of the Institution of Fire Engineers (IFE), an international fire service organization based in the United Kingdom. The intent of the interview was to gather knowledge of the origins of the current vehicle reflective striping system

used by the Plano Fire Department as detailed in a six-part roadway incident safety series by Ron Moore (Firehouse, 2004) and traffic incident management techniques as reported in the FEMA publication *Emergency Vehicle Safety Initiative* (2004, p. 34). Chief Peterson was chosen for this interview for his knowledge of European traffic management techniques.

A telephone interview was conducted with Bob Barraclough from the author's office on April 25, 2005. Mr. Barraclough is a member of the NFPA 1901 committee. Mr. Barraclough was interviewed in reference to work done by Dr. Stephen Solomon regarding fire apparatus color. Questioning for Mr. Barraclough centered on the NFPA 1901 committee discount of Dr. Solomon's work. Mr. Barraclough also sent a facsimile of an article he had written for Fire Apparatus on the subject of vehicle visibility (2002, p. 22) for the author's review.

NCTCOG Initiatives

NCTCOG is the Metropolitan Planning Organization (MPO) for the Dallas/Fort Worth area. As such, NCTCOG developed a set of freeway incident management courses to improve the efficiency and safety of responses to traffic incidents. To gain an in-depth knowledge of NCTCOG initiatives for freeway incident management in the Dallas/Fort Worth area, the author attended two courses provided on the subject by NCTCOG. The first course attended was an executive level course held on February 11, 2005, in the Transportation Board Room at the NCTCOG offices located at 616 Six Flags Drive, Arlington, Texas. The course consisted of an overview instructed by law enforcement and city management personnel. The length of the course was approximately two hours. The second course attended was a first responder and manager course held on February 28 and March 1, 2005, at the NCTCOG Regional Training

Center, 624 Six Flags Drive, Arlington, Texas. This course was an instruction in best practices methods for traffic management as used throughout the country. Members of law enforcement, fire service, towing industry, and the department of transportation instructed the two-day course designed for individuals with daily involvement in responding to freeway incidents.

Assumptions and Limitations

The researcher acknowledges that some limitations exist in the survey method chosen and the instrument that was used. Assumptions were made that the chief of the department or a knowledgeable department member completed the survey instrument. The sample size for the survey was determined by time and resource limitations. Other limitations of the survey method include the selection of graduates or current students of the Executive Fire Officer program.

Definition of Terms

Upstream and Downstream: Upstream refers to an area of a roadway where traffic is approaching the incident area. Downstream refers to the area of the roadway past the incident scene.

Block: Positioning of an apparatus at an angle on the roadway across one or more lanes of traffic for shielding of emergency responders and incident victims.

Taper: The use of signs, cones, flares, or blocking vehicles to direct approaching traffic from the normal traffic lanes into a fewer number of open lanes.

Temporary traffic control zone: A traffic control zone on a roadway that consists of the advance warning area, transition area, activity area and termination area.

Advance Warning Area: The section of highway where road users are first informed about the incident they are approaching.

Transition Area: The section of highway tapered to move traffic out of its normal path of travel into a fewer number of open lanes.

Activity Area: The critical work area of a traffic incident. This area consists of the workspace, traffic space, and buffer space.

Termination Area: Lane or lanes of highway where drivers are allowed to return to their normal travel paths

Traffic Space: Lane or lanes of highway where drivers are transitioned around the activity area.

Buffer Space: Consists of longitudinal (protection space from upstream traffic) and lateral (protection space from redirected traffic around activity area).

RESULTS

The results of the literature review, survey instrument, and examination of the returned procedures from the surveyed fire departments were used and applied to the appropriate research questions.

Research Question 1. What industry or governmental guidelines/procedures are applicable to highway incident scene safety?

Research finds there are several recognized industry and governmental guidelines applicable to highway incident scene safety. These industry and governmental guidelines cover

safety from the perspectives of incident management, traffic control, work zone set up, and vehicle and worker conspicuity.

Incident Management

The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 78) explains that the incident management system must be implemented with the first arriving resources on the scene of highway incidents. Responding resources to highway incidents consist of several disciplines including law enforcement, fire, EMS, and towing companies. Responding resources can also consist of several agencies depending on geographical boundaries and the type and extent of the incident. The incident management system can be employed to organize this responding workforce into an effective, efficient, and coordinated workforce (2004, p. 3). If implementation is delayed, it will result in confusion and loss of a coordinated, directed, and efficient effort to mitigate the incident.

Highway Incident Operations and Traffic Control

The *2003 TIMTOW Guide* (2003, p. 1) list responders' safety, secondary crash prevention, traffic control, traffic incident management, and quick clearance as five main issues that must be managed by a team effort of all traffic incident responders. Proper temporary traffic control through the use of signs, cones, variable message signs, and highway advisory radio coupled with the proper positioning of response vehicles, emergency light discipline, prioritized resource deployment, and teamwork are used to manage these five issues safely and effectively (2003, p. 2-3).

FEMA's *Emergency Vehicle Safety Initiative* publication (2004, p. 39) list seven recommendations for highway operations:

1. Position the responding engine at a 45-degree angle to traffic lanes, with the pump panel toward the incident and the front wheels rotated away from the incident.
2. Extinguish forward-facing emergency vehicle lighting, especially on divided roadways.
3. Reduce the use of lighting as much as possible at the scene.
4. Require members to wear highly reflective material when conducting highway operations.
5. Remain vigilant during all phases of highway operations.
6. Work with neighboring districts to develop similar highway operating policies.
7. Allow all members to submit suggested policy changes.

The Federal Highway Administration publishes a document titled *Manual on Uniform Traffic Control Devices* [MUTCD]. Although each state adopts and sometimes amends the MUTCD, it is the federal standard for the design, application, and placement for all traffic control devices. The latest edition of the MUTCD is the 2003 edition. The 2003 edition contains a dedicated section for *Control of Traffic Through Traffic Incident Management Areas* (2003, p. 6I-1). This new section lists traffic control that is done as part of the management of traffic incidents as "temporary traffic control" [TTC]. Traffic incidents are divided into three classes in the 2003 MUTCD based on duration:

Major- Duration of incident is more than 2 hours

Intermediate- Duration of incident is between 30 minutes to 2 hours

Minor- Duration of the incident is less than 30 minutes

Traffic control for each class differs and becomes more stringent the longer the incident takes to clear from the highway. Emergency responders are tasked, within the first 15 minutes of arrival on the scene, with estimating the length of time it will take to clear the incident from the roadway. The appropriate TTC should be set up based on this time estimate (2003, p. 6I-1).

Traffic control for minor incidents is the on –scene responders' responsibility, and the setup of lane closure with TTC devices is often not needed. During intermediate and major classes of operations, approved TTC devices should be on hand and set up. The MUTCD (2003, p. 6I-2, 6I-3) explains that for both intermediate and major traffic incidents, "The TTC should include the proper traffic diversions, tapered lane closures, and upstream warning devices to alert approaching traffic of the end of a queue." Approved traffic control devices can be found in Chapter 6F (2003, p. 6F-1).

The primary purpose of TTC at emergency incidents is to move motorists around the traffic incident safely and to reduce the likelihood of secondary crashes (2003, p. 6I-1). Components of a TTC zone (2003, p. 6C-01) consist of an advance warning area, vehicle transition area, incident activity area, and incident termination area. Other components of a TTC consist of buffer spaces to separate workers from moving traffic and a downstream taper to realign traffic back into the proper driving lanes once past the incident area. An example of a TTC zone is included as Appendix D.

The proper spacing for the advance warning area of a TTC zone is determined by the road type and is listed in the MUTCD in Chapter 6C (2003, p. 6C-4, Table 6C-1). This distance can extend back 2,640 feet (one-half mile) from the activity area on expressway/freeway-type roads.

The proper spacing of taper devices in both the transition and termination areas of a TTC zone are determined based on the formula 1.0 times the speed limit (2003, p. 6C-7). The proper length of a taper is based on the type of taper, width of the offset, and the speed limit of the roadway. On roadways with a speed limit over 45 mph the length of a transition taper can be determined by the formula L=WS, where L= length of taper, W= width of the offset, and S= posted speed limit (2003, p. 6C-8, Table 6C-3).

The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 159) recognizes the MUTCD recommended placement of traffic warning devices as supported by both field experience and scientific research but recognizes that its guidance does presume a static traffic flow situation as in a construction work zone. The Guide (2003, p. 161) provides an adapted schedule of placement of advanced warning devices and taper length distances based on the fact that, “Incidental congestion is characterized by rapidly growing and slowly shrinking queues of blocked vehicles.” The adapted advanced warning distance from the incident activity area is greatly increased for expressway/highway road types to approximately one mile. The adapted distance includes the MUTCD recommended three advanced warning signs but acknowledges that this warning would progress further and further upstream into the regional transportation

system and the responsibility should pass from the Incident Commander to regional resources better equipped to deal with the problem (2004, p. 161). Taper length and layout are also adapted given the fact that the MUTCD is based upon highway work zone criteria. This criterion sought to maximize traffic flow around a long duration work zone. During traffic incidents the safety of responders, patients, and other personnel in and around the work zone is of paramount importance. Movement of traffic is secondary. This leads to the recognition of the need to reduce traffic speeds (25-35 mph) of passing motorists and the shorting of the transition tapers necessary for the lower speeds (2004, p. 161, Table E.2). Spacing of taper devices, e.g. cones or flares, was also decreased to reflect the reduced traffic speeds. The authors of the guide recommend spacing of one car length between taper devices (2004, p. 162).

NFPA Standard 1500 *Fire Department Occupational Safety and Health Program* (2002, ¶8.4.25) states, "When members are operating at an emergency incident and their assignment places them in potential conflict with motor vehicle traffic, they shall wear a garment with fluorescent and retro-reflective material." NFPA Standard 1500 (2002, ¶8.4.26) also directs that apparatus be utilized as a shield for personnel from oncoming traffic whenever possible, and when the apparatus is used in this capacity, warning lights shall remain on, if appropriate. Other requirements of the standard include the use of DOT-approved advanced warning signage, traffic cones, and other illuminating warning devices for traffic control of the incident scene (2002, ¶8.4.27).

Emergency Vehicle and Firefighter Conspicuity

NFPA Standard 1901 *Standard for Automotive Fire Apparatus* (2003, ¶15.9.3) controls the amount and type of retro-reflective stripes that are affixed to fire apparatus. These stripes are required on fire apparatus for passive visibility at night. The standard states:

> At least 50 percent of the cab and body length on each side, at least 50 percent of the width of the rear, and at least 25 percent of the width of the front of the apparatus shall have the reflective material affixed to it (2003, ¶15.9.3.2).

NFPA Standard 1901 also controls the type, color, number, and operation of optical warning devices installed on fire apparatus (2003, ¶13.8). These devices are installed for both day and night visibility of the apparatus.

The results of a telephone interview conducted with Bob Barraclough from the author's office on April 25, 2005, revealed that the NFPA 1901 committee had considered Dr. Solomon's work relating to the effect that emergency vehicle color had on accident rates. As early as the late 1970s Dr. Solomon presented his work to the NFPA 1901 committee but was not successful in persuading the committee to recommend lime-yellow as the preferred color for fire apparatus.

The National Highway Traffic Safety Administration [NHTSA] (2003, 49 CFR Chapter V, Part 571, ¶S5.7.1) requires truck tractors and trailers to be equipped with retro-reflective sheeting of specific construction, size, color, and location on the truck and tractor. This federal regulation does not apply to most fire apparatus. The result of this federal regulation is to standardize the retro-reflective markings on all truck tractors and trailers that use the Nation's roadways. The retro-reflective elements in the standard serve the purpose of outlining the outer

edges of the vehicle. This outlining effect allows motorists to quickly determine the dimensions of the marked vehicle at night.

NFPA 1971 *Standard on Protective Ensemble for Structural Fire Fighting* (2000, ¶4-1.12) controls the type and amount of fluorescent and retro-reflective material that is attached to fire fighting garments. The use of fluorescent and retro-reflective trim on fire fighting garments enhances firefighter visibility during both day and night operations.

The International Safety Equipment Association [ISEA] published the first American National Standard [ANSI] for high-visibility safety apparel in 1999 (ISEA, 2005, ¶ 1). The standard provides a uniform guide for the design and performance specifications for high-visibility worker apparel. This standard was updated in 2004 and now is listed as ANSI/ISEA 107-2004. The standard consists of three "Conspicuity Class Levels" (AmeriTees, 2004, ¶1). Each class category gives an example of a typical working environment for which the garment is designed or used in. The highest rated garment is Class III and is designed for workers whose tasks include working in environments where traffic exceeds 50 mph.

Research Question 2. What best practices have other fire departments developed to effectively and safely operate at highway incident scenes?

Fire Department Survey

A fire department survey on highway incident management was mailed to 50 fire departments around the United States. Departments were asked to fill out the 13-question survey and submit any procedures dealing with highway incident safety back to the author. Of the

original 50 surveys mailed 40 were returned (80%). Total responses to each survey question can be found in Appendix C.

Survey questions one through six deal with demographics, size, and miles of limited access highways in a department's response area. Of the 40 returned surveys 36 departments were paid, and 4 were combination paid/volunteer. The distributions of population served by the responding departments are displayed in Table 1.

Table 1. Population Served

Population Served	Number of Responding Departments	Percentage of Total
10,000- 50,000	3	7.5%
50,001- 100,000	7	17.5%
100,001-250,000	17	42.5%
250,001-500,000	4	10%
Over 500,000	9	22.5%

Of the 40 departments that responded, 18 (45%) had greater than 20 miles of limited access highway in their response area, and only 7 (17.5 %) had 1 mile or less.

Survey question number seven asks the responding departments if they have an official standard procedure for responding to highway incidents. Of the departments responding, 20 (50%) answered yes. Of the 20 departments that answered no or left the question blank, 17 carried cones or flares for traffic control on their response apparatus. The size of the department

did not seem to matter in regard to question seven as all were represented in their yes and no answers.

Question eight on the survey instrument asks the responding departments if they utilize a "blocking vehicle" for protection of responders at highway incidents. Of the departments responding 36 (90%) answered yes. Of the 4 departments that answered no to question eight, all 4 also lacked official standard procedures for responding to highway incidents.

Survey question nine expands on the blocking vehicle question and asks the responding departments if they utilized more than one "blocking vehicle" at highway incidents. Of the departments responding 13 (32.5%) answered yes.

Survey question 10 asks the responding departments if they had a "blocking vehicle" hit at a highway incident in the last two years. Of the 40 responding departments, 15 (37.5%) answered yes. Interestingly, 6 of 15 departments that had a "blocking vehicle" hit in the last two years answered no to question seven regarding an official standard operating procedure for highway incidents.

Question 11 on the survey instrument asks responding departments what types of traffic control devices they carry on their apparatus. Of the departments responding 32 (80%) carried cones. The average number of cones carried by the departments responding yes was 6 cones per apparatus. A total of 18 departments responding (45%) carry flares, and of the 8 departments that did not carry cones, 4 of those departments do carry flares for traffic control. This leaves only 4 of the 40 responding departments that do not carry cones, flares, or both for traffic control

purposes. Other traffic control devices used were temporary signs- 3 out of the 40 (7.5%), arrow sticks- 14 out of 40 (35%), light-emitting diode markers [LED markers]- 2 out of 40 (5%).

Survey questions 12 and 13 ask the responding departments about ANSI-approved high-visibility safety reflective vests/apparel. Question 12 asks the responding departments if ANSI-approved vests/apparel are provided to all first responders. Of the 40 responding departments, 23 (57.5%) responded yes. Question 13 asks if the first responders are required to wear the ANSI-approved vests/apparel while working all highway incidents. Of the 40 responding departments, 22 (55%) responded yes. It is worth noting that 9 out of the 20 departments that do not have an official standard procedure for highway incidents do carry and require their members to wear ANSI-approved vests\apparel while working all highway incidents.

Highway Procedure Review

Of the 20 standard operating procedures submitted with the survey, most require that an incident management system be used for all highway incidents. Several of the procedures identify law enforcement as the primary agency for traffic control and stress the use of a unified command system with law enforcement.

Several of the procedures call for units to be dispatched from both directions on limited access highways. Several procedures also caution against crossing over medians on limited access highways to work incidents on the opposite lane of travel unprotected by apparatus.

The MUTCD terminology and procedures were followed in several of the procedures submitted. Most procedures address the need to use the response apparatus as a blocking vehicle and that the apparatus must be positioned with the front wheels turned away from the protection

zone and the pump panel facing away from oncoming traffic. Two procedures submitted gave specific distances that the blocking vehicle should be placed from the incident. One procedure gave 100 ft. from the incident to create a lateral buffer zone for workers, and the other used the thumb rule [speed limit mph=ft. from the incident], e.g. 55 mph=55 ft. from the incident.

The most-used standard for the length of a merging taper for oncoming traffic on a limited access highway was 150 feet. The average spacing for cones and flares in a merging taper was 25 to 30 feet apart. Two procedures had specific instructions on how responders are to place traffic cones to ensure their personal safety while setting them up. Most procedures addressed the need to shut down one extra lane of traffic as a buffer for protecting personnel, and most gave the option of shutting down the entire highway with caution and restraint. Several of the procedures addressed the need to stage unnecessary apparatus off the highway until needed.

Several of the respondent highway procedures addressed the need for apparatus light shedding once on scene. The most common theme in the procedures dealt with turning off apparatus headlights to prevent blinding of on coming motorists. Two procedures submitted cautioned against the use of warning devices (sirens and warning lights) when responding on limited access highways. These departments directed their responders to go with the flow of traffic until arrival.

Most procedures call for some type of high visibility personal protective equipment [PPE] to be worn by responders on highway incidents. Most department procedures consider the use of fire fighting turnout gear to fulfill this need. Over half of the departments surveyed provide ANSI-approved safety vests to their responders and require the use of the vests when

turnout gear is not in use. One department commented in the survey that consideration was being given in making their firefighter PPE ANSI Class II compliant. Only a few departments address the need to wear head protection while operating on highway incidents.

The results of an interview done with City of Plano Fire Chief Bill Peterson on April 20, 2005, revealed that the current Plano vehicle reflective striping system originated in the United Kingdom [UK]. The UK striping system is used on the back and front of fire and police vehicles and has both retro-reflective and fluorescent properties. Chief Peterson brought the UK system back to the Plano Fire Department about 10 years ago.

Literary Findings

The findings of the literary review show that highway traffic incident management activities of many departments include responses from both directions of travel, fire apparatus blocking techniques for worker safety, safe parking procedures, deployment of traffic control devices, vehicle emergency light management procedures, and the use of high-visibility PPE for response workers. John Coleman in a roundtable article for Fire Engineering Magazine (2005, p. 38) asks 25 fire service professionals from around the United States about their department procedures for protecting firefighters working vehicle accidents on streets and highways. Points from his article worth noting are a positive working relationship with law enforcement for traffic control assistance, the use of apparatus as traffic blockers to provide a safe working environment for workers, safety benefits of quick clearance policies, responses from both directions of travel on limited access highways so that workers avoid working across highway dividers, worker use

of high-visibility PPE on all roadway incidents, and the recognition of the potential problems topography and weather can have on traffic management.

Research Question 3. How will current NCTCOG initiatives to quickly clear traffic congestion caused by highway incidents affect highway scene safety?

As detailed in the executive course of the NCTCOG Freeway Incident Management in the Dallas/Fort Worth Area (2005, p. 6), the need for this initiative is five fold:

1. Improve responder and motorist safety
2. Reduce incident-related congestion
3. Improve response and clearance times
4. Prevent secondary collisions
5. Improve traffic flow and air quality

Two of these five components, responder and motorist safety and prevention of secondary collisions, positively affect responder safety at highway incidents.

The NCTCOG initiate promotes the use of the incident command system by all highway emergency responders to create a more effective response for all responding agencies (2005, p. 21). The use of a unified command structure is detailed in the initiate and includes all responding agencies with command transferred as soon as an agency has completed their duties (2005, p. 113).

Traffic control is addressed in the NCTCOG initiative to both improve responder safety and to also reduce the incidents of secondary accidents in the traffic queue. The initiative addresses the need to stage equipment off the highway until needed for safety and reduced

impact on traffic flow (2005, p. 128). Proper response vehicle positioning is addressed as being protective, based on function, planned, and coordinated with other responding agencies (2005, p. 126). The use of proper traffic control devices is covered in the initiative with an overview of the 2003 MUTCD and how to apply the MUTCD principles to emergency incidents (2005, p. 133).

The NCTCOG states the definition of clearance as, "To safely and quickly remove vehicles, debris, and spilled cargo, and to restore the roadway to full capacity (2005, p. 138)." The initiative makes clearance a priority to emergency responders. Decreasing the amount of time responders spend on the highway decreases the chances that a secondary accident will occur (2005, p. 139).

Liability concerns over clearance actions are addressed by the NCTCOG by the use of a good incident management program that provides the following (2005, p. 146):

1. Puts public safety ahead of property concerns
2. Limits responder exposure
3. Reduces secondary crashes
4. Validates that the actions taken are in the "interest of safety"

The NCTCOG initiative for quickly clearing highway incidents covers fundamentals of good traffic incident management, response, site management, clearance procedures, and the importance of multi-agency traffic incident management training.

DISCUSSION

Research shows there are many laws, standards, and best practices covering highway incident response and safety. Breaking the topic down into components reveals that each component is covered by standards and best practices and each deserves careful study. Each component can be viewed as a link in a chain. Break one link and disaster could follow. The components to highway incident safety have been broken down in this applied research project as incident management, incident response and traffic control, and emergency vehicle and firefighter conspicuity.

The use of an incident command system with a unified command structure for highway incidents is stressed in the literary review for this project and in most of the surveyed department procedures. The National Fire Service Incident Management System Consortium in its *Model Procedures Guide for Highway Incidents* document (2004, p. 3) stresses the use of the ICS for all responding resources to provide an effective, efficient, and coordinated workforce. This advice is echoed in the white paper titled *Protecting Emergency Responders on the Highway* in which successful operations are defined as being skillfully orchestrated efforts (Cohen, 1999, p. 6). The requirement that all agencies adopt the new NIMS, to remain eligible for emergency preparedness grants, will ensure that more responding agencies to highway incidents will be familiar with and use ICS to manage these scenes.

Making incident clearance a priority for command and all emergency responders helps to manage the five needs defined in the NCTCOG Freeway Incident Management initiative. These needs are to improve responder and motorist safety, reduce incident related congestion, improve

response and clearance times, prevent secondary collisions, and to improve traffic flow and air quality (2005, p. 6). Managing two of these five needs, improving responder and motorist safety and the prevention of secondary collisions, positively affects responder safety at highway incidents. Many of the fundamentals included in the NCTCOG initiative are found elsewhere in the literary review as best practices, standards, or laws.

Several standard operating procedures from fire departments surveyed for this research project call for apparatus to be dispatched to limited access highway incidents from both directions. This practice is to avoid having crews working across the center median unprotected from oncoming traffic. Captain Tony Tricarico of the Fire Department of New York (FDNY) wrote in Fire Engineering Magazine (2005, p. 43) that FDNY members try to avoid working across highway dividers, but that when such a situation is encountered, units dispatched from the opposite direction take over once they arrive. It is clear from both the literary review and fire department survey that working an incident without the benefit of a "blocking apparatus" is not good practice and is to be avoided. It is also noted in the literary review that parking of smaller vehicles and apparatus, especially ambulances, should be within the protected location of a blocking vehicle. Ron Moore (Firehouse, 2003, p. 27) explained, "All ambulances must be positioned in a protected location at a highway incident scene…The downstream protected activity area created by the block of a major apparatus is the first place to consider for parking the ambulance."

Positioning additional apparatus as "secondary blockers" upstream from highway incidents was reported by 32.5% of the 50 departments surveyed for this research project. The

Phoenix Regional Standard Operating Procedure for *Safe Parking While Operating in or Near Vehicle Traffic* (2003, p. 1) recognizes the higher speeds associated with highway operations and provides the option of using additional companies to provide for additional blocking if needed. Several surveyed departments automatically dispatch "secondary blockers" to all highway incidents.

The MUTCD (2003) standardizes traffic control methods and devices in the United States. Section 6I of the MUTCD *Control of Traffic Through Traffic Incident Management Areas* (2003, p. 6I-1) divides incidents into three classes based on the duration of the incident. Traffic control methods and devices are based on the time duration of the incident. Emergency responders are tasked with estimating the length of time of an incident within 15 minutes of arrival and arranging for necessary traffic control needs based on the MUTCD requirements.

Traffic control for minor incidents with durations of up to 30 minutes is the on-scene responder's responsibility. During these short duration incidents the setup of lane closures with TTC devices is often not needed (MUTCD, 2003, p. 6I-2). Given the background on firefighter and police officer fatalities due to being struck by passing vehicles, traffic control should be the first thing accomplished at all highway incidents. Michael Wilbur recommended in Firehouse Magazine (2001, p. 24) that firefighters responding to a highway incident must first control the oncoming vehicles before turning their attention to the emergency. Although the setup of lane closures for minor incidents does not have to conform to the MUTCD requirements, lane closures are necessary and provided by blocking apparatus and the use of traffic control devices such as cones and flares.

The results of surveyed departments for this project show that 90% of the responding departments carry cones and/or flares on responding apparatus for temporary traffic control. The average number of cones carried on responding apparatus per the survey was six. The most used standard for the length of the initial merging taper for limited access highways was 150 feet. If the average complement of 6 cones is used to cover the average 150 feet of taper length, cone spacing will need to be approximately 25 feet apart. This merging taper length and device spacing should be considered the minimum acceptable for MUTCD classified minor incidents on limited access highways.

Traffic control for MUTCD classified intermediate and major incidents will require that an approved TTC zone be in place. A unified command structure with law enforcement will help to mobilize the resources necessary to set up an approved TTC zone. By adhering to the 15 minute MUTCD required estimation of clearance time, responders should be in a better position to mobilize enough resources to comply with the MUTCD TTC zone setup requirements. Resources can be pulled from the Department of Transportation, county, Department of Public Safety, and even from contracted towing companies. Many of these agencies and private companies have resources that include cones, mobile arrow boards, temporary signage and variable message boards. Support vehicles are new to some towing company fleets. These vehicles carry the necessary traffic control devices to set up a MUTCD approved TTC zone. In the TIMTOW Guide (2003, p. 13) the Towing and Recovery Association of American reports that, “The justification of requiring these support vehicles is long overdue in the towing and

recovery industry…The costs of this service can be claimed, documented and paid for under the towing contract."

Apparatus optical warning devices provide the initial hazard warning to motorists on highway incidents. To attract motorists' attention NFPA standard 1901 specifies optical warning device requirements for fire apparatus. There is disagreement in the fire service regarding the number, color and type of optical warning devices on fire apparatus. Although Dr. Stephen Solomon (2002, chap.3, p. 17) writes that, "we will notice what stands out," he also cautions that the assumption that flashing lights convey a certain message might not be entirely true and that the operation of flashing lights can also provide a stimulus that some drivers steer into (2002, chap. 5, p. 56). Guidance on emergency warning light management is provided in FEMA's *Emergency Vehicle Safety Initiative* (2004, p. 36). This guidance suggests that public safety agencies should examine their use of emergency vehicle lighting with the goal of reducing its use after the traffic incident is secured. Several surveyed departments for this research project included emergency light management in their roadway response procedures. Most direct the apparatus driver to extinguish apparatus headlights to reduce the likelihood of blinding motorists traveling the opposite direction of parked emergency apparatus.

Passive apparatus warning is achieved through the use of retro-reflective striping and also by the color of the apparatus. NFPA 1901 specifies the type and amount of retro-reflective material that should be applied to fire apparatus (2003, ¶15.9.3). Fire apparatus color is not specified in NFPA 1901. Although this standard exists, there is disagreement in the fire service on the use of color and retro-reflective material use. Dr. Steven Solomon was unable to persuade

the NFPA 1901 committee of the need to specify lime-yellow as the preferred color for fire apparatus (Barraclough, personal communication, April 25, 2005) but the use of lime-yellow and red chevron striping is prevalent in the United Kingdom and is gaining popularity in the United States (Peterson, personal communication, April 20, 2005). The effect of fluorescent colors on visibility is already recognized in NFPA 1971 *Standard on Protective Ensemble for Structural Fire Fighting* (2000, ¶4-1.12) and NFPA 1500 *Fire Department Occupational Safety and Health Program* (2002, ¶8.4.25). It really makes no difference whether the color comes from the paint or the striping as long as the effect of increase visibility is achieved.

Firefighter visibility can be considered the last line of defense for firefighters working highway incidents. NFPA 1971 *Standard on Protective Ensemble for Structural Fire Fighting* (2000, ¶4-1.12) specifies the visibility requirements of fire fighting garments. NFPA 1500 *Fire Department Occupational Safety and Health Program* (2002, ¶8.4.25) directs that firefighters will wear a garment with fluorescent and retro-reflective material when members are operating at an emergency incident that places them in potential conflict with motor vehicle traffic. The ISEA/ANSI 107-2004 standard classifies high-visibility worker apparel into three classifications depending on the working environment of the worker (AmeriTees, 2005, ¶1). Class III garments are designed for workers whose tasks include working in environments where traffic exceeds 50 mph. Over half of the fire departments surveyed for this research project supply their members with ANSI-approved reflective vests/apparel. Most procedures submitted as part of the fire department survey require responders on highway incidents to wear some type of high-visibility PPE. Most of these departments consider the use of NFPA-approved fire fighting turnout gear to

fulfill this need. One element of firefighter PPE that only a few departments surveyed require is the use of the firefighter helmet at highway incidents. Ron Moore wrote in Firehouse Magazine (2004, p.32) that the fire helmet provides reflective trim material for firefighter visibility in addition to the obvious head protection.

The results of this research have provided standards and best practices that can be used for the development of highway incident procedures. The results have also determined that many of the fundamentals included in the NCTCOG initiative are considered best practices and standards and should be considered in the development of highway incident procedures.

RECOMMENDATIONS

The research concludes that several standards and industry best practices are available to guide the MFD in the development of highway incident procedures and training. The research also concludes that apparatus and firefighter conspicuity standards and best practices exist and must be used in the design of apparatus emergency lighting, conspicuity striping, and firefighter protective gear and clothing.

The first recommendation is that all MFD members and Mesquite Police Department (MPD) members be trained in the purpose and use of the NIMS. This training must be followed up by the revision of the current MFD incident management procedure as well as training in the use of the new procedure.

The second recommendation is that MFD SOP 205.01 *Driving* be revised to include MUTCD standards on traffic control for all three classes of traffic incidents. Special emphasis must be placed on the incident commander's required estimated clearance time and the

significance clearance time has on the type and amount of traffic control necessary for the incident. The SOP must include a section dedicated to MUTCD classified minor incidents and the traffic control methods used for these short duration incidents. Included in this section will be blocking and parking techniques, temporary traffic control device use and placement, emergency warning light management, and the use of high visibility protective clothing by all emergency responders. The revised procedure must prohibit responders from working incidents across highway medians and also give the option to the incident commander to utilize a secondary blocking vehicle if traffic and road conditions warrant it. Vehicles used in this secondary blocking capacity are to be identified and equipped with the appropriate NFPA 1500 DOT-approved retro-reflective advanced warning sign and other approved traffic control devices to warn oncoming traffic of emergency operations. SOP 205.01 must also be re-titled to reflect the increase scope of the procedure and for easy reference by department members.

Third, the NCTCOG freeway incident management initiative should be adopted by the City of Mesquite. This initiative is based on sound fundamentals of good traffic incident management. Training on this initiative must be a joint MFD and MPD endeavor. Since highway incidents are frequent events where MFD and MPD work together, joint training in this area will help ensure that both departments can work under a unified command structure to safely and quickly mitigate these incidents.

Fourth, changes must be made to the retro-reflective striping on all MFD emergency vehicles. The new striping will exceed NFPA 1901 requirements and incorporate fluorescent

properties for better daytime visibility. Visibility standards must also be evaluated on all new and existing firefighter turnouts, cold weather/rain coats, and high-visibility vests.

MFD must constantly research and implement new or revised standards as they relate to highway incident management. Governmental and industry standards are updated on a regular time frame and are reflected in best practices of the industry. Standards listed in this ARP represent the most up-to-date at the time it was written. Researchers reading this project are encouraged to check for more recent versions of the listed standards as well as for new standards covering the subject matter.

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Appendix A
Fire Departments Surveyed

1. Garland Fire Department	Garland, TX 75040
2. Dallas Fire Department	Dallas, TX 75201
3. Lubbock Fire Department	Lubbock, TX 79403
4. Albuquerque Fire Department	Albuquerque, NM 87121
5. Hanover Park Fire Department	Hanover Park, IL 60133
6. Richmond Fire and Emergency Services	Richmond, VA 23219-1867
7. Portland Fire and Rescue	Portland, OR 97230
8. Kent Fire Department	Kent, WA 98030
9. Oklahoma City Fire Department	Oklahoma City, OK 73106
10. Aurora Fire Department	Aurora, CO 80012
11. San Diego Fire-Rescue Department	San Diego, CA 92101
12. City of Riverside Fire Department	Riverside, CA 92522
13. Birmingham Fire and Rescue	Birmingham, Alabama 35203
14. Hartford Fire Department	Hartford, CT 06103
15. Fort Lauderdale Fire-Rescue Department	Fort Lauderdale, FL 33311
16. Savannah Fire and Emergency Services	Savannah, GA 31401
17. Peoria Fire Department	Peoria, IL 61603
18. Naperville Fire Department	Naperville, IL 60540
19. Fort Wayne Fire Department	Fort Wayne, IN 46803
20. Wichita Fire Department	Wichita, KS 67202

21. Shreveport Fire Department	Shreveport, LA 71101
22. Baltimore Fire Department	Baltimore, MA 21286
23. Saginaw Township Fire Department	Saginaw, MI 48603
24. Minneapolis Fire Department	Minneapolis, MN 55415
25. Hattiesburg Fire Department	Hattiesburg, MS 39403
26. Independence Fire Department	Independence, MO 64050
27. Omaha Fire Department	Omaha, NE 68102
28. Reno Fire Department	Reno, NV 89501
29. Las Vegas Fire Department	Las Vegas, NV 89101
30. Trenton Fire Department	Trenton, NJ 08618
31. Albany Fire Department	Albany, NY
32. Charlotte Fire Department	Charlotte, NC 28202
33. Bismarck Fire and Inspections Department	Bismarck, ND 58501-1936
34. Canton Fire Department	Canton, OH 44702
35. Tulsa Fire Department	Tulsa, OK 74120
36. Broken Arrow Fire Department	Broken Arrow, OK 74012
37. Philadelphia Fire Department	Philadelphia, PA 19123
38. York Department of Fire/Rescue Services	York, PA 17401
39. Providence Fire Department	Providence, RI 02903
40. Sioux Falls Fire Rescue	Sioux Falls, SD 57105
41. Brentwood Fire Department	Brentwood, TN

42. El Paso Fire Department	El Paso, TX 79925
43. Arlington Fire Department	Arlington, TX 76010
44. Fort Worth Fire Department	Fort Worth, TX 76102-6311
45. Abilene Fire Department	Abilene, TX 79601
46. Salt Lake City Fire Department	Salt Lake City, UT 84111
47. Murray City Fire Department	Murray, UT 84107
48. Burlington Fire Department	Burlington, Vermont 05401
49. Fairfax County Fire and Rescue	Fairfax, Virginia 22030
50. Milwaukee Fire Department	Milwaukee, WI 53233

Appendix B
Survey Cover Letter

February 18, 2005

Dear Chief:

My name is Mark Kerby and I am the Fire Chief of the Mesquite Fire Department in Mesquite Texas. I am currently enrolled in the Executive Fire Officer (EFO) Program at the National Fire Academy in Emmitsburg, Maryland. As part of the four year EFO program, I am required to complete an applied research project after each course. I have just completed an Executive Development course and I am conducting a survey of fire departments regarding responder safety at highway incidents.

I am asking that you or someone on your staff complete the attached survey "Highway Scene Management". If at all possible, I would also like a copy of any standard procedures that your department may have on the subject of highway scene management. The information gathered will be combined with information from other departments in the United States and your department will not be identified by name.

I realize that everyone's time is limited and that surveys are not always popular. I have purposely tried to make the survey instrument as short as possible and your returned response is greatly appreciated. It is important that all the surveys and procedures be returned by March 31, 2005. A pre-addressed stamped envelope has been enclosed for submitting these documents to me. Responses can also be faxed to 972-216-6436 if preferred.

Thank you in advance your participation.

Sincerely,

_____

Mark Kerby
Fire Chief
Mesquite Fire Department
1515 N. Galloway Avenue
Mesquite, TX 75150

Appendix C
Fire Department Survey

NFA Executive Fire Officer Program
Applied Research Project Survey

Highway Scene Management

This survey has been developed to seek information of how other fire departments respond to and manage safety at highway scene incidents. It is being sent to fire departments across the United States. Please provide answers to all the questions. Thank you for your participation.

1. Please indicate which of the following best describes your department.
   ___36___ Fully paid
   ____0___ Volunteer
   ____4___ Combination

2. What is the approximate population of the area that your department serves?
   ____0___ 10,000 and below
   ____3___ 10,001 – 50,000
   ____7___ 50,001 – 100,000
   ___17___ 100,001 – 250,000
   ____4___ 250,001- 500,000
   ____9___ Over 500,000

3. What is the approximate number of fire personnel in your department?
   0-50=2, 51-100=3, 101-200=8, 201-500=13, 501-1000=12, >1000=2

4. What is the approximate square miles of the area that is served by your department? _*This data was not used in the project.*_____

5. What is the approximate number of undivided limited access highway miles in your service area?
   ____7___ 0-1 miles *2 responses were left blank*.
   ____3___ 1.1- 5 miles
   ____4___ 5.1 – 10 miles
   ____6___ 10.1 – 20 miles
   ___18___ Over 20 miles

6. What is the approximate number of incidents your department responded to in 2004? <1k=1, 1K-5K=7, 5K-10K=2, 10K-20K=9, 20K-100K=18, >100K=2, blank=1

7. Does your department have an official standard procedure for responding to highway incidents? **Yes***=20 No=20

* If yes, please enclose a copy of any standard procedures that your department may have on the subject of highway scene management. ***20 were received***

8. Does your department utilize a "blocking vehicle" for protection of responders at highway incidents? Yes=36 No=4

   If yes, what type vehicle? _*Answer varied too much to utilize*.__

9. Does your department utilize more than one "blocking vehicle" at highway incidents? Yes=13 No=27 If yes, how many? *Data not utilized*_

10. Has your department had a "blocking vehicle" hit at a highway incident within the last two years? Yes=15 No=25 If yes, how many times *Data not utilized*__?

11. Which of the following temporary traffic control devices does your department carry on its first response vehicles? Circle all that apply.

    Traffic Cones=33 (# carried_*avg.=6*) Road Flares 18 Temporary Signage 3

    Vehicle Arrow Sticks 14 Portable Barriers 0 LED Road Markers 2

    Other ____0_____

12. Are ANSI approved High-Visibility Safety reflective vests\apparel provided to all first responders? Yes=23 No=17

13. Are first responders required to wear ANSI approved High-Visibility Safety reflective vests\apparel while working all highway incidents? Yes=22 No=18

Comments:_____

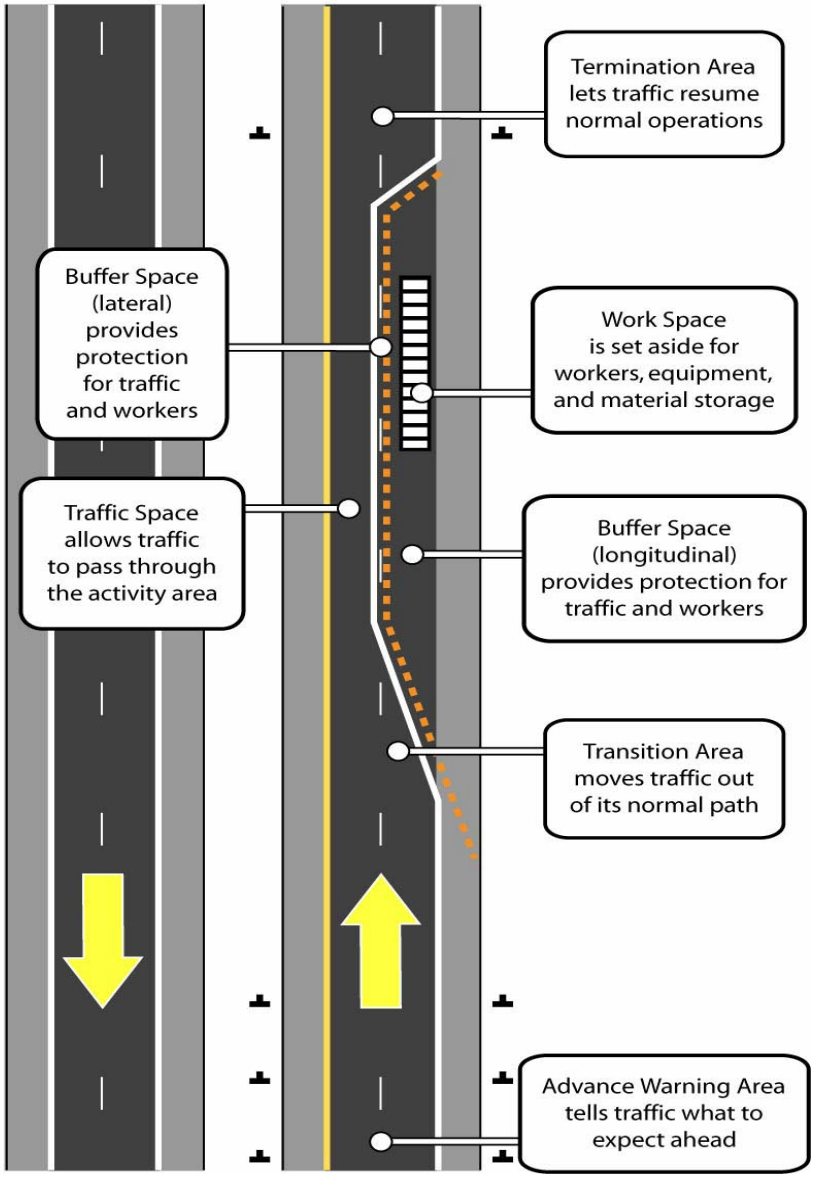
_____

Please remit to the following address in the stamped envelope provided:

Mark Kerby
Fire Chief
Mesquite Fire Department
1515 N. Galloway Avenue
Mesquite, TX 75150

Appendix D

Component Parts of a Temporary Traffic Control Zone



[1]

[1] Captions and diagram derived from the Federal Highway Administration Manual of Uniform Traffic Control Devices for Streets and Highways 2003 Edition [MUTCD], p. 6C-3, Figure 6C-1.