Project Responder 5

August 2017

Homeland Security

Science and Technology

TASK LEAD
Michelle Royal

TASK TEAM

Homeland Security Studies and Analysis Institute
Sherry Reichow, PhD

Tara Conway

Laura Sappelsa

Consultants
Amy Donahue, PhD

Elizabeth Dugan, PhD

Jennifer Sollars Miller

Steve Chabolla

Manager, Business Enterprise Analysis Division

Howard Smith, PhD

Director, Resilience and Emergency Preparedness/Response

PROJECT RESPONDER 5

Final Report

Prepared for
Department of Homeland Security
Science and Technology Directorate, Support to the Homeland Security Enterprise and First Responders Group

ACKNOWLEDGEMENTS

For Project Responder 5, the authors spoke with emergency responders that participated in response activities for many of the largest manmade incidents and natural disasters in the United States over the past several years. This report greatly benefits from the men and women who took the time to share their experiences and reflect on those capabilities that would improve future response operations. This document is dedicated to the emergency responders in the United States—those that contributed to this effort and the millions of responders throughout the country that put their own lives at risk on a daily basis.

For information about this publication or other research, contact

HOMELAND SECURITY STUDIES AND ANALYSIS INSTITUTE
A DHS Federally Funded Research and Development Center Operated by Analytic Services Inc.

5275 Leesburg Pike, Suite N-5000
Falls Church, Virginia 22041
Tel (703) 416-3229 • Fax (703) 379-2556

Publication Number: RP16-18-02

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Project Responder 5 (PR5) is the fifth iteration in the Project Responder series of studies. The purpose of Project Responder is to identify, validate and prioritize capability needs for emergency response to critical incidents, including complex, multi-jurisdictional, large-scale, high-risk, high-probability or high-consequence incidents, or incidents that have important social or economic impacts. Capability needs are not static, but evolve as operating environments and organizations themselves change. This argues for a process of continuous assessment of these needs. Since the first Project Responder report was published, the U.S. Department of Homeland Security (DHS) has funded a periodic re-examination of capability needs based upon changes in the response environment and technological advances.

The timing of PR5 is appropriate because the threat environment continues to change, requiring capabilities to address a wide spectrum of threats and hazards. Increased incidence of weather-related natural disasters, mass civil disturbance and riot events, violent acts against emergency response personnel and terror events emphasize the need for evolving capabilities. This document also describes how other factors, including the actions of bystanders, societal perceptions of mistrust, the growing involvement of traditional and social media and advances in technology, have changed how responders operate during routine daily events and on large-scale incidents.

This document describes 37 capability needs identified by emergency responders who participated in the nation's recent large-scale incidents and validated by groups of responders across the United States. Each need reflects a capability that responders believe necessary to safely, efficiently and effectively address large-scale incidents in the future. The First Responder Resource Group, a multi-disciplinary group of responders from across the nation, subsequently reviewed and prioritized the capability needs. Each capability need provides contextual information to describe the need, goals articulated by emergency responders, a high-level description of the current state of technology and a list of standards or regulations (if applicable) that may impact efforts to address the need.

The DHS Science and Technology Directorate's Support to the Homeland Security Enterprise and First Responders Group funded PR5 to ensure that its technology development and transition are built on the needs of the emergency response community. The results, however, can be equally beneficial to other federal agencies, private industry and academia as they continue their efforts to support the response community.

(This page intentionally left blank.)

INTRODUCTION

In April 2001, the Memorial Institute for the Prevention of Terrorism (MIPT) commissioned the Project Responder study to identify the capabilities that emergency responders most needed to respond to large-scale incidents. In the wake of the Oklahoma City Murrah Building bombing, MIPT sought to understand the gaps between the existing capabilities of responders and what was actually needed for effective and timely response.[1] The need to understand response capability has endured as the threat environment continues to evolve. The purpose of Project Responder is to identify, validate and prioritize capability needs for emergency response to critical incidents, including complex, multi-jurisdictional, large-scale, high-risk, high-probability or high-consequence incidents, or incidents that have important social or economic impacts. Capability needs are not static, but evolve as operating environments and organizations themselves change. This argues for a process of continuous assessment of these needs. This is what Project Responder, over its five iterations, offers.

In this dynamic environment, and confronted by a broad spectrum of risks, threats and hazards, agencies charged with emergency preparedness at all levels of government must decide how best to allocate scarce resources to position themselves to respond effectively when incidents occur and to then recover efficiently. Since its inception before September 11, 2001 (or 9/11), Project Responder has sought to provide the federal government, academia and private industry with an evolving description of operational requirements and capability needs against which they can focus their ongoing technology development efforts. The signature of Project Responder is its success in developing a comprehensive set of priorities that has been validated by experienced and respected emergency response professionals from a wide array of disciplines.

This fifth round of Project Responder (PR5) reexamines and updates emergency response capability needs in light of current operational demands, new and emergent threats and hazards, new environmental conditions and recent technology advancements. These capability needs are substantially different from those with which the field was most concerned in the wake of 9/11. The findings from the project can inform the U.S. Department of Homeland Security's (DHS) decisions about investments in projects and programs to promote capability enhancement, with particular attention to technology development, but also in the areas of related research initiatives, training and education and policy analysis and development.

The results of PR5 are primarily intended for the DHS Science and Technology (S&T) Directorate's Support to the Homeland Security Enterprise and First Responders Group (FRG), the sponsor of this effort. The FRG is responsible for developing and transitioning technologies, knowledge products and standards to improve the capabilities of emergency responders. The FRG uses the results of the Project Responder studies to support technology investments and acquisition decisions. The results, however, can be

[1] For the purposes of this document, a capability is defined as "the means to accomplish one or more tasks under specific conditions."

equally beneficial to other federal agencies, private industry and academia as they continue their efforts to support the response community.

Project Responder closely engages emergency responders throughout the process. This document describes the capabilities that the responders—the men and women responsible for saving lives and protecting property—believe are needed to perform the missions demanded of them.

BACKGROUND

Prior to the original Project Responder study, there had been few efforts to examine the capability needs of emergency responders across disciplines. Each traditional response discipline (i.e., fire service, law enforcement, emergency medical services [EMS] and emergency management) has associations and organizations that work to advance capabilities for its constituents. However, all disciplines share many capability needs—needs like situational awareness, communications and logistics, among others. To be effective, capabilities in these areas depend on collaboration across disciplines. If capabilities are developed by individual disciplines in isolation, rather than collaboratively across disciplines, this thwarts the opportunity to promote robust interoperability during incident response.

Project Responder is fundamentally designed to promote a broad perspective on capability needs that accounts for a wide variety of disciplinary perspectives by carefully gathering detailed input from the traditional response disciplines. In addition, the process also collects input from other agencies and groups that are critical to successful large-scale incident response (e.g., public health, public works, incident management and search and rescue teams and nongovernmental organizations).

Project Responder focuses on large-scale incidents because the field generally understands how to respond effectively to more routine events. However, the capabilities needed to address large-scale incident response are less understood, less developed and less available. Large, complex incidents exceed the resources of local or regional jurisdictions, require regional or national mutual aid and entail long-term response and recovery operations. Yet, the response community is made up of thousands of career and volunteer agencies from multiple disciplines, each with capabilities, priorities and requirements generally driven by the events and incidents their particular jurisdictions must be prepared to handle on a day-to-day basis. There is no nationwide coordinating body to gather requirements, fund the development of new capabilities or procure them for the large, complex incidents these myriad agencies may someday face. This argues for involvement at the federal level to facilitate the development of technologies and standards that benefit responders nationwide for these more rare, but catastrophic, incidents.

Through four previous iterations, Project Responder has identified the capability needs of emergency responders based on the threats and hazards that were of greatest concern at the time.[2] Much of the data gathering for the initial Project Responder effort occurred in the months following the 9/11 terrorist attacks. The capability needs captured in that study focused on weapons of mass destruction and terrorism response. The years following publication of the first Project Responder report saw a significant operational change in focus to “all-hazards” response following Hurricane Katrina and other incidents, as well as the evolution of the National Incident Management System (NIMS). This required a reexamination of capability needs to better align with the changing

[2] See Appendix A for a more detailed description of the previous iterations of Project Responder.

operating environment. New attention to industrial accidents, environmental disasters, pandemic disease, active shooter, terrorism incidents and civil unrest, in addition to natural disasters, demonstrate the contemporary array of threats that responders face and the spectrum of capabilities that they need.

The Project Responder study, sparked by the momentous events of the Oklahoma City bombing and 9/11, offers an enduring perspective on what responders in the field really need. Further, it is a focused examination of how these needs change based on a dynamic and ever-changing response environment. While many of the needs identified in the original report remain valid, federal agencies, private industry and academia must also keep pace with current needs as they develop policy, standards and technology for the emergency response community. Periodic reexamination of capability needs is essential to ensure that emergency responders have the appropriate protection, equipment, systems, technologies and apparatus required to carry out their missions safely, efficiently and effectively.

THE EVOLVING RESPONSE ENVIRONMENT

Emergency responders are being asked to react to a growing number of violent events and natural disasters as well as evolving threats, such as mass rioting and targeting of response personnel. This section describes how the operational environment has changed, illustrating the need for a reexamination of capability needs. New and evolving threats and hazards, the actions of bystanders, the growing involvement of traditional and social media and advances in technology have all changed how responders operate during routine daily events and large-scale incidents.

Threats and Hazards

Violent Incidents

DHS released the last Project Responder report more than two years ago. Since then, there have been 23 incidents of terrorism in the United States, 11 of them in the first nine months of 2016.[3] These include attacks on civilians and emergency responders via shootings, bombings and attacks with other weapons. In some cases, attackers employ secondary devices, intended to harm or kill responders after they have arrived on scene. In 2013, the shooter at the Century 16 Theater in Aurora, Colorado, set a booby trap in his apartment to explode and catch fire when responders entered. The Los Angeles field office of the Federal Bureau of Investigation (FBI) reported that the terrorists who shot and killed 14 people in San Bernardino, California, in December 2015 planted an explosive device inside the building; the remote-control detonation device was in their vehicle. These examples demonstrate that emergency responders continue to be at great risk from violent attacks, and the incidence of attacks is rising.

[3] "Terrorist acts and related incidents in the United States," Johnston Archive, last updated September 19, 2016, http://www.johnstonsarchive.net/terrorism/wrjp255a.html.

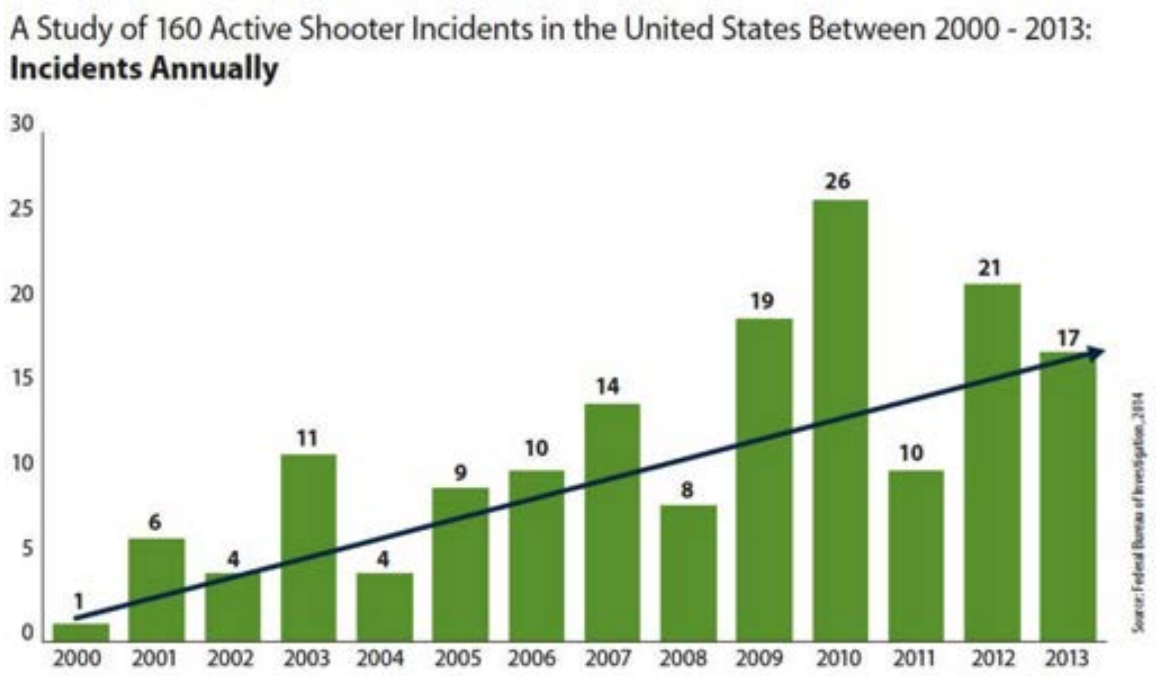

Figure 1. Growth of active shooter incidents in the United States

A 2013 study by the FBI reports a growing number of active shooter incidents between 2000 and 2013.[4] During the first seven years included in the study, an average of 6.4 incidents occurred annually. In the last seven years of the study, however, that average increased to 16.4 incidents annually.[5] Figure 1 shows the trend. Seven of the 10 deadliest mass shootings in the United States occurred within the last 10 years.

Mass civil disturbance and rioting is not a new phenomenon in the United States. American citizens have rioted over racial inequality, social activism and other issues throughout the country's history. After three decades of a relatively low incidence of these events, however, the frequency has increased in recent years. There have been more violent riot events from 2014 to date than there were in the years 2000-2009. Rioting activities include looting, arson and destruction of public and private property. During the 2014 Ferguson, Missouri, riots, protestors set nearly 30 buildings on fire. Responding to these events puts the safety of emergency responders at high risk. Approximately 130 police officers were injured during the 2015 Baltimore, Maryland, riots.

In addition, a July 2016 *Mid-Year Law Enforcement Officer Fatalities Report* from the National Law Enforcement Officers Memorial Fund reported 14 ambush-style attacks on law enforcement officers in the first half of 2016.[6] This represents a more than 300 percent increase from the same period in 2015. Five officers were targeted and killed in Dallas, Texas, and three in Baton Rouge, Louisiana, in July 2016. While law enforcement

[4] *A Study of Active Shooter Incidents in the United States between 2000 and 2013*, (Washington: Federal Bureau of Investigation, September 16, 2013).

[5] Ibid, 8.

[6] *2016 Mid-Year Law Enforcement Fatalities Report*, (Washington: National Law Enforcement Officers Memorial Fund, July 2016), http://www.nleomf.org/facts/research-bulletins/.

officers have previously been the targets of violence by gangs or political groups, responders report an increased willingness among attackers to harm those in uniform.[7] Moreover, the animosity toward responders no longer applies only to law enforcement officers. Violence now threatens firefighters and EMS providers. Anonymous online threats in July 2016 called for gangs throughout the country to "attack everything in blue" and stated that "firemen and police are on the same side." Targeted violence toward emergency responders is now prompting changes in tactics, resourcing and training throughout the country.

Natural Disasters

The incidence and severity of natural disasters is also rising. Figure 2 below shows the increase between 1950-2016.[8] There are several factors behind this increase. Global climate change is one significant cause. Multiple indicators provide evidence that the Earth's climate is changing, affecting the number of natural disasters and the amount of damage caused.[9] Superstorm Sandy provides one example: researchers attribute the 2012 storm's intensity and heavy rains to the increased surface sea temperatures that fed moisture into the storm.[10] Scientists expect this trend to continue as climate change increases global surface temperatures, resulting in more droughts and increased intensity of storms.[11]

[7] "Police worry about their own safety after killings: "It's a different world," *Los Angeles Times*, August 31, 2015, http://www.latimes.com/nation/la-na-blue-lives-matter-20150831-story.html.

[8] Geophysical disasters include earthquakes, volcanoes and mass movement of dry terrain (e.g., rockfall, landslide and avalanche). Climate-related disasters include floods, storms, extreme temperatures, drought, wildfire and mass movement of wet terrain. Data derived from the International Disaster Database (EM-DAT) developed and maintained by the Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain, Brussels, Belgium. http://www.emdat.be/advanced_search/index.html.

[9] Evidence for climate change includes rising sea levels, global temperatures, ocean temperatures and ocean acidity levels; shrinking ice sheets, sea ice, glaciers and snow cover; and the number of record high temperature weather events. "Climate change: how do we know," National Aeronautics and Space Administration, last modified October 5, 2016, http://climate.nasa.gov/evidence/.

[10] Kevin Trenberth, John Fasullo and Theodore Shepard, "Attribution of climate extreme events," *Nature*, June 22, 2015, http://www.nature.com/nclimate/journal/v5/n8/full/nclimate2657.html.

[11] "How can climate change affect natural disasters," U.S. Geological Survey, last modified June 15, 2016, https://www2.usgs.gov/faq/node/5611.

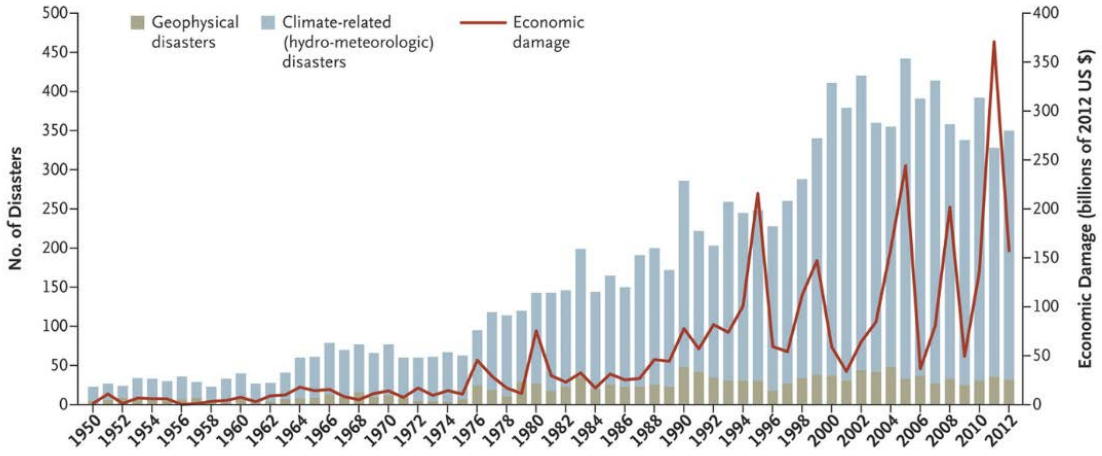

Figure 2. Growth in the number and severity of natural disasters, 1950-2012

Human activities are also affecting the severity of storms. For example, patterns of urban and coastal development alter the terrain. Activities like removing vegetation and soil, grading land surfaces and constructing drainage networks decrease the ability of the soil to store moisture and increase runoff from rainfall and snowmelt. This increases the frequency of floods in nearby streams and rivers.[12] Similarly, the removal of barrier islands causes coastal areas to become fully exposed to weather effects and water conditions.

Coastal population trends also impact the severity of natural disasters. The National Oceanic and Atmospheric Administration (NOAA) estimates that 39 percent of the population lives in coastal shoreline counties, with a population density more than three times that of the U.S. average. Figure 3 illustrates this issue.[13] Commercial and residential development in these areas exacerbates coastal erosion. This erosion is responsible for the landward migration of beaches and destabilizing coastal structures, making them more susceptible to storm effects. Moreover, as more Americans migrate to coastal areas, more people are in harm's way when natural disasters strike. Officials in Florida, Georgia and South Carolina ordered the evacuation of more than 2.5 million residents before the arrival of Hurricane Matthew in 2016, and North Carolina authorities reported rescues of more than 2,300 people in over 600 rescue operations.[14]

---

[12] C.P. Conrad, *Effects of Urban Development on Floods*, Fact Sheet 076-03 (Washington: U.S. Geological Survey, November 2003), http://pubs.usgs.gov/fs/fs07603/pdf/fs07603.pdf.

[13] *National Coastal Population Report: Population Trends from 1970 to 2020* (Washington: National Oceanic and Atmospheric Association, March 2013), 3.

[14] "Flooding in North Carolina From Hurricane Matthew Incurs $1.5 Billion In Damage, Authorities Say," Weather.com, published October, 16, 2016, https://weather.com/news/news/hurricane-matthew-north-carolina-update.

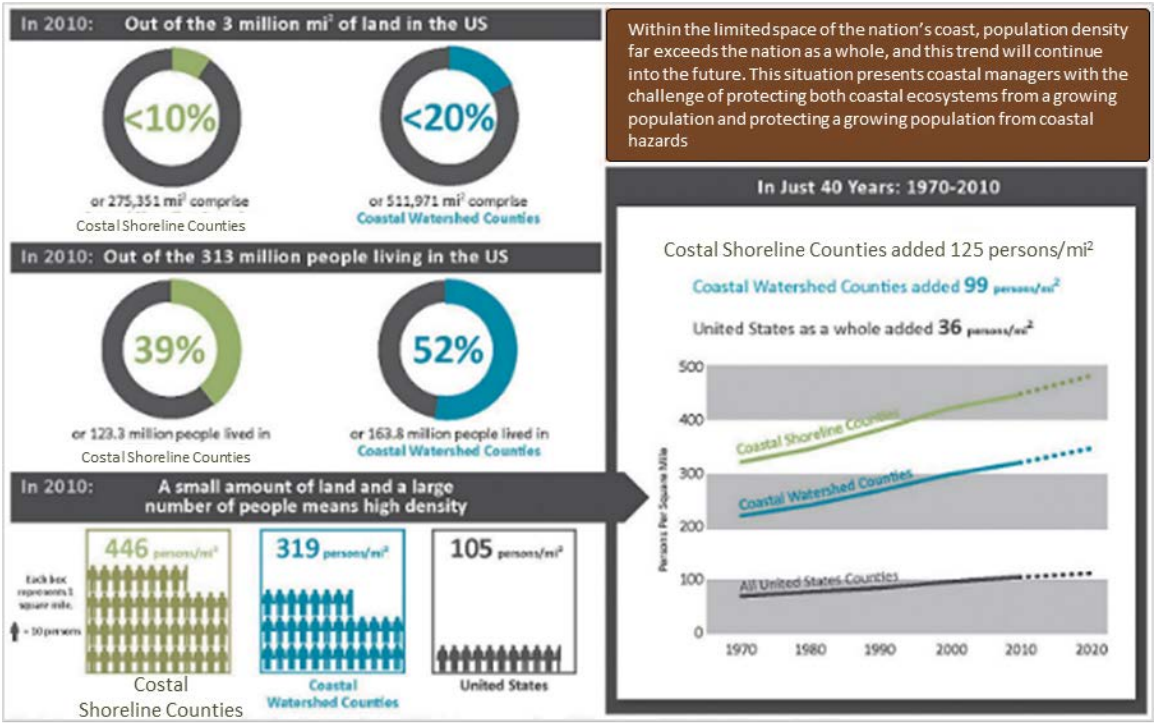

Figure 3. NOAA estimates of coastal population growth

Human Behavior

It is not a new phenomenon that human behavior can impede response operations. Past incidents have seen citizens who were capable of evacuating, but unwilling to do so, before hurricane landfall or knowingly drove into flooded areas. These people endanger the lives of emergency responders who are tasked to rescue them as the situation becomes more perilous. Human behavior has changed the response environment in recent years, however, as people now rush toward the area of greatest danger. During the attack on law enforcement officers in Dallas in July 2016, a number of people ran toward the gunfire in an attempt to capture the incident on video using their smart phones. Responders have noted similar behavior in other incidents as well. Where onlookers once encircled a scene after a crime was committed, many are now intent on capturing and live-streaming the action as it occurs. This puts responders at risk as they must try to protect the public at the same time they are trying to neutralize a threat. Responders expect this behavior to proliferate.

Not all public interest is detrimental to response operations, however. The emergency response field has long recognized that people can collect and share information valuable to response operations. Some citizens who are intent on capturing incidents on video can provide valuable data and information to responders. Some firefighters en route to a call are able to view live video of a structure before they arrive on scene due to the action of "fire scene hobbyists" who live-stream video of fires on Periscope and similar applications. Similarly, citizens in hazard-prone areas (e.g., tornado and hurricane zones) often post images and video on response agency and traditional media sites, as well as social media feeds, providing improved situational awareness for these types of incidents.

Perceptions

Emergency responders and citizens increasingly feel vulnerable to groups that they believe are targeting them for violence. As evidenced by the Black Lives Matter and Blue Lives Matter movements, and by racially motivated violence, the perception that one group is targeting another has impacts on the operational environment, even when violence does not manifest. Long-standing mistrust based on race and religion has exploded in recent years, resulting in growing levels of fear by citizens and emergency responders. Increased incidence of shootings and bombings in which the perpetrator(s) have aligned themselves with terrorist organizations, rhetoric seeking or promising mass deportations for religious and national groups, and incidents of violence against minority groups all combine to produce a charged atmosphere in which the tension and division are growing. Many emergency responders have expressed concerns for their community should one incident trigger something that is much more widespread.

In the response community, this fear is driving changes in operational tactics, resourcing decisions and community relationships. Based on the outcomes of riot events in Baltimore and Ferguson, Missouri, for example, response agencies in many communities are changing procedures for engagement with crowds and protesters. Agencies are also increasing the protection that they provide to their personnel. One volunteer fire agency that participated in this effort reported that it delayed the purchase of new, critically needed radios to purchase ballistic protection for firefighters.

Traditional and Social Media

The traditional media (television, radio and newspaper outlets) provide ongoing coverage of large-scale incidents. In many cases, an agency's public information officer has developed working relationships with the media, and those media representatives can be trusted not to report information that has not been released by officials or presents a danger to responders. However, some media coverage can result in first responders being put at risk. A television station in Dallas broadcast the location of tactical teams as they tried to corner the sniper who opened fire on Dallas police officers. In Oso, Washington, members of the media repeatedly tried to circumvent police cordons to obtain footage of the search for and removal of remains from the 2014 landslide. Unethical reporting by the media can lead to injury or death of emergency responders, cause greater suffering to affected family members or hinder response operations. In addition, many news agencies maintain consulting relationships (both on-air and off-air) with members of the public safety community. During a response, these consultants offer analysis and assessment of tactics and operations, often without full awareness of incident-specific facts or circumstances. This can lead to the dissemination of misinformation that is not easily remedied.

Nontraditional media sources (including social and Internet-based media) are not encumbered by the existing relationships with public safety agencies. In this era, every bystander can become a reporter. The ability to live-stream incidents while they are occurring can significantly impact response operations, both with positive and negative effects. In many cases, information shared via social media during an incident can augment situational awareness. Although still in early stages, responders in some incidents have been able to obtain data directly from the incident scene before they

arrive. The Periscope application (app) is used both by amateur journalists and emergency response agencies to live-stream active fires. Responders in several states report the ability to access the feeds from "pyro-enthusiasts" who arrive on scene and start broadcasting before response units arrive. Social media can also be used to benefit those impacted by incidents. In 2014, people stranded on highways following a snowstorm in Atlanta used social media to crowdsource for assistance. In response, members of the community used the #snowedoutatlanta hashtag on Twitter and Facebook to communicate and organize their willingness to help.[15] In October 2016, following severe flooding in the aftermath of Hurricane Matthew, a man in Texas used Twitter to direct searchers to the location of his brother who was stranded in North Carolina and in need of rescue.[16] Conversely, social media apps also allow people to conspire and collaborate on an unprecedented scale. Social media posts in Baton Rouge in July 2016 called for a "purge" of law enforcement officers and asked others to share the posts. The call for the purge occurred less than 10 days before a man ambushed six Baton Rouge law enforcement officers, wounding three of them fatally.

Technological Advances

Emergency responders have ever greater access to new technology that increases their capabilities, most notably with regard to situational awareness and communications. The availability of video and accessibility of data provides on-scene responders and incident commanders with greater awareness of the incident prior to arriving on scene, increased understanding of incident-specific characteristics during response operations, and better ability to reconstruct or investigate the incident after it occurs. Although most land-mobile radios (LMR) customarily used by responders cannot access data sources, many responders use personal smart phones to access apps for navigation, information and decision support.

Some technology, such as the use of unmanned aircraft systems (UAS), shows potential for significantly increasing situational awareness. Civilian hobbyists are able to capture and display real-time video using their UAS. Military models have extensive capabilities, carrying chemical sensors, communications repeaters, etc. However, federal, state, and local regulations must evolve to incorporate first responder UAS use. Currently, Federal Aviation Administration regulations severely restrict UAS operations in vehicle size and weight, speed, altitude, and proximity to manned aircraft operations. In some instances, local legislation prohibits UAS use or is more restrictive than federal regulations due to privacy and civil liberty concerns.

---

[15] "#snowedoutatlanta," Twitter, https://twitter.com/hashtag/snowedoutatlanta.

[16] "Drone and Social Media Help Rescuers Save Veteran in Hurricane Matthew Flooding," ABC11 WTVD, posted October 11, 2016, http://abc11.com/weather/drone-and-social-media-help-rescuers-save-veteran-in-hurricane-matthew-flooding/1550476/.

What Does Not Change

Despite many new developments that affect the response environment, there are a number of factors that do not change. These factors continue to affect how public safety personnel respond to large-scale incidents.

- Limited budgets: Resources remain scarce for many public safety agencies. Technology developers need to recognize that many agencies have very restricted budgets. The National Fire Protection Association (NFPA) reports that 85 percent of fire departments in the United States consist of mostly or all volunteer personnel, and these departments serve a large portion of the country.[17] Small fire and police departments across the nation often need to rely on increasingly rare grant funding to purchase new equipment. As a result, high-cost items may be beyond the means of many agencies.

- Culture, tradition and perception: Firefighters have an adage that the fire service is "100 years of tradition unimpeded by progress" to describe their resistance to change. As for most organizations, change can be uncomfortable and challenging for emergency response agencies. Emergency responders resist new technologies and practices, even though these offer important enhancements to their response capabilities. In some cases, this resistance is born of a generational gap. Younger responders have grown up using technology in a way that seems foreign to more seasoned and senior responders and leaders, and so advancements filter slowly into response operations. Technology developers need to consider that equipment perceived as a revolutionary (or even slight) change in the way things are currently done may meet notable resistance.

- Need for daily use: Responders do not want a set of special tools and equipment that is only useful for and used on large-scale or catastrophic incidents, which are rare. Without the opportunity for regular use, responders may not remember how to operate the equipment or forgot their access passwords, and internal calibrations or data libraries may be out of date. Responders want equipment they can use for daily response activities, so they are naturally familiar with it on major incidents. Their investment in the equipment pays off with better response capability every day.

[17] "U.S. fire department profile," NFPA, published January 2016, http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/administration/us-fire-department-profile.

METHODOLOGY

The purpose of PR5 is to identify, validate and prioritize capability needs for emergency response to large-scale incidents. This section describes the methodology the project employs to engage experienced and respected emergency response professionals from a wide array of disciplines to meet these objectives.

Identification of Emergency Response Capability Needs

As discussed above, capability needs are not static. They evolve as operating environments and organizations themselves change, and they must be continually reassessed and revised. The increased incidence of weather-related natural disasters, mass civil disturbance and riot events, violent targeting of emergency responders and terror events accentuate the need to reexamine emergency responder needs and priorities at this time.

To assess the impact of evolving operational environments on capability needs, the study team began by selecting a set of 18 recent natural disasters and man-made incidents to examine for the PR5 effort. These include complex, multi-jurisdictional, large-scale, high-risk, high-probability or high-consequence incidents, or those that had important social or economic impacts. While many incidents fit this description, the study team sought to identify a subset that represents the current operational threats across different regions of the country. The study team looked at five specific factors:

- Incident type: inclusive of natural disasters and man-made incidents (both intentional and accidental)[18]
- Time frame: inclusive of incidents that occurred in the past five years
- Population density: inclusive of urban and rural areas
- Geographic dispersion: representative of different areas of the country
- Atypical: inclusive of incidents of previously unseen scale or severity

In addition, two relevant incidents occurred during the study—the June 2016 Orlando club shooting and the July 2016 Dallas law enforcement shooting—that merited inclusion in the data-gathering processes because they met the factors listed above. Table 1 below lists the identified incidents:

Table 1. PR5 incidents

Incident	Incident Type	Year	Urban/Rural	Region	Atypical
Century 16 Theater (CO) Shooting	Man-made	2012	Urban	Central	

[18] The study team originally sought to include public health events such as the Ebola patient and Flint, Michigan water-based poisoning, as well as technology events such as cyber-ransom incidents and widespread identity theft of a federal agency. However, time constraints on this effort prohibited inclusion. The Homeland Security Studies and Analysis Institute team and responders involved in this effort strongly encourage similar capabilities-based assessment of these areas.

Incident	Incident Type	Year	Urban/Rural	Region	Atypical
Baltimore (MD) Riots	Man-made	2015	Urban	East	♦
Boston (MA) Marathon Bombing	Man-made	2013	Urban	Northeast	
Emanuel AME Church (SC) Shooting	Man-made	2015	Urban	Southeast	
Dallas (TX) Law Enforcement Shooting	Man-made	2016	Urban	South	♦
Ferguson (MO) Riots	Man-made	2014	Urban	Central	♦
Hurricane Sandy	Natural Disaster	2012	Urban, Rural	Northeast	♦
Joplin (MO) Tornado	Natural Disaster	2011	Urban	Central	
Kalamazoo (MI) Shootings	Man-made	2016	Urban	North	
Moore (OK) Tornado	Natural Disaster	2013	Urban	Central	
Pulse Nightclub (FL) Shooting	Man-made	2016	Urban	Southeast	
Oso (WA) Landslide	Natural Disaster	2014	Rural	Northeast	
Planned Parenthood (CO) Shooting	Man-made	2015	Urban	Central	
Inland Regional Center (CA) Shooting	Man-made	2015	Urban	West	
Sandy Hook Elementary (CT) Shooting	Man-made	2012	Urban	Northeast	
Chaffee (MO) Train Collision and Bridge Collapse	Man-made	2013	Rural	Central	
South Carolina Floods	Natural Disaster	2015, 2016	Urban, Rural	Southeast	
Texas Floods	Natural Disaster	2015, 2016	Urban, Rural	South	
Umpqua Community College (OR) Shooting	Man-made	2015	Rural	West	
West (TX) Fertilizer Plant Explosion	Man-made	2013	Rural	South	

Figure 4 illustrates the location and type of incidents used to gather proposed capability needs.

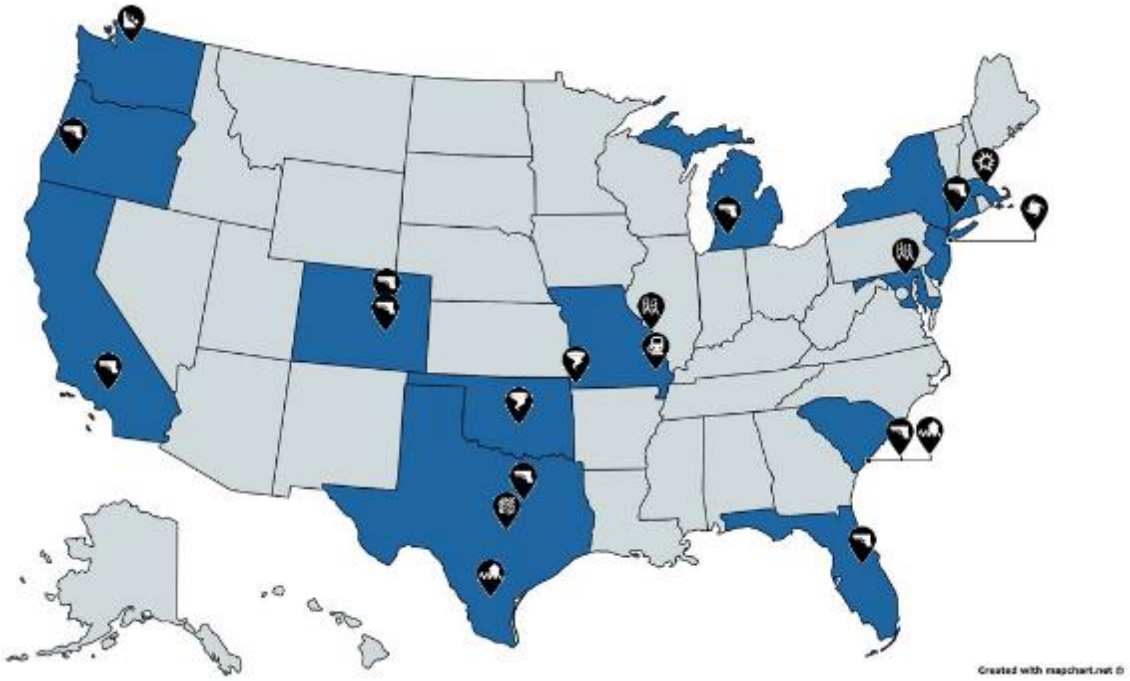

Figure 4. Geographic location of identified incidents

Incident Summaries

The study team created a summary of each incident based on a careful review of after-action reports, evaluations, media accounts and other public safety documentation. The summaries served two purposes: (1) to identify a provisional set of capability needs as captured in after-action reports and other incident documentation that would be subject to further development and validation throughout the balance of the PR5 process; and (2) to familiarize the study team with the details of the incidents in advance of a subsequent series of interviews with responders who participated in the response to many of these incidents. Each incident summary contains a brief accounting of events and response activities, as well as a list of lessons learned and identified capability gaps. The incident summaries can be found in Appendix B.

Interviews

During the summer of 2016, the study team conducted a series of semi-structured interviews across the United States with command staff and on-scene responders to understand gaps in current response capabilities. Querying responders with direct leadership experience on these incidents allowed the study team to obtain assessments of current operational challenges and capability needs that are grounded in recent experience with what is working and what is not working in the field today for large, complex incidents.

The team sought to conduct interviews for all 20 incidents. However, this was not possible given time constraints of the project and lack of access to some personnel (due to availability or ongoing prosecutions of alleged perpetrators). The team was able to conduct interviews for 13 of the incidents. When possible, the study team interviewed personnel from:

- More than one discipline for the same incident
- More than one jurisdiction for the same incident
- Both command staff and on-scene responders who participated in the same incident, to obtain multiple perspectives on capability needs

The study team conducted interviews with responders associated with the following incidents:

Century 16 theater shooting in Aurora, Colorado	Moore, Oklahoma, tornado
Baltimore, Maryland, riots	Oso, Washington, landslide
Boston Marathon bombing	Inland Regional Center shooting in California
Dallas, Texas, law enforcement shooting	Chaffee Bridge collapse in Missouri
Ferguson, Missouri, riots	South Carolina floods
Hurricane Sandy	Umpqua Community College shooting in Oregon
Joplin, Missouri, tornado	

The study team requested that participants complete a questionnaire prior to the interview. The questionnaire asked about jurisdiction-specific capability needs and solicited views on current operational requirements and priorities before responses were affected by incident-related discussions.[19]

The study team traveled to the local jurisdiction for each interview and used a detailed interview protocol to query the responders about the capabilities they needed during response activities but were deficient or not available. The interviewer asked the reason that capabilities were not available (e.g., technology, training or policy gaps). In some cases, the team also received tours of the scene or detailed presentations about the incident response. A team member took comprehensive notes during each interview.[20] The PR5 interview protocol can be found in Appendix D.

Provisional capability needs

At the conclusion of the interview process, the team identified a set of provisional capability needs based on information from the documentation, questionnaires and

[19] The pre-interview questionnaire can be found in Appendix C.

[20] Each interview was based on non-attributional input from participants.

interview notes. The provisional capability needs are specific statements describing the means to accomplish one or more tasks under specific conditions. For PR5, these statements reflect capabilities that responders from diverse incidents believe are necessary to effectively and efficiently respond to large-scale incidents in the future. The statements are based on existing deficiencies that hindered response efforts or gaps in capability that impact responder safety. The team then analyzed the list, combining similar needs or deleting duplicates. The team excluded any capability needs for items that currently exist and are readily available.[21] There were 42 distinct needs resulting from this process. The study team organized the needs according to capability domains.[22]

Figure 5. Project Responder capability domains

Capabilities were categorized into domains in previous iterations of Project Responder. The domains are broad operational categories in which similar needs are consistently identified. The domains serve as an organizational construct to allow research and discussion that spans response disciplines. The Project Responder capability domains are listed in Figure 5. Capability needs throughout this document are categorized according to these domains.

Validation and Prioritization of Emergency Response Capability Needs

The study team used the draft capability needs as a foundation for discussions with a wider group of emergency responders. It was necessary to validate the draft capability needs with a larger set of responders to ensure that those needs represent common or universal requirements across disciplines and jurisdictions. The study team organized four focus group meetings across the United States to obtain this validation. The intent of the meetings was to bring together personnel who participated in response activities for large-scale incidents to discuss and prioritize the capability needs. The focus group

[21] Often, capability gaps exist when a jurisdiction lacks available funding for acquisition of newer or more technically advanced equipment or training. This is especially true for smaller jurisdictions. While this represents a capability gap for that particular jurisdiction, it does not require the application of federal research and development funding for resolution. As an example, one jurisdiction noted the need for a swift water rescue team. These teams exist and function as designed in other jurisdictions, but developing this capability requires adequate funding for acquisition and maintenance.

[22] The list containing the 42 provisional capability needs can be found in Appendix E.

format allows interactive and collaborative discussion of capability needs among participants from many jurisdictions, disciplines and agencies. These interactive discussions resulted in a comprehensive and consensus-based list of needs. The meetings were held in Dallas, Seattle, New York City and Charleston, South Carolina.[23]

Each focus group meeting used a general form of Nominal Group Technique, where a group is convened to identify a problem, devise solutions and make a decision through a collaborative process designed to identify consensus. Each meeting was also informed by Delphi designs, which rely on experts to anonymously make predictions through iterative assessments using questionnaires that help the group converge on a decision or answer. In this case, the groups included approximately 10 expert emergency responders from multiple disciplines and jurisdictions. The decision they were asked to make is what capabilities emergency responders need most to respond effectively to significant incidents, and why. Thus, much of these focus group discussions were devoted to carefully defining and validating capability needs through facilitated discussions.

At the beginning of each focus group meeting, the facilitator asked the participants to complete a brief written questionnaire. The questionnaire was similar to those completed in advance of the interviews, asking respondents to comment on the most significant threats that their jurisdiction must be prepared for. During morning and afternoon sessions, the facilitator guided participants through a methodical discussion of a set of approximately 12 capability needs. The facilitator first asked participants to verify that the capability need was correct as stated, and whether any edits were necessary to ensure legitimacy and accuracy. The objective was to arrive at a brief, specific statement of each distinct capability need that would be readily understood by other responders. During the balance of the discussion, the facilitator reviewed each draft capability statement one at a time, asking participants to discuss each requirement fully, by explaining what issue, problem, challenge or need each proposed capability would address. Participants described specific goals for each capability need and potential barriers that may impact efforts to address the need. Finally, the facilitator led participants through a prioritization process.

The facilitator asked the participants to reach consensus about which needs are most urgent to help inform investment choices on technology development by DHS and others. To prioritize the list of needs, the focus groups employed a multi-voting approach. Multi-voting is a group decision-making technique that allows the group to select a defined number of priorities from a larger set of items using an iterative form of approval voting. Multi-voting reveals underlying agreement about a popular or favored option among group members by identifying options that may not be anyone's top choice (or may only be the top choice of a few), but that is seen as important by many. Additional advantages of the technique are that it permits prioritization of an extensive set of options, and that it is simple to understand and quick to use.

[23] These cities were chosen because of their proximity to multiple large-scale incidents, allowing the study team to assemble groups of participants who could review and discuss the capability needs across different types of threats and hazards.

The facilitator asked participants to review the list of capability needs discussed during the day and identify all needs on the list they viewed as high priority. Participants recorded those needs on a ballot. The study team tallied the ballots and generated a new, more limited list containing all needs that received votes from at least four participants. The facilitator asked participants to review the new list and choose no more than half of the capability needs. Participants recorded their choices on a ballot, which were then tallied by the study team. This process was repeated until the group reached consensus on three or fewer needs.[24]

After the capability need discussions and multi-voting, participants completed a post-meeting questionnaire asking them to rank each of the capability needs according to a set of criteria relevant to their utility and urgency. The data from these responses allowed the team to rank order the priorities in aggregate and provide insight into why each capability is deemed important.

Following the focus group meetings, the study group asked members of the First Responders Resource Group (FRRG) to complete a survey and rate all 37 capability needs ultimately identified through the interview and focus group processes according to how urgent of a priority they think each is, and to identify their top three priorities.[25] The study group used this subsequent evaluation and prioritization to gain broader perspective on the results from the focus group meetings.

Analysis of Related Technology and Standards

The final part of the PR5 methodology was high-level evaluation of available and emerging technologies, as well as standards and guidelines, which may impact the development of solutions to address the PR5 capability needs. Ongoing federal technology initiatives, such as the Next Generation First Responder Apex program and Responder Technology Alliance First Responder of the Future, are making advances in situational awareness and personal protection for responders. In addition, academic institutions and private industry continue to develop new products and technologies that will address responder capability needs. To avoid duplication of effort and leverage ongoing research, it is advantageous for the FRG to understand the state of technology related to the capability needs. As such, the study team conducted high-level research to identify existing and emerging technologies related to the PR5 capability needs. This research included interviews with subject matter experts and technology developers and review of open-source material and data available on the Internet. The study team created short technology summaries for each of the high priority needs, which can be found in the next section of this document as part of the discussion of each capability need.

Furthermore, standards and regulations can impact the design, testing, performance and certification of products or solutions being developed to improve the capability of

[24] Appendices F and G contain the prioritization framework (including pre- and post-meeting questionnaires) and analysis of the data derived from the prioritization processes.

[25] The FRRG is a multi-disciplinary group of over 100 emergency responders compiled to provide end-user input to DHS S&T.

emergency responders. These regulations and standards are in place to ensure minimum levels of protection, consistency in performance, uniform testing criteria and the safety of responders and the public. Compliance with these standards during technology development is critical because response agencies cannot use federal grant funds to purchase equipment that does not comply with existing standards. Technology that does not comply with existing standards will have a limited market. It is important that the FRG be aware of standards and regulations related to the PR5 capability needs as part of its funding decisions. In addition, it is worthwhile to identify where existing standards and regulations need to be written or updated to keep pace with emerging technologies. As such, the study team identified specific standards and regulations related to the PR5 capability needs, including existing standards and those being developed or revised. The team then assessed the standards and regulations to identify potential effects on technology development. A list of related standards follows each capability description in this document, and Appendix H contains a description of each relevant standard.

Participation

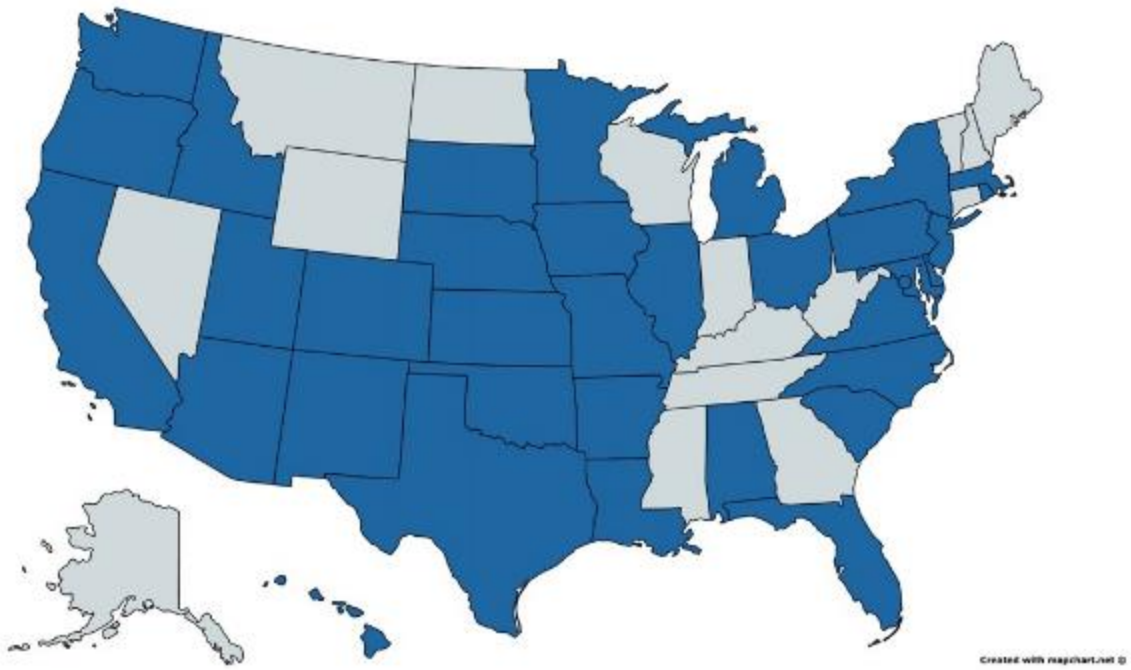

Figure 6. PR5 participation by state

As noted above, responder input is the foundation of the Project Responder process. In total, the study team conducted in-person interviews with 40 responders who played a significant role in response to many of the nation's large-scale incidents; assembled 35 responders during the focus group meetings to validate, discuss and prioritize the PR5 capability needs; and received input from 66 FRRG members to validate the prioritization of needs.[26] In total, over 120 responders from 34 states and the District of Columbia

[26] Appendix I contains a list of all responders that participated in PR5.

(represented in blue on the map above) participated in PR5 through one or more of these methods. Figure 6 illustrates the responder participation by state and Figure 7 illustrates participation by discipline.

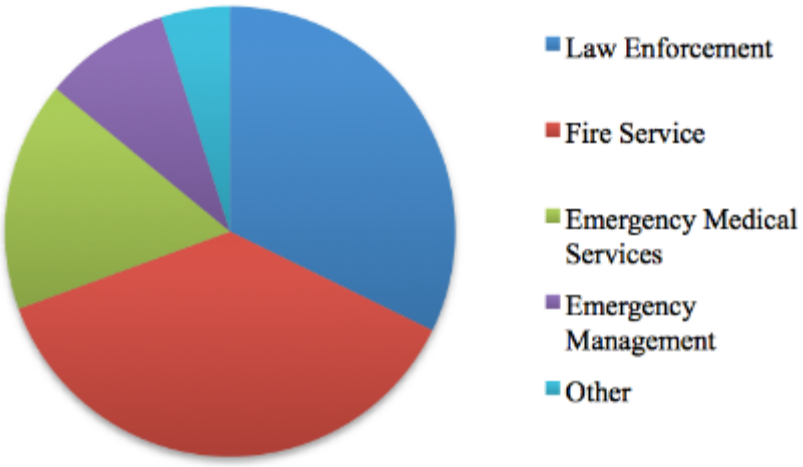

Figure 7. PR5 participation by discipline

Constraints

The original intent for the PR5 effort was to conduct one large workshop, bringing together emergency responders from across the nation to validate and prioritize the capability needs. The United States is diverse in geography and climate, which dictates distinct needs in different areas. For example, the capability needs of a jurisdiction in the Northeast may be different from those of a jurisdiction in the Southwest. Likewise, a locality with ample humidity may have different requirements than a jurisdiction with an arid climate. For that reason, it is ideal to validate the identified capability needs with a larger group of emergency responders to ensure that those needs represent common or universal requirements across disciplines and jurisdictions. All prior Project Responder iterations used a large multi-day workshop for this purpose, which was the intended design in PR5 as well. Ultimately, however, the timelines required for DHS conference approval significantly impacted the planned methodology for this effort. The study team chose to use four regionally diverse focus group meetings as a substitute for the one large workshop. Focus group meetings provide an adequate, but not ideal, alternative to the large workshop. The study team was concerned that the smaller number of participants discussing each need offers less opportunity for differing opinions. At the conclusion of the PR5 process, the study team believes that the capability needs described below accurately represent the needs of the emergency response community nationwide. However, future Project Responder efforts should try to assemble responders from across the United States to discuss and prioritize capability needs.

(This page intentionally left blank.)

PROJECT RESPONDER 5 CAPABILITY NEEDS

This section contains descriptions of each PR5 capability need. During the focus group meetings, diverse groups of emergency responders reviewed the draft capability needs. For a small number of the draft capability needs, the focus group participants determined that either the need did not represent a national-level gap or that the need was a subset of another. At the end of the focus group series, 37 capability gaps remained. Figure 8 below illustrates the PR5 capability needs by domain.

The 37 capability gaps are described below by domain. They are not listed in priority order. The study team analyzed the results of the multi-voting and prioritization exercises completed at the end of each focus group meeting as well as the national-level prioritization done by the FRRG. Based on those results, responders identified eight capability needs as the highest priorities that rise to the top among both the focus group participants and the national-level group. Those needs were:

> *The ability to quickly establish joint command between jurisdictions and agencies*
>
> *The ability to geolocate responders on the incident scene (indoors and outdoors) including latitude, longitude and altitude/depth*
>
> *The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation*
>
> *The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on the scene during response operations*
>
> *The ability to share incident-related information among agencies and disciplines during response operations*
>
> *The ability to merge and synthesize disparate data sources in real time to support situational awareness*
>
> *The ability to create actionable intelligence based on data and information from multiple sources*
>
> *The ability to access, integrate, share and display images and video pertinent to the incident scene for the responder and incident command*

Further detail on the results of the prioritization activities can be found in appendix F.

Each capability need description contains a brief summary of contextual information that describes the need, a list of goals articulated by the emergency responders that participated in the focus group meetings, a high-level description of the current state of technology and a list of standards or regulations (if applicable) that may impact technology development.

When possible, this section contains references to the incidents that were the focus of the PR5 research and interviews. Due to the non-attribution nature of the interviews, such

references will not be individually cited, even if derived from after action reports or other documentation. However, a full bibliography of all documents used during the research phase of this effort can be found in Appendix K.

The goals listed below describe the capabilities emergency responders believe necessary to safely and effectively respond to large-scale incidents. The goals should not be viewed as an “all or nothing” proposition. Responders involved throughout the PR5 process agreed that incremental advancement in technology was the ideal alternative to waiting multiple years for the development of all requirements.

Figure 8. PR5 capability needs

Situational Awareness

The Situational Awareness domain is defined as the capability to provide and distill specific knowledge concerning emerging threats, hazards and conditions in a timely fashion to support incident management decisions across all phases of incident response. There are seven capabilities in this domain:

- The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command
- The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth
- The ability to detect and identify threats and hazards on the incident scene
- The ability to generate maps for indoor and outdoor locations integrating incident data with existing geographic information system (GIS) data
- The ability to merge and synthesize disparate data sources in real time (e.g., known hazards, building blueprints, ownership records) to support situational awareness
- The ability to identify cascading effects of the incident that impact the response and/or the surrounding community
- The ability to obtain and maintain a bird's-eye view of the incident scene

Figure 9 below illustrates the PR5 Situational Awareness needs:

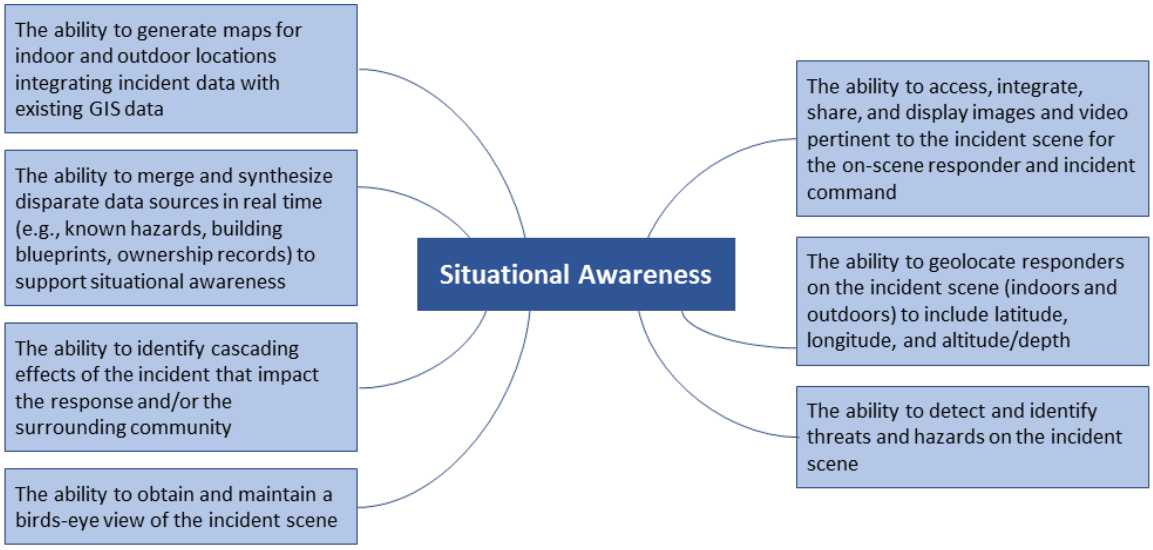

Figure 9. PR5 Situational Awareness capability needs

Each of the Situational Awareness capability needs is discussed below:

The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command

Video feeds and other types of imagery can augment real-time situational awareness with remarkable accuracy. The most immediate benefit to accessing the information provided by video feeds is enhanced situational awareness, which can allow for better and timelier decision making. However, video feeds and imagery allow for much longer-term benefits as well, including recording of events for after-action reporting and collection of visual evidence.

With live video feeds, on-scene responders and incident command are able to see critical events, including response actions, personnel and materiel resources and changes in the threat as they unfold. Responders envision the ability to track suspects as they move through crowds or large buildings, monitor visual hazards or obtain a first-person view of operations as responders complete their tasks. Had this capability been available during the Orlando club shooting, for example, responders may have been able to track the movement of the suspect through the building. Likewise, access to body-worn video by law enforcement officers surrounded by rioters in Baltimore may have led to different command decisions.

However, the number of live video streams can be overwhelming. There are numerous sources of images and videos that are currently available. Law enforcement worn body cameras, traffic cameras, privately controlled surveillance video and school camera footage all offer a wealth of video and imagery information. Each of these sources offers unique perspectives that can be more or less relevant given the situation.

Command staff and responders want the most wide-ranging ability to access all sources of video and determine what information they would like to extract, but there needs to be a mechanism to help select and sort the most relevant information. Responders engaged in an active response cannot simply stop what they are doing to watch video feeds or sort through imagery. Command staff may have more bandwidth to view video feeds; however, they are also constrained in their ability to consume vast amounts of information.

Finally, the actual hardware provided to responders to view this type of information cannot be added haphazardly to the already cumbersome number of items they are required to carry. Command staff can access video feeds or other imagery by more traditional means, such as computers or other stationary screens. However, responders in the field will not be able to view this information in the same manner and will need this capability to be seamlessly integrated into their discipline-specific response gear.

Goals

- Displays in multiple data layers that can be selected by the user
- Allows user to choose or toggle between images or video feeds
- Provides 360 degree field of view

- Accesses, transmits and displays images and video in real time
- Ingests data in multiple file formats
- Disseminates images and video via role-based permissions (i.e., task level and command)
- Allows multiple users to access and share images and video
- Includes mechanism to prevent information overload
- Accessible in a communications-degraded environment
- Provides visually relative orientation (points of reference)
- Encrypts or protects images and video feeds
- Ruggedized to operate in hazardous environments
- Integrates components (e.g., display device) into existing equipment
- Allows user to access video feeds immersively (i.e., first-person point of view) in three dimensions
- Functions with facial recognition or other biometric technologies

State of Technology

There are systems currently available that help monitor multiple sources of video. Video management systems (VMS) technology allows users to monitor multiple video feeds at once and enables mobile surveillance and communication. There are several examples of VMS being used to observe all types of incidents in real time so that an informed and coordinated response can occur quickly.

Several jurisdictions are successfully using video feeds from a variety of sources to manage emergency response. The Houston, Texas, Office of Emergency Management uses traffic cameras from four local and state transportation agencies in times of emergency. They also have access to additional camera feeds coming from Houston's public safety agencies, such as the city's Department of Public Works, the Port of Houston, and the Texas Medical Center.[27] Combined, their Emergency Operations Center (EOC) has "access to literally hundreds of live video feeds."[28] In Orlando, Florida, the city's EOC has access to a large network of cameras that allows staffers to monitor evacuation routes during hurricanes. Orlando is a primary destination for evacuees when hurricanes approach, so the Orlando EOC monitors traffic and public safety cameras as well as those

[27] "Wealth of Video Intelligence is an Exceptional Resource for EOC's," *Emergency Management*, posted June 30, 2015, http://www.emergencymgmt.com/safety/-Wealth-of-Video-Intelligence-Is-an-Exceptional-Resource-for-EOCs.html.

[28] Ibid.

operated by the Florida Department of Transportation on the state's Atlantic and Gulf coasts. This enables them to observe and anticipate traffic problems on the roads coming into their city. In Norfolk, Virginia, and New York City, live feeds from traffic cameras operated by transportation departments are vital in dealing with either human-driven incidents or environmental disasters such as hurricanes.

Video management systems are ideal for EOCs or command vehicles where responders can view multiple video screens at the same time. On-scene responders do not have this capability, and their video and image needs are more tactical in nature. For individual responders, portable technology similar to police officer body cameras exists, which can be applied and improved upon for incident response. For example, small devices that are attached to the body not only allow for voice communication but also feature real-time video, still images, voice recording and emergency alerting all in one.

The Defense Advanced Research Projects Agency (DARPA) Virtual Eye program provides advanced capabilities for visualization of the incident scene using live video feeds, including the location of known and potential threats. Responders can deploy a set of cameras via UAS or ground robot. The Virtual Eye software fuses the images into a live virtual scene, using extrapolation to fill in the missing pixels. Users get a continuous video feed that they can rotate around in real time, allowing them to gain situational awareness in spaces that are too dangerous to enter.[29] Virtual Eye does not require specialized cameras; the graphics processing unit, which fits on a laptop, stitches the images together.

However, an easily obtainable ability to access, integrate, share and display images with the responder requirements identified above is not currently available. Portions of this technology exist, but they need to be integrated and customized for use in emergency response.

Related Standards and Guidelines

- Association of Public-Safety Communications Officials (APCO) ANS 1.112.1-2014: Best Practices for the Use of Social Media in Public Safety Communications
- National Information Exchange Model (NIEM)

The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth

Geolocation of responders on the incident scene has been a highly prioritized capability gap in each iteration of Project Responder. This is a fundamental capability for ensuring responder safety during the incident, as well as accounting for their whereabouts at the conclusion of the event. Incident command staff in Dallas did not know that a self-

[29] "DARPA's 'Virtual Eye' lets soldiers see around obstacles," Engadget, posted June 24, 2016, https://www.engadget.com/2016/06/24/darpas-virtual-eye-lets-soldiers-see-around-obstacles/.

dispatched tactical team was approaching the parking garage as responders were neutralizing the threat inside with an explosive device. The ability for incident command to know the location of all responders on the incident scene is critical, especially when there is the potential for secondary devices or after-effects.

This capability is largely unavailable. Currently, responders may be visually tracked, able to use their radios to report position, or theoretically tracked using LMR devices equipped with global positioning system (GPS) transmitters. However, the capability that emergency responders believe is necessary would provide a graphic display of all responders on the incident scene. This information can be used to determine their proximity to threats and hazards, the relative position of responders for tasking or the location of responders in distress.

The goals listed below mirror many of the goals listed in the Project Responder 4 report. However, participants in the PR5 focus group meeting also expanded on those goals.

Goals

- Provides accurate geolocation of responders to within one to three feet for x, y and z coordinates
- Provides graphic display of the location of all responders on the incident scene
- Operates in hazardous outdoor environments and in remote areas
- Provides real-time and recurring transmission of responder location to incident command
- Integrates with graphic display of on-scene hazards and threats
- Integrates with three-dimensional display of buildings and structures to identify the room or specific area in which the responder is located
- Integrates with other information about the responder's condition (such as physiological data, personal alert safety system [PASS] alarm activation)
- Incorporates terrain data
- Integrates with GIS coordinates
- Integrates with common electronic situational awareness tools
- Made to be rugged, simple and transparent; users should not be able to turn them off

- Integrates transmitters into personal protective equipment (PPE) or other existing equipment with minimal or no net weight gain for the responder[30]
- Has suitable size, weight, and power (SWP) for responder operating conditions
- Assumes no prior knowledge of the environment (for example, no maps available or prior information about the building)
- Incorporates a confidence level to indicate the accuracy of location
- Affordable to outfit entire workforce
- Caches data when connectivity is offline and automatically forwards when connection is restored
- Functions across broad distances and remote places
- Functions in a communications-degraded environment
- Allows sharing of geolocation data across response agencies
- Disseminates data to incident command and on-scene responders

State of Technology

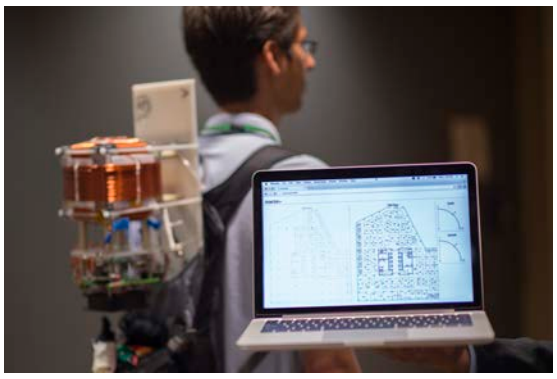

Figure 10. Recent POINTER demonstration

The DHS S&T Directorate has developed the Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders (POINTER). Utilizing low-frequency magnetic fields that can transmit through materials and obstructions, the POINTER sensor system enables accurate track positioning in the most diverse and complex environments. The electrically small magnetic field that is generated by POINTER does not lose energy as it passes through obstructions, enabling location to the exact floor in a building. First responders wear a small tracking device that relays a signal to receivers at a command unit.

Functionally, POINTER administers 3D location and motion tracking and works indoors, outdoors, below ground and underwater. It can also be applied to long-range situations or where line of sight is severely blocked, such as when individuals are located in mines or bunkers. POINTER is a significant technological advancement in the field of emergency

[30] PPE is defined here to include all garment layers and associated protective equipment (for example, a self-contained breathing apparatus) designed to provide body and respiratory protection for emergency responders.

response. It is currently in phase II of development, with a fully commercialized system scheduled for availability in 2017.[31]

DARPA has several programs to advance technology in positioning, navigation and timing:

- The Adaptable Navigation Systems (ANS) project is designed to leverage quantum physical properties to create extremely accurate inertial measurement devices that can operate for long periods without needing external data to determine time and position. Additionally, ANS seeks to exploit non-navigational electromagnetic signals—including commercial satellite, radio and television signals and even lightning strikes—to provide additional points of reference for positioning, navigation and timing. In combination, these various sources are much more abundant and have stronger signals than GPS, and so could provide position information in both GPS-denied and GPS-degraded environments.[32]

- The Microtechnology for Positioning, Navigation, and Timing program comprises a portfolio of diverse efforts collectively devoted to develop highly stable and precise chip-scale gyroscopes, clocks and complete integrated timing and inertial measurement devices. The self-calibrating, high-performance and cost-effective microscale sensors that DARPA is developing could offer tremendous size, weight and power improvements over existing sensors.[33]

There are also commercially available technologies that use positioning, navigation and timing tools in environments where GPS signals are weak or completely unavailable. These tools can be integrated with existing methods and leverage several sensors that help to determine individual locations, even during long periods of lacking GPS. While these tools are ideal for use in emergency response environments, they also tend to be cost prohibitive for most jurisdictions to procure.

Related Standards and Guidelines

- International Organization for Standardization/International Electrotechnical Commission Draft International Standard (ISO/IEC DIS) 18305: Real-time locating systems—Test and evaluation of localization and tracking systems

---

[31] "Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders," Department of Homeland Security Science and Technology Directorate, 2016, https://www.dhs.gov/sites/default/files/publications/Precision-Outdoor-and-Indoor-Navigation-and-Tracking-for-Emergency-Responders-Fact-Sheet-508.pdf.

[32] "Adaptable Navigation Systems," Defense Advanced Research Projects Agency, accessed October 21, 2016, http://www.darpa.mil/program/adaptable-navigation-systems.

[33] "Beyond GPS: 5 Next Generation Technologies for Positioning, Navigation, and Timing," Defense Advanced Research Projects Agency, July 24, 2014, http://www.darpa.mil/news-events/2014-07-24.

The ability to detect and identify threats and hazards on the incident scene

The ability to detect and identify threats and hazards on the incident scene is fundamental to responder safety and has been addressed in multiple iterations of Project Responder. However, many jurisdictions do not have the means to consistently accomplish this. In 2014, Project Responder 4 provided detailed information about this capability need, which was termed "Remote Monitoring of Threats and Hazards." Although the wording of this capability has changed slightly, the intent remains the same.[34]

There is a spectrum of possible threats that can be present at an incident. Even when the primary threat or hazard is quickly identified, several secondary threats may remain. For example, after the mudslide in Oso, Washington, the location of chemicals, propane tanks or even sewage tanks was not discernable. Responders searched through mud and debris containing multiple hazards and became aware of the hazard locations after serendipitously discovering them. Additionally, incidents such as chemical spills or explosions can cause secondary hazards such as a plume. The plume location and the movement projection need to be quickly ascertained to prevent further casualties and assist command in decision making.

There are also incident types, such as active shooters, when the threat can be extremely difficult to locate and isolate. Responders often do not know the ideal direction to evacuate people to safety, nor are they able to systematically work to contain the shooter. This makes operations to neutralize the threat very challenging.

Goals

- Detects hazardous agents in real time, including chemical, biological, radiological and explosive particles and signatures, within a set perimeter around response personnel
- Locates and tracks red forces[35]
- Identifies the specific agent or isotope
- Detects or measures other pertinent data (for example, oxygen displacement) that impacts hazardous conditions
- Measures the current concentration and records exposure over time
- Provides pertinent information, including modes of exposure and protective action information (for example, appropriate PPE, standoff distances, immediate treatments and decontamination requirements)

---

[34] *Project Responder 4: 2014 National Technology Plan for Emergency Response to Catastrophic Incidents,* (Washington: Department of Homeland Security, July 2014), https://www.dhs.gov/sites/default/files/publications/Project%20Responder%204_1.pdf.

[35] Red forces denote a specific threat or hazard and could be a person or persons (for example, active shooters or suspects), or an item such as a weapon or an explosive device.

- Generates automated alerts in multiple formats (e.g., audible, visible and tactile) when preset or site-specific thresholds have been reached
- Integrates with GIS coordinates
- Integrates with incident-specific maps
- Integrates with responder geolocation data
- Integrates components into PPE, communications devices or other daily equipment
- Affordably outfits entire workforce
- Relays information in real time to incident command, caches data when connectivity is offline and automatically forwards when connection is restored
- Integrates with common electronic situational awareness tools
- Deploys on multiple platforms (for example, manned and unmanned ground and aircraft systems, fixed and mobile)
- Is ruggedized to operate in hazardous conditions and intrinsically safe
- Identifies potential secondary devices or hazards
- Models potential hazards in real time (e.g., fire behavior analysis)
- Distinguishes between blue and red forces
- Determines structural stability in real time

State of Technology

Several platforms and tools currently exist for threat and hazard detection and identification. However, they are highly varied in affordability and function. Many basic approaches can be used to detect and identify threats. Camera feeds allow for visual identification of some types of threats, and simple alarms or handheld scanners can be used to detect others. There are also more sophisticated methods, including the use of robots and sensors, which collect vast amounts of data on very specific hazards. Additionally, modeling and tracking the dispersion of chemical, biological, radiological and nuclear agents is available to jurisdictions but can be plagued by the inability to resolve variations in models and to get the predictions as quickly as needed. Most of these technologies and corresponding issues were addressed in detail in the Project Responder 4 report.

However, these technologies also continue to advance and expand. For example, there have been advances in using acoustic footprints of threats, especially related to gunfire. There are commercially available technologies that can provide real-time data to dispatch and responders, through phones, computers and tablets, about the exact location of a firearm discharge. This information includes the number of shots fired as well as a precise location of the gunfire.

The DARPA Virtual Eye technology described above also has applications for this capability need. Virtual Eye allows responders to "walk" around a room virtually before entering. The fused multi-dimensional view could allow firefighters to see the location of downed victims or hot spots. Law enforcement officers would be able to see the position of a shooter or whether a room is booby-trapped.[36]

Although these advances represent significant progress in hazard and threat detection, there is still no standardized and affordable "toolbox" for responder use. There is extreme variation in what jurisdictions possess in terms of hazard detection and identification technologies. Most jurisdictions have a limited ability to perform this function because they are typically only focused on their most likely and frequently occurring threats. It is simply too cost-prohibitive to purchase and maintain threat- and hazard-specific detection and identification technologies for the wide range of possible incidents.

Related Standards and Guidelines: None applicable

The ability to generate maps for indoor and outdoor locations integrating incident data with existing GIS data

Incidents vary greatly in terms of location and size. Some incidents are broad and encompass vast square footage, while others may be very localized and contained within a single building. Regardless of size and location, precise and real-time maps are a critical part of incident response. In large incidents, it can be difficult to determine the extent of the damage. For example, tornados often inflict miles of damage and destroy infrastructure and directional signage. Therefore, it is not possible to use street signs or other common landmarks to denote the parameters of the incident. Similar issues exist in cases of widespread flooding when structures and landmarks may be underwater or have washed away. Even when responders are familiar with the response area or can use landmarks for orientation, those that augment the response during mutual aid may be completely unfamiliar with their surroundings and require assistance to safely navigate.

In smaller incidents, such as an active shooter in a building, responders may be unfamiliar with the layout of the building. They may be unable to quickly navigate the building layout to perform response actions. This would require near-real-time access to building blueprints, which are often not updated or provided to response agencies. Further, depending on the nature of the business or organization, it may be necessary for responders to recognize and understand what is stored inside the building and what could present additional threats to their safety.

In addition to the actual maps for indoor and outdoor locations, responders need a way to visualize other incident data on the map. It would be helpful for responders to be able to

[36] "DARPA Virtual Eye Lets Responders 'See' What They Can't See," NVIDIA, posted June 23, 2016, https://blogs.nvidia.com/blog/2016/06/23/darpa-virtual-eye/.

integrate individual sets of information, such as resource location, responder location and hazard specifics on the most accurate and real-time map of the incident site.

Goals

- Provides three-dimensional graphical depiction of incident scene
- Creates map in real time
- Provides map updates as situation evolves
- Allows user to view changes in incident scene over time; both historical and within the incident
- Integrates with digital images and video of the incident scene
- Provides spatially accurate representation
- Interfaces with existing data sources (e.g., building information modeling data or fire dynamics simulators) and common electronic situational awareness tools
- Ingests data in multiple file formats
- Integrates with responder geolocation and hazard data
- Integrates with digital building blueprints
- Integrates with indoor and outdoor infrastructure data (e.g., location of hydrants, gas lines)
- Displays data in layers

State of Technology

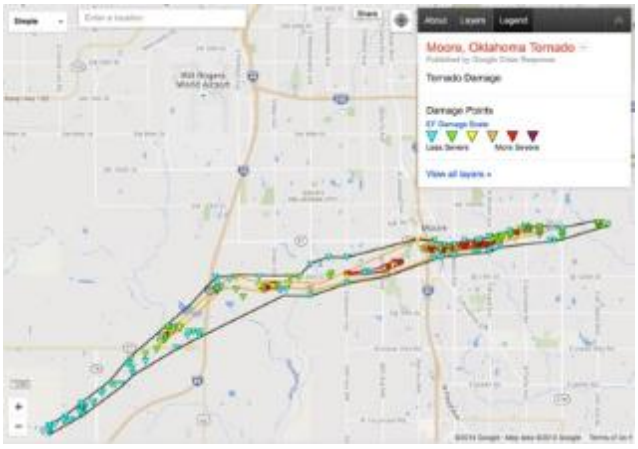

Figure 11. Google Crisis Map from 2013 Moore OK tornado

Several platforms and technologies currently exist that offer responders assistance in generating real-time outdoor and indoor maps with additional data layers. For example, Google Crisis Response is provided without cost through partnerships to government, non-profit organizations and commercial groups. The suite of tools offers several emergency management specific support tools, including Google Crisis Map, which displays geographic and incident specific data in customizable data layers. It

also allows responders to contribute to the data owned by Google to enhance and update the maps. These maps are easily shared or embedded on response websites, and the data layers can be managed in real time to add or subtract details. Crisis Map has open-source code to allow for maps to be hosted on various app engines, and the maps are formatted for use on multiple devices. However, Google Crisis Map is currently focused on use in natural disasters only.[37]

Other systems such as Active911 generate maps based on incident coordinates. Active911 includes mapping and routing, as well as displaying the live position of responders in real time (using device GPS for location data). It also integrates additional map layers that depict the location of custom data, including hydrant locations, staging locations, etc.[38]

There is also a suite of technologies that uses crowdsourcing combined with GIS information to develop real-time navigational maps. The maps include multiple data layers that visually represent additional information, such as car accidents, road closures and location of law enforcement officers. One of these applications is Waze. Waze has already been used in incident responses through a program called the Connected Citizen Program. This program is a free data exchange program between Waze and government entities and integrates with jurisdictions' current platforms. Waze helps responders get advance notice of road closures, traffic and other issues that could impact ingress, egress and responder safety.[39]

One commercially available product virtually fuses multiple live data streams in real time on a single map. Data sources that can be integrated include databases, weather, live video, social media, GPS trackers and more. The system includes an interactive timeline, allowing users to view historical or live data. The location of assets and personnel can be displayed on-scene, and users can add shapes or markers to the map view. Features include the ability to import three-dimensional shapes, measurement and projection tools and the ability to export and share map images. The system was originally developed for U.S. warfighters and Special Operations forces.

Related Standards and Guidelines:

- NIEM
- EDXL-DE-V2.0: Emergency Data Exchange Language (EDXL) Distribution Element, v. 2.0

---

[37] "Crisis Map," Google, accessed October 24, 2016, https://sites.google.com/site/geomedialab/crisis-response.

[38] "Active911," Active911, accessed October 12, 2016, http://active911.com/assets/active911_overview.pdf.

[39] "Connected Citizens by Waze," Waze, accessed October 24, 2016, https://docs.google.com/gview?url=https%3A%2F%2Fs3-eu-west-1.amazonaws.com%2Fwaze-partner-assets%2FCCPFactSheet.pdf.

The ability to merge and synthesize disparate data sources in real time (e.g., known hazards, building blueprints and ownership records) to support situational awareness

Responders are often inundated with large amounts of incident data. Maps, hazard information, live video feeds, social media and witness reports are just a few of the many sources of real-time information that responders may collect, analyze and turn into actionable intelligence or use to direct response actions. This can be overwhelming and extremely time consuming for responders. For example, during an active shooter incident, one jurisdiction reported that its Twitter feed was scrolling so fast that it was impossible to visually isolate even a single tweet. Twitter was only one of the many sources providing information about the incident; command staff was also using eyewitness reports, video feeds and a jurisdiction-specific application that citizens use to report emergency information.

In addition to data that are being "pushed" to responders, they may also request or "pull" specific data. Building blueprints, ownership records and locations of known hazards are often requested to aid in situational awareness and decision making. These data add to the overwhelming volume of information and increase the difficulty of analysis.

Further, data formats can vary widely. For example, tweets are text rich, video feeds contain visual data, images may have metadata and eyewitness reports can be transcribed from audio reports. Even data that are in the same format, such as text, can be problematic. Some information is represented as a number, such as numbers of citizens in a specific zip code, and can be very difficult to integrate with narrative text to provide a comprehensive situational awareness capability. In addition to data format issues, different locations and jurisdictions use different equipment, which presents compatibility issues with displaying the data easily and readily.

Given these challenges, responders need a user-friendly platform for disparate data collection, integration and analysis. This is essential to increasing situational awareness and supporting real-time response decision making. Also, given the amount of available data, jurisdictions need the ability to customize information to their exact needs and discipline-specific requirements. This will help to filter the most relevant data for incident response.

Goals

- Integrates data from disparate sources (e.g., jurisdiction- and agency-specific data, social media feeds and commercial data)
- Ingests data in multiple file formats
- Ingests data sources in real time
- Maintains open-standard format for outputs
- Displays data in layers

- Allows customization of data visualization
- Allows user queries of data
- Includes ability to filter data and customize filter criteria
- Includes ability to compare data across time (historical and incident-specific)
- Generates outputs that are immediately usable by responders
- Generates outputs in real time
- Integrates with incident-specific maps
- Integrates with responder geolocation data
- Easy to use and navigate between data layers
- Integrates with existing records management, dispatch, and incident management software systems
- Allows off-line access
- Includes ability to back up outputs

State of Technology

There are commercially available technologies that provide some of the functionality that responders require. One example is an incident and emergency management tool that is customized for both daily use and actual crisis response. It creates a common operating picture (COP) for emergency responders by integrating and analyzing several types of data from varied sources. This tool can correlate geospatial and operational information to provide holistic situational awareness to responders. In addition to providing data storage and analysis, it is also capable of identifying issues and providing prompts on determining the best course of action for responders. Furthermore, this tool helps responders explain and predict outcomes that result from their operational decisions in real time.

Another commercially available technology performs data integration to enhance situational awareness. It is capable of tracking a responder's position and automatically routing vehicles. Using the jurisdiction's GIS-enabled maps, it automatically displays the closest pre-incident plans and building information, such as blueprints and other pre-planning drawings. The software adds layers to display other hazards or landmarks, such as sewage and power lines and hydrants. It can be customized to provide guidance based on the data collected and preprogrammed operating guidelines.

Though some fairly robust commercially available tools are available, there is no current technology that supports all of the responder needs. This is a rapidly advancing field with continual enhancement to technologies.

Related Standards and Guidelines

- EDXL-DE-V2.0: Emergency Data Exchange Language (EDXL) Distribution Element, v. 2.0

The ability to identify cascading effects of the incident that impact the response and/or the surrounding community

The planning process allows responders to anticipate potential second- and third-order effects resulting from an incident. For example, hurricanes generate strong winds that may damage or destroy utility equipment, leaving many without power. They also cause flooding, destroying buildings and leaving people trapped or in need of shelter. With pre-planning, many of these cascading effects can be estimated before an incident occurs.

Many incident-specific characteristics cannot be determined during planning, but they can significantly affect response operations. Responders need the ability to generate accurate forecasts and models in real time that address incident-specific variables. Responders at the Oso, Washington, mudslide were concerned about secondary slides, which would endanger the responders and volunteers conducting search operations. The ability to know where new slides might occur, given the new topography of the terrain after the initial slide, would provide increased situational awareness and improve responder safety. Likewise, if responders had more accurate models of which areas are likely to flood and which roads and bridges are likely to fail given incident-specific data, they would have better ability to evacuate residents, restrict movement, and direct operations to critical locations.

This capability is not limited to natural disasters. Responders at mass shooting events would like models that indicate potential outcomes based on alternate entry or evacuation routes. Likewise, responders involved in riot events are interested in how the crowd might be contained or dispersed given alternate perimeter locations. Historical data about incident response as well as responder experience allows responders to anticipate cascading events in certain types of incidents. Additionally, predictive modeling capabilities can help responders determine effects from many natural and man-made incidents. Federal modeling capabilities described in the Project Responder 4 report continue to provide models and projections for the response community, including the National Hurricane Center track and intensity models and Interagency Modeling and Atmospheric Assessment Center products.[40]

Addressing this challenge requires the ability to model outcomes for several types of cascading events. Responders need a very complex understanding of the impacts of a disaster. Some cascading events may be fairly straightforward to determine, such as the need to order an evacuation in the case of a hurricane. However, other resulting impacts

[40] *Project Responder 4*

may be much more difficult to estimate, such as potential locations for secondary devices.

Goals

- Calculates incident-specific secondary effects
- Allows user to modify input data
- Projects consequences of secondary effects (e.g., if flood waters inundate a selected area, x, y and z roads and bridges will be impacted)
- Allows user to compare alternate outcomes
- Integrates multiple modeling inputs
- Integrates real-time sensor data
- Provides decision-support prompts
- Integrates with incident-specific maps
- Integrates data layers (e.g., infrastructure)
- Allows user to designate geographical boundaries

State of Technology

Tools with the ability to generate real-time models incorporating incident-specific data are in use and being further developed in a number of areas. Real-time dynamic flood inundation mapping, in development by the U.S. Geological Survey (USGS), uses a library of flood inundation maps, in conjunction with USGS real-time data from streamgages and National Weather Service flood forecasts. Advanced models create flood maps for current flood areas and an advanced flooding forecast for up to five days.[41] The application is experimental and not publicly available, but it could produce significant improvement in situational awareness for hurricanes, severe storms and snowmelt flood incidents.

Figure 12. Inundation map generated by experimental mapping application

[41] "Emerging Technologies," U.S. Geological Survey, last modified February 10, 2016, http://water.usgs.gov/osw/flood_inundation/science/emerging-tech.html.

Federal and state transportation departments use models to estimate congestion impacts or secondary crashes. Responders use incident-specific analytical tools to predict delay impacts, capacity reduction, the likelihood of secondary incidents and the duration of the incident.[42] The ideal is for traffic management centers to be able to use real-time traffic data, project delays, and communicate that information to travelers and employ control measures to mitigate issues. However, many state-of-the-art models are still in development and others rely on default general traffic assumptions (e.g., human behavior and road availability), which may be different during a disaster.

Another area in which models include real-time incident-specific data is fire behavior modeling. Anticipating the movement of a wildland fire requires an understanding of terrain, fuels and winds in the area of the fire. However, relying on estimates or external measures of wind is not sufficient because a large fire "alters local weather, creating winds within the fire that may be more than 10 times stronger than those outside. These internal winds can contribute to potentially deadly accelerations, increases in intensity, unexpected shifts in direction, or splits in which the flames go in multiple directions."[43] The National Center for Atmospheric Research, a federally funded research and development center sponsored by the National Science Foundation, is developing the Coupled Atmosphere-Wildland Fire Environment model to accurately predict the course of a fire over one to two days. The model is currently being field tested.

Related Standards and Guidelines: None applicable

The ability to obtain and maintain a birds-eye view of the incident scene

A birds-eye view is typically achieved from an elevated position, also referred to as an aerial view. This type of perspective provides a unique ability to see large, or complete, portions of the incident. It also allows for responders to see damage in the full context of the entire incident, rather than in the disjointed sections often provided when viewing the scene at ground level. It is often difficult for incident commanders to obtain this aerial view as fixed- and rotary-wing aircraft may not be able to take off because of conditions in the area or air assets may be stationed at a considerable distance from the scene. These aerial views can provide situational awareness of the entire incident scene and allow for the most efficient response. Most importantly, however, this ability could significantly increase the safety of responders and the ability of incident command to make key decisions.

Responders believe that a technology already exists for this gap in capability. Aerial views are most easily achieved by using a UAS, often referred to as a drone. In some

[42] "Analysis, Modeling, and Simulation for Traffic Incident Management Applications," U.S. Department of Transportation, Federal Highway Administration, last modified October 20, 2015, http://www.ops.fhwa.dot.gov/publications/fhwahop12045/2_synth.htm.

[43] "NCAR to Develop Wildland Fire Prediction System for Colorado," National Center for Atmospheric Research, December 9, 2015, http://www2.ucar.edu/atmosnews/news/18317/ncar-develop-wildland-fire-prediction-system-for-colorado.

cases, UAS have been used with great success in emergency settings. Some locations have used camera-equipped UAS to assist in locating missing persons and to help fire-fighters survey burning buildings prior to entry. While their benefits are indisputable, there have been significant obstacles inhibiting the use of UAS by most jurisdictions. The Federal Aviation Administration (FAA) requires all government entities to obtain a COA (Certificates of Waiver or Authorization) for public UAS operations.[44] Previously, COAs were difficult to acquire and entailed restrictions for use, even in the realm of emergency response. In June 2016, the FAA released a set of rules (Part 107) governing the commercial use of small UAS (defined as small unmanned aircraft weighing less than 55 pounds).[45] Part 107 rules do not apply to public UAS, but jurisdictions have the option to register as a civil aircraft and waive the COA. In July 2016, Congress passed additional UAS legislation that includes provisions related to emergency response.[46]

However, restrictions still hinder use of UAS. The FAA restricts airspace near airports and other facilities. UAS are not permitted to operate in these areas without receiving approval and establishing communications with the proper controlling agencies and towers in advance of operations. This is especially problematic in cities that have multiple airports with large portions of restricted air space encompassing large areas within their jurisdiction.

Goals

- Provides aerial view for duration ranging from 20 minutes (tactical) to 12 hours or more (strategic)
- Transmits data in real time
- Encrypts or protects data during transmission
- Captures video: 720-degree, high-definition, zoomable, remote camera control
- Captures still images
- Provides multiple camera options (e.g., infrared)
- Carries modular payloads, including threat, hazard and biometric sensors, lighting and communications equipment
- Integrates data feeds when new system is rotated into operation to maintain a continuous picture of the scene for as long as needed

---

[44] "Know Before You Fly," Know Before You Fly, accessed October 24, 2016, http://knowbeforeyoufly.org/for-public-entities/.

[45] Fact Sheet, FAA, "Fact Sheet – Small Unmanned Aircraft Regulations (Part 107)," June 21, 2016, https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20516.

[46] FAA Extension, Safety, and Security Act of 2016, Pub. L. No. 114-190 (2016).

- Is readily identifiable to aircraft
- Operates in covert or highly visible mode
- Deploys within 20 minutes or less, based on capability
- Incorporates interchangeable battery system
- Deploys in all weather conditions
- Poses low risk to operators, responders and civilians
- Caches data when connectivity is offline, and automatically forwards when connection is restored
- Operates in confined spaces, indoors and outdoors
- Calculates measurements between objects using video and image data (photogrammetry)

State of Technology

UAS are widely available and incorporate advanced technology. Simple platforms that capture live video as well as GPS data are affordable and sold by a number of national retailers. They offer a range of sizes and customizable features such as nighttime flying and different control options. However, because they are designed for consumers or hobbyists, many do not provide much of the operational capability that responders need.

Figure 13. Customs and Border Protection UAS

UAS that have significantly more capability are used throughout the Department of Defense (DoD) and in certain components of DHS. In addition to video, these UAS are equipped with multiple sensors for hazard detection and communication nodes. These UAS can address all responder requirements. However, they tend to be cost-prohibitive to local governments. For example, one class of UAS, the MQ-9 Reaper (formerly referred to as Predator B), can cost over $10 million per unit.

As the technology underpinning UAS continues to improve, it has given way to small UAS, which allows for increased capability on smaller airframes. However, these technologies can be costly as well, and given the number of competing resource needs for responders, it may be difficult to justify the purchase of a UAS. Therefore, while mature UAS technologies exist, responders must overcome policy and affordability issues to make this tool routinely available for incident response.

Related Standards and Guidelines

- Small Unmanned Aircraft Rule (Part 107)

Communications and Information Sharing

The second of nine capability domains, Communications and Information Sharing, is defined as the ability to access, integrate and display images and video from the incident scene (for the on-scene responder and incident command). There are four capabilities in this domain:

- The ability to effectively communicate in the presence of loud ambient noise
- The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations
- The ability to facilitate the management of communications channels and frequencies among multiple disciplines
- The ability to share incident-related information among agencies and disciplines during response operations

Figure 14 below illustrates the PR5 Communications and Information Sharing needs:

Figure 14. PR5 Communications and Information Sharing capability needs

Each of the Communications and Information Sharing capability needs is discussed below:

The ability to effectively communicate in the presence of loud ambient noise

Sounds or noise intrinsic to the incident scene can significantly hinder the ability of responders to receive or transmit messages using radio systems or smartphones. Accounts from Orlando, Florida, San Bernardino, California, and Aurora, Colorado, specifically mentioned the problems caused by loud fire alarms that impacted communications. During the response to the Aurora, Colorado, theater shooting, the movie, with its surround-sound audio track, continued to play. Cellular phones of on-scene casualties (living and deceased) continued to ring as loved ones tried to make contact. It is not uncommon for emergency sirens to continue to sound during tornado or hurricane response. There is also the sound of victims, screaming in pain or yelling to alert responders that they are in need of treatment. During response operations, the sounds of pneumatic tools, generators, chain saws and other equipment degrade the ability of

responders to communicate effectively. Acoustic tube earpieces and facepiece-integrated communications capability address this gap to some extent, although both have shortfalls. Responders require the ability to hear and convey messages regardless of the sounds on the incident scene.

Goals

- Neutralizes the effects of sound, regardless of proximity, decibel or frequency
- Provides multi-sensory (i.e., visual and haptic) communications
- Integrates with existing (e.g., facepiece and eyewear) or future (e.g., heads-up display) PPE and equipment
- Integrates voice-to-talk functionality
- Allows seamless transition between devices and configurations
- Allows user configuration and customization

State of Technology

Both conventional and Special Operations forces within the DoD currently use communication interfaces integrated with their PPE that are designed to facilitate better communication in the presence of ambient noise. Such systems enable clear radio and/or intercom communications with benefits for the user that include lightweight construction, hearing protection, PPE integration and noise-cancelling features. Many have the option of an unobtrusive bone-conduction microphone.

The Public Safety Communications Research (PSCR) program conducts research, development, testing and evaluation to foster nationwide communications interoperability. PSCR's Audio Quality project is working with responders to develop and implement tests that measure how digital radios and other communication system components operate in the presence of loud background noise. PSCR is working to mitigate this problem in current systems and is guiding technology choices to prevent this problem in future systems.[47]

Additional advancements in wearable technology may also increase responders' situational awareness and communications capability through successful integration with PPE. Displaying visual information on a heads-up display or in eyewear may reduce the amount of information that needs to be communicated verbally. These types of displays are already integrated into the facepiece of self-contained breathing apparatus (SCBA), and display information and communications. Continued advancement of these technologies, as well as expansion to other disciplines may decrease the amount of communications that need to be verbally transmitted on the incident scene. However,

[47] "Public Safety Audio Quality," Public Safety Communications Research Program, 2016, http://www.pscr.gov/projects/testing_evaluation/audio_quality/pscr_audio_quality_research.pdf.

additional information streams and notifications must not reduce situational awareness or prove distracting to the responder because that could compromise their safety or the safety of others.[48]

Related Standards and Guidelines: None applicable

The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations

Public safety dispatchers receive calls from the public when assistance is needed from fire service, law enforcement or EMS personnel. Using computer-aided dispatch (CAD) software systems, the dispatchers identify the nearest available units and assign them as needed to respond. Dispatchers generally assign personnel resources at the apparatus or vehicle level, but can assign individual responders, especially for law enforcement. Larger incidents require more resources and dispatchers are often responsible for notifying off-duty personnel that they have been called to duty or requesting mutual aid from other jurisdictions.

In smaller jurisdictions, one agency is often responsible for dispatching units to fire, law enforcement and medical calls. Larger cities frequently have different dispatch centers for discipline-specific calls (e.g., one dispatch center addresses all calls for fire suppression, another for calls requesting police assistance). On a daily basis, these dispatch centers usually work well together. The potential for communication breakdowns between dispatch centers within the same jurisdiction or between different jurisdictions arises during large-scale incident response. For example, data from the Aurora, Colorado, theater shooting shows missed and broken communication between fire and law enforcement dispatchers. Similar phenomena occurred in other incidents, caused by breakdowns in procedure and CAD systems that do not interoperate to produce a comprehensive COP for dispatch functions and notifications.

In and of itself, this capability need does not require a unique technology solution. The issue of data integration is addressed in a separate capability gap description.[49] However, those in the public safety community continue to cite the ability to coordinate dispatch functions across jurisdictions and agencies as an area that needs improvement. Although bridging technologies exist to increase the ability to share information, the process of facilitating information sharing and the coordination of that effort remain problematic. PR5 participants agreed that this critical capability should be developed through updated procedures that are frequently exercised.

---

[48] TF Sanquist, MP Baucum, and BR Brisbois, *Attention and Situational Awareness in First Responder Operations, Guidance for the Design and Use of Wearable and Mobile Technologies*, prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, http://nwrtc.pnnl.gov/PDFs/RTAs/RTA_Situational_Awareness.pdf.

[49] For more information, see the discussion of "The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident-specific response."

Related Standards and Guidelines

- NIEM

The ability to facilitate the management of communications channels and frequencies among multiple disciplines

Modern radio systems, in use by many response agencies, provide multi-band functionality and can offer thousands of channels in each portable radio. Response agencies can program channels to interoperate with other disciplines and agencies. For example, a fire service can allocate a set number of channels that are integrated with the radio system of the local police department and other local or regional fire departments. Despite the availability of the frequency bands and channels, the full functionality of these systems is rarely used. In fact, command staff in one major city regularly carries two, and sometimes three, different radios at the same time to separate different types of communications. This practice is not uncommon. Further, agencies frequently do not pre-program the interoperable channels or use them on a daily basis. The result is reliance on a small number of channels during a large-scale incident response. Responders who participated in some of the PR5 incidents reported that they often defaulted to one to three channels during the most intense response operations. This degraded the ability for different agencies and jurisdictions to communicate, share information and work together. Further, when everyone is working on the same limited number of channels, the channels become overloaded quickly as many responders try to transmit information of variable subject, type and priority.

The most common solution for this problem is to position a responder from one discipline (e.g., fire service) with a radio next to a person from another discipline (e.g., law enforcement) and have them share information. The problem is that this introduces a significant point of failure if information is not fully or correctly conveyed. Responders need procedures and training to effectively use the technology that is available to them, as well as technology that will streamline or support the use of those radios.

Goals

- Assigns channels automatically, based on role and user
- Switches users to assigned channel remotely, including notification and ability to refuse switch before it occurs (e.g., “all members of tactical team will be switched to channel X for task-related communications”)
- Does not preclude user switch to other channels as necessary
- Provides audible alert to confirm the switch was successful
- Provides automatic divert and channel restriction override for emergency communications
- Provides over-the-air programming of new channels

- Provides list or graphic display of responders not actively using the assigned channel
- Allows direct communications with responders not actively using the assigned channel
- Automates functions that traditionally require voice communications (e.g., roll call)

State of Technology

This gap can be partially attributed to the disparity between older radio systems used by many jurisdictions and the advanced technology used in others. Many communities lack systems that can operate on different frequency bands or be programmed to interoperate with other agencies. To address this issue, the Radio Internet-Protocol Communications Module (RIC-M) was developed as a radio interoperability solution by DHS S&T.[50] RIC-M is an interface device that, regardless of equipment brand, connects radio frequency (RF) system base stations, consoles and other RF equipment. RIC-M facilitates these connections over the Internet or a private Internet protocol bridge. The technology converts a commonly used V.24 serial communications protocol to an open-standard Voice-over-Internet–Protocol (VoIP), while supporting both encrypted and unencrypted Project 25 (P25) digital communications. By upgrading legacy systems, responders can communicate across jurisdictions regardless of proprietary differences between equipment manufactures.[51] The RIC-M upgrade allows local, state and federal responders to stay connected with their legacy systems, via a low-cost upgrade, instead of having to replace base stations with newer models.

However, this issue is not solely a function of outdated technology. State-of-the-art radio systems have tri-band functionality (supporting VHF, UHF and 700/800mHZ frequencies) and feature thousands of distinct channels. Many jurisdictions, especially large cities, use these advanced systems. Responders want added functionality that augments the technical features and makes them easier to use. Many of the goals listed above are not available in land mobile radio systems or smartphone devices.

Related Standards and Guidelines

- Project 25 (P25) Technology Interest Group Standards

---

[50] "S&T's Interoperable Solution Makes It Easier and Cheaper for First Responders to Communicate," U.S. Department of Homeland Security, release date Jan. 6, 2015, https://www.dhs.gov/science-and-technology/can-you-hear-me-now.

[51] "Radio Internet-Protocol Communications Module," Department of Homeland Security, Science and Technology Directorate, last updated May, 26, 2016, https://www.dhs.gov/sites/default/files/publications/Radio-Internet-Protocol-Communications-Module_SLUpdate-160526v2-508.pdf.

The ability to share incident-related information among agencies and disciplines during response operations

This is a general capability need that reflects the difficulties regularly encountered in sharing incident-critical information within and among agencies and jurisdictions. During one of the incidents studied for PR5, responders from one discipline obtained early sensor readings indicating there was no radiological contamination at the scene. Unfortunately, because this was "good news," commanders failed to communicate this within their own department, with other disciplines or with the hospital systems. This caused significant worry on the part of individual responders and hospital staff. Responders in other incidents cited reticence to share information between levels of government or agencies because of "need to know" policies. However, this is a not just a policy issue; it includes training and technology. Responders want to be able to share resource information, operational plans, threat and hazard data and other information to have a COP for integrated response.

Goals

- Ingests data in multiple file formats
- Disseminates data based on role-based permissions (i.e., task level and command)
- Integrates with GIS coordinates
- Integrates with common electronic situational awareness tools
- Generates automated alerts in multiple formats (e.g., audible, visible and tactile)
- Integrates with incident-specific maps
- Displays data in layers
- Ingests data sources in real time
- Maintains open standard format for outputs
- Allows customization of data visualization
- Allows customization based on jurisdiction-, incident- and role-based variables
- Can be scaled for daily use and large-scale incident response
- Creates data layer for integration into incident management and situational awareness products
- Functions on multiple operating systems (e.g., iOS, Android and Windows)
- Allows on-scene and off-line access
- Displays standardized public safety icons

- Encrypts data

State of Technology

DHS S&T developed the Next-Generation Incident Command System (NICS) as a collaborative information-sharing tool for responders. NICS is described as "an online incident map, with a virtual whiteboard that allows responders to collaborate, pool resources and plot strategies."[52] NICS manages and maintains real-time feeds for decision makers, which are integrated as part of the online map using geographic data. Credentialed responders can add data, make designations on the map or type a message. These features allow for a "higher command view" of incidents, which facilitates greater degrees of coordination and communication. DHS released NICS for public use in August 2016.[53]

DHS also maintains the Homeland Security Information Network (HSIN), which is available to federal, state and local government agencies to share information among users. HSIN tools include a virtual meeting space, document sharing, alerts and instant messaging.[54]

DoD also uses software technologies to visualize the battlefield and plan the mission through a collaborative workspace. Through the Command Post of the Future program, users can see the terrain in context and manipulate data, customize activity and share work in real time across applications and among multiple collaborators.[55]

Related Standards and Guidelines

- EDXL-DE-V2.0: EDXL Distribution Element, v. 2.0
- Common Alerting Protocol (CAP), v. 1.2
- Global Justice XML Data Model (JXDM)
- NIEM

---

[52] "Next Generation Incident Command System-NICS," DHS S&T, https://www.dhs.gov/sites/default/files/publications/Next%20Generation%20Incident%20Command%20System-NICS_0.pdf.

[53] News Release, DHS S&T, "NICS, A communication Platform For First Responders, Now Available Worldwide" (August 8, 2016), https://www.dhs.gov/science-and-technology/news/2016/08/08/news-release-nics-communication-platform-first-responders-now.

[54] "Homeland Security Information Network," DHS, accessed October 21, 2016, https://www.dhs.gov/homeland-security-information-network-hsin.

[55] "Command Post of the Future (CPOF)," General Dynamics Mission Systems, accessed October 21, 2016, https://gdmissionsystems.com/c4isr/cpof/.

Command, Control and Coordination

Command, Control and Coordination is the ability to identify incident priorities, allocate scarce resources and exchange relevant information to make effective decisions in a stressful environment. There are three capabilities in this domain:

- The ability to provide decision-support templates and prompts during incident operations
- The ability to electronically document and track command decisions, actions and assignments during response operations
- The ability to quickly establish joint command between jurisdictions and agencies

Figure 15 below illustrates the PR5 Communications and Information Sharing needs:

Figure 15. PR5 Command, Control and Coordination capability needs

Each of the Command, Control and Coordination capability needs is discussed below:

The ability to provide decision support templates and prompts during incident operations

Some types of incidents, such as active shooters, unfold very quickly. In these types of situations, incident commanders must make numerous decisions in rapid succession. Often they have to make new decisions without fully being aware of the outcome of previous decisions. Under these conditions, even the most experienced incident commanders can become overwhelmed and fail to consider all possible variables in decision-making. To resolve this, incident commanders require the assistance of pre-scripted decision support templates and prompts. Decision support tools help emergency responders make decisions based on the level of risk involved.

In some jurisdictions, the dispatcher provides prompts to the incident commanders. However, this approach is not without issues. Dispatch does not always know exactly what has been accomplished and what is occurring in real time. This is a product of the time and speed of unfolding events. Therefore, dispatch cannot always provide the best and most relevant prompts to the incident commanders.

Additionally, some jurisdictions have CAD systems that can provide simple analysis and informational statistics, such as how long it takes units to arrive on the scene. While this information can be helpful in decision making, it is often too delayed to be useful in rapidly evolving events.

Goals

- Provides audible and visual prompts
- Is available in command vehicles and in the field
- Allows customization based on jurisdiction-, incident- and role-based variables
- Produces outputs electronically and in print
- Allows ability to import audible and text prompts for customization
- Incorporates "snooze" and "delete" features
- Protects data and communications

State of Technology

There is a wide range of solutions to assist responders with decision templates and prompts. The most basic approach, which is not technologically driven, is pre-developed templates for possible incident scenarios that could be easily accessed by an incident commander when needed. This concept is similar to the FBI Bomb Program: Bomb Threat Call Checklist (which has been adapted by DHS to develop Bomb Threat Call Procedures).[56] This checklist helps a person to calmly obtain key pieces of information in a crisis situation. These checklists can be printed or accessed electronically for ease of use in the field.

Another example of pre-developed templates is the U.S. Coast Guard incident handbook. This handbook does not provide specific response steps but provides assistance on how to best use the NIMS Incident Command System (ICS) during response operations. Essentially, this handbook is a "job aid" that provides guidance, samples and thoughts for consideration in incident response.[57]

From a technology perspective, DARPA's ongoing Resilient Synchronized Planning and Assessment for the Contested Environment (RSPACE) is developing software decision aids that will help operators manage daily operations, including composing mission packages, responding to emerging opportunities and assessing progress toward achieving

---

[56] "Bomb Threat Call Procedures," Department of Homeland Security, accessed October 24, 2016, https://emilms.fema.gov/is906/assets/ocso-bomb_threat_samepage-brochure.pdf.

[57] *U.S. Coast Guard Incident Management Handbook*, COMDTPUB P3120.17B, (Washington: Department of Homeland Security, May 2014), https://www.uscg.mil/d9/D9Response/docs/USCG%20IMH%202014%20COMDTPUB%20P3120.17B.pdf

the commander's intent.[58] Through a similar effort, the Distributed Battle Management program, DARPA is developing automated decision aid for combat missions.[59] Although both of these programs are focused on military operations, the resulting products may be adapted to public safety operations.

There is also commercially available technology in the incident response field that uses information from an integrated COP, comprising geospatial and operational data, to identify potential issues and provide prompts to incident commanders. These prompts assist responders in decision making as well as determining the likely outcome of key operational decisions. Other commercially available technology quickly sorts information and provides incident-specific guidance on hazard type and the impact of that particular hazard on specific response roles. The list of hazardous situations that the system provides guidance for includes fire, crime, medical, search and rescue and natural disasters. Guidance is provided in the form of checklists and includes federally mandated procedures.

There are also technologies in other fields that could be further developed and transitioned to emergency responders. In the medical field, there is a suite of technologies, called assistive technologies. One product has a microprocessor that stores data, which can be downloaded via a telecommunication network. The device features an alarm and liquid crystal display screen that are used to prompt patients and doctors to perform certain functions at certain times. Furthermore, new information and protocols can be uploaded to the device for different scenarios and quickly changing environments.

Related Standards and Guidelines: None applicable

The ability to electronically document and track command decisions, actions and assignments during response operations

Incident response requires many sequential and concurrent actions that must be recorded and archived. Often, jurisdictions do not have the ability to electronically accomplish this task and instead rely on a scribe. The scribe accompanies the incident commander and hand writes all the actions, decisions, and assignments as the incident unfolds.

This approach is less than desirable for several reasons. First, incident commanders and operational chiefs often need to refer back to previous decisions or statements. For example, "Did I assign a team to secure the rear of the building? If so, who?" It is difficult for a commander or chief to do this currently without paging through copious notes. Likewise, written notes do not allow for alerts when there are duplications or conflicts in decisions. Responders noted that during stressful response operations, it is possible to assign multiple teams to the same task, or to assign one team to multiple tasks

[58] "Resilient Synchronized Planning and Assessment for the Contested Environment (RSPACE)," Defense Advanced Research Projects Agency, accessed October 21, 2016, http://www.darpa.mil/program/resilient-synchronized-planning-and-assessment-for-the-contested-environment.

[59] "Distributed Battle Management," Defense Advanced Research Projects Agency, accessed October 21, 2016, http://www.darpa.mil/program/distributed-battle-management.

concurrently. Incidents can move very quickly and it can be difficult to accurately capture all the data. Second, once notes are hand recorded, the record must then be transcribed electronically. This is another avenue to introduce errors into reporting. The incident commander's notes are often used as part of incident reconstruction efforts for after action reports and investigations.

Goals

- Scales for daily use and large-scale incident response
- Includes voice-activated recording of all command decisions, actions and assignments
- Integrates with decision support systems
- Transfers data among incident commanders and others in leadership positions
- Allows user to query past decisions, actions and assignments
- Transcribes data into electronic documents automatically
- Incorporates shortcut language
- Integrates with existing CAD and P25 radio systems
- Incorporates open-source software components

State of Technology

One commercially available software product meets many of the requirements listed above. The product integrates with CAD systems and provides extensive situational awareness, communications and resource-tracking capabilities. It is capable of recording all information about response and operator actions, including a time stamp. It also provides a visual display of all logged actions and requests. Features include interactive and collaborative maps, decision support tools and the ability to upload videos, images and documents in support of incident operations. The system can be accessed from multiple platforms, including mobile devices. However, this technology is proprietary, and the source code is not currently open source. In addition, not all features are activated by voice command. Although this technology exists, it may not be easily and affordably accessible to all response agencies.

Related Standards and Guidelines: None applicable

The ability to quickly establish unified command between jurisdictions and agencies

More than 10 years after the introduction of NIMS and the associated ICS procedures, the ability to quickly establish unified command among jurisdictions and agencies remains a challenge for responders. Establishing unified command among agencies within the same jurisdiction is challenging because of the uniqueness of each response discipline coupled

with the variations in training backgrounds and cultures. For example, fire departments exclusively use ICS in all incident responses. However, law enforcement may only use ICS when involved in an incident that requires a joint response with firefighters. Therefore, it can be challenging to seamlessly integrate this concept between agencies. This issue is further exacerbated when multiple agencies from multiple jurisdictions are involved in a response, because they default to both their discipline specific command culture as well as jurisdictional nuances.

Many of the incidents that are the focus of the PR5 effort involved breakdowns in ICS, specifically the lack of or ineffectual unified command. Responders agreed that although this capability is improving, breakdowns in establishing unified command often occur during large-scale incidents and can significantly hinder effective response operations. This capability is one of the highest prioritized capability needs by the responders that participated in PR5.

The ability to quickly establish unified command among jurisdictions and agencies is not an issue that can be resolved with technology. Rather, this is an issue that requires more training (potentially through exercises) to help develop relationships and further the consistent use of ICS throughout all disciplines. This is an ability that is enhanced through application both in training and real-world events.

Related Standards and Guidelines: None applicable

Responder Health and Safety

The Responder Health and Safety domain is defined as the ability to identify hazards to public safety personnel and develop appropriate mitigations to reduce morbidity and mortality associated with response activities. There are four capabilities in this domain:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability
- The ability to provide individually appropriate mental health services following incident response
- The ability for responders to ascertain exposure type and level
- The ability to monitor the physiological signs of emergency responders

Figure 16. PR5 Responder Health and Safety capability needs

Each of the Responder Health and Safety capability needs is discussed below:

The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

This capability gap refers specifically to duty or station uniforms and garments; it does not address discipline-specific items such as turnout gear. Emergency responders' duty uniforms are generally made of cotton, polyester, wool or a blend of fibers. They provide limited, if any, protection from hazards common on the incident scene. In addition, these garments might pose a threat if used in the wrong circumstances. For example, if a law enforcement officer is wearing a polyester uniform, and operating near high temperatures, their uniform may melt and adhere to their skin. Law enforcement officers who provided force protection to firefighters during the Ferguson, Missouri, riots stated that this was a potential issue during their response. In addition to not providing thermal protection, existing duty uniforms do not provide any protection against slashes, punctures, blood-borne pathogens or ballistic threats. Responders to the Baltimore riots reported their duty uniforms provided no protection from the projectiles and other

weapons used against them. Over 130 officers were injured during the Baltimore riots.[60] In addition, responders do not know when a routine operation or call may present bodily threats. Ultimately, the duty uniform has to be comfortable for extended daily use. Responders do not want another garment on top of their duty uniform, but need enhanced protection against threats in the clothing they wear daily.

Goals

- Provides protection from thermal, puncture, slash, ballistic, blood-borne and chemical hazards
- Includes hand and foot protection
- Integrates with hazard sensors
- Provides notification upon exposure to hazards
- Includes range of styles and colors (inclusive of undercover operations)
- Includes options for multiple climates
- Requires no special laundering (able to be laundered in the station)
- Maintains protective qualities through regular laundering
- Able to be easily decontaminated
- Able to be repaired in the station
- Affordably outfits entire workforce

State of Technology

Military uniforms offer higher levels of threat protection than those available to emergency responders. Currently, DoD uniforms offer protection from some chemicals and insect- and tick-borne diseases and are flame retardant.[61] In fact, the Defense Threat Reduction Agency is currently funding a project that is developing a new material using carbon nanotubes that can repel biological and chemical agents. A Lawrence Livermore National Laboratory (LLNL) study team referred to the material as a "smart second skin." The study described the material as being "able to switch reversibly from a highly breathable state to a protective one in response to the presence of the environmental

[60] "About 130 officers injured during Baltimore riots released from hospital," *Baltimore Sun*, published May 6, 2015, http://www.baltimoresun.com/news/maryland/crime/bs-md-ci-officer-injuries-20150505-story.html.

[61] "Permethrin-treated uniforms protect against lethal diseases," U.S. Army, published July 1, 2014, https://www.army.mil/article/129210/Permethrin_treated_uniforms_protect_against_lethal_diseases.

threat. In the protective state, the uniform will block the chemical threat while maintaining a good breathability level."[62]

Another DoD textile technology research effort includes integration of electronic devices inside garment fibers. In one application, the devices make the fabric light sensitive. If a sniper were to target a warfighter using a laser or infrared beam, the fabric would be able to sense the light and deliver a signal that a laser is interrogating the fabric.[63]

A British company has developed a lightweight, flexible and high shock-absorbing material that can be applied to fabrics. The normally soft material becomes rigid under a high-impact force and returns to its soft state after the impact passes. This has applications for ballistic protection in duty uniforms.[64]

Related Standards and Guidelines

- NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting
- NFPA 1975: Standard on Emergency Services Work Clothing Elements, 2014 Edition
- Authorizing Body: American National Standards Institute (ANSI) and International Safety Equipment Association (ISEA) 107-2015: American National Standard for High-Visibility Safety Apparel and Accessories
- Authorizing Body: American Society of Testing Materials (ASTM) F2413: Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear
- NFPA 1851: Standard on Selection, Care and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting
- NFPA 1951: Standard on Protective Ensembles for Technical Rescue Incidents
- NFPA 1992: Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies
- NFPA 1994: Standard on Protective Ensembles for First Responders to Chemical, Biological, Radiological and Nuclear (CBRN) Terrorism Incidents

---

[62] "'Second skin' uniform protects soldiers from biological and chemical agents in the field," LLNL, published August 3, 2016, https://www.llnl.gov/news/%E2%80%98second-skin%E2%80%99-uniform-protects-soldiers-biological-and-chemical-agents-field.

[63] "The Military Is Pouring Money into Smart Fabrics, But There's a Holdup," Defense One, published April 18, 2016, http://www.defenseone.com/technology/2016/04/military-wants-smart-fabrics-theres-holdup/127589/.

[64] "Success in smart textiles – now and in the future," Advanced Textiles Source, October 9, 2015, http://advancedtextilessource.com/2015/10/09/success-in-smart-textiles-now-and-in-the-future/.

- NFPA 1999: Standard on Protective Clothing and Ensembles for Emergency Medical Operations
- ASTM F1671/F1671M-13: Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System
- National Institute of Justice (NIJ) Standard 0108.01: Ballistic Resistant Protective Materials

The ability to provide individually appropriate mental health services following incident response

Many incidents, large and small, can significantly impact the responders who participate in the response and recovery operations. It is not unusual for responders to experience long-term effects from these incidents. Temporary and chronic effects of post-traumatic stress disorder (PTSD) among emergency responders are common because of repeated exposure to traumatic incidents. The risks are especially high for those who participate in events such as shootings, bombings and natural disasters with a significant loss of life. Not every responder suffers from PTSD and for those who do, the symptoms manifest in different ways. Often, following large-scale incidents, responders will be encouraged or required to attend debriefing sessions or assessments by mental health professionals. Although decreasing, a stigma remains about seeking help in dealing with symptoms or issues, so responders are often reticent about seeking mental health support and treatment. This capability need is focused on the ability to determine the appropriate mental health treatments based on the individual symptoms and experiences of each responder. In this case, one size does not fit all, but that is often what is provided to public safety personnel.

Goals

- Integrates baseline mental health assessments gathered before an incident
- Provides a match of incident-specific parameters with provider expertise against a standard or a certification
- Provides responder rating capability for mental health providers
- Tracks a responder's mental health reports throughout the incident life cycle while also addressing Health Insurance Affordability and Accountability Act (HIPAA) concerns
- Maintains anonymity until certain thresholds are crossed
- Integrates with existing health tracking systems (e.g., Emergency Responder Health Monitoring and Surveillance [ERHMS])
- Includes training for post-incident behavior recognition

- Features personal monitoring for specific behaviors (e.g., sleep patterns, heart rate and physical tension)

State of Technology

Although there are goals presented here, responders agree that this is generally not a technology problem. Addressing this issue will require changes to policy and training, as well as a greater emphasis on addressing the issue by leadership.

There is one goal listed above that may be addressed by technology. Personal monitoring for symptoms of PTSD or other mental health impacts may be achieved in the future by combining existing sleep pattern monitoring, available now through wearable activity monitors and physiological monitoring devices. See the discussion of *the ability to monitor the physiological signs of emergency responders* below for a more detailed description.

Related Standards and Guidelines

- HIPAA

The ability for responders to ascertain exposure type and level

With the exception of a small number of responders who carry personal radiation detectors, public safety personnel do not carry any hazard detectors. Some apparatus and vehicles have mounted detectors for common gases and hazards, but unless responders are in the immediate vicinity of that vehicle when the sensor alerts, they do not know they have been exposed. Chemical, biological and radiological exposures can have life-long health consequences, including fatality. Responders and workers who participated in the 9/11 response and recovery operations at the World Trade Center (WTC), the Pentagon, Shanksville, Pennsylvania, and the Fresh Kills, New York, landfill (used as a sorting ground for WTC debris) suffer from higher incidences of lung disease, cancers, upper airway issues, gastroesophageal acid reflux disease, PTSD and anxiety, panic and adjustment disorders.[65] Responders believe that knowledge of exposure to chemicals, biological agents and ionizing radiation that they are exposed to, including specific agent, particle type and level of exposure will allow them to better mitigate the effects.

Goals

- Identifies specific chemical and biological agents, blood borne pathogens, explosive compounds and ionizing radiation particles
- Calculates exposure amount automatically
- Monitors continuously and calculates exposures in real time

[65] "9/11's second wave: cancer and other diseases linked to the 2001 attacks are surging," *Newsweek*, published September 7, 2016, http://www.newsweek.com/2016/09/16/9-11-death-toll-rising-496214.html.

- Produces outputs that compare exposure level with permissible exposure limits (PEL) (e.g., immediately dangerous to life or health [IDLH] levels)
- Transmits alerts for responders and command if preset thresholds are reached
- Allows user to reset device for each use and store cumulative readings for long-term exposure calculations
- Adapts to monitor for threat-appropriate levels (e.g., carbon monoxide will be present during fire suppression operations, so the system should account for applicable levels)
- Adapts to monitor zone-appropriate exposure levels (i.e., hot, warm and cold zones)
- Aggregates data for summaries and reports
- Produces low false positive and false negative rates for specificity and sensitivity
- Produces outputs and alerts that are easy to read and understand
- Allows for simple calibration in station

State of Technology

The Occupational Safety and Health Administration developed PELs to define the amount of a chemical substance or physical agent a worker can be exposed to. The limits are defined by an 8-hour exposure period, a short-term exposure or a ceiling exposure. There are complex formulas for calculating exposure levels. Generally, the calculations are used after a shift to determine the estimated exposure for the duration of the shift. Responders need to know a significant amount of information to calculate exposures, including variables such as the percentage of the substance in air samples, total weight of dust collected, total sampling time for each air sample, etc. Response agencies or public health departments may maintain equipment to take samples and calculate exposures. However, this can be time consuming. The study team was unable to locate any technologies that provide real-time identification of exposure type and level, much less meet the goals described above.

Related Standards and Guidelines: None applicable

The ability to monitor the physiological signs of emergency responders

Despite expanding use of physiological sensors in other industries, responders do not currently monitor physiological signs in the field. Yet, according to the NFPA, "overexertion/stress/medical" causes are the leading source of firefighter fatalities (59 percent), with sudden cardiac arrest as the leading nature of death.[66] While the

[66] "Firefighter deaths by nature and cause of injury," NFPA, last updated: June 2016, http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/fatalities-and-injuries/firefighter-deaths-by-cause-and-nature-of-injury.

percentage of law enforcement and emergency medical technician and paramedic deaths tied to medical causes is much lower, responders in both disciplines regularly experience high levels of physical exertion.[67] Responders cannot operate at peak levels if physiological factors are outside of normal parameters. Responders want to be able to monitor physiological signs to identify when personnel are experiencing or are developing symptoms related to a medical issue or emergency. The ability to monitor responders' vital signs would enable commanders to direct personnel to rehab or medical stations before measurements reach critical levels.

Goals

- Measures physiological conditions continuously, including body temperature, heart rate, blood pressure, oxygen saturation, hydration, exhalation composition and signs of cognitive overload for individual responders
- Generates automated alerts in multiple formats (e.g., audible, visible and tactile) when preset or site-specific thresholds have been reached
- Compares exposure data against baseline readings
- Relays information in real time to responder and command
- Addresses HIPAA concerns
- Integrates with responder geolocation data
- Produces outputs that can be used for triage
- Is ruggedized to operate in responder operating environments
- Caches data when connectivity is offline and automatically forwards when connection is restored
- Integrates components into PPE when feasible
- Includes components designed for all disciplines
- Has minimal SWP for all components

State of Technology

As reported in the Project Responder 4 report, the National Aeronautics and Space Administration (NASA) has conducted significant research on remote monitoring of physiological signs. NASA developed the LifeGuard system, including a small wearable device that measures electrical activity of the heart, respiration, activity, temperature,

[67] The data available for law enforcement officers and EMS personnel does not report any deaths due to medical causes in the most recent reporting period. However, "medical causes" does not appear to be a category of causation measured for either report.

heart rate, pulse oximetry and blood pressure.[68] The device can log activity for nine hours or transmit activity in real time to a base station. Because the system has been ruggedized to withstand operating environments in space, there are possible applications for responder use. This technology has already been transitioned for military applications and use by professional sports teams.

DARPA also has an In Vivo Nanoplatforms (IVN) project that aims to develop implantable nanoplatforms using bio-compatible and nontoxic materials that could provide continuous physiological monitoring of the warfighter.[69] DARPA envisions that the nanoplatforms could also be used to rapidly treat diseases.

Multiple commercial vendors are developing smart fabrics that integrate physiological sensors. Available smart shirts, bras, socks, and sneakers can measure heart rate, breathing rate, oxygen consumption, and other metrics. Other systems under development use disposable "tattoo-like" electronics to monitor physiological signs. There are commercially available physiological monitoring products specifically designed for emergency responders. These products measure critical physiological signs, as well as posture (to determine if a responder is in a prone position), and have geolocation capabilities, as well. Although there are some options available to address this capability need, current products fall short of some of the goals listed above.

Related Standards and Guidelines

- HIPAA

[68] "LifeGuard: Wireless Physiological Monitor," National Aeronautics and Space Administration, accessed October 18, 2016, http://www.nasa.gov/centers/ames/research/technology-onepagers/life-guard.html.

[69] "In Vivo Nanoplatforms (IVN)," Defense Advanced Research Projects Agency, accessed October 18, 2016, http://www.darpa.mil/program/in-vivo-nanoplatforms.

Logistics and Resource Management

The Logistics and Resource Management domain is defined as the capability to identify, acquire, track and distribute available equipment, supplies and personnel in support of catastrophic incident response. There are seven capabilities in this domain:

- The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident-specific response
- The ability to geolocate non-personnel resources within the incident response area
- The ability to account for and manage on-duty, off-duty and self-reporting personnel in real time (including check-in and staging direction)
- The ability to verify the credentials of all on-scene responders
- The ability to centrally manage incident-specific logistics information
- The ability to identify resource needs for rescue and shelter of citizens with access and functional needs
- The ability to digitally request resources from the field and track disposition of request, resource status and resource location

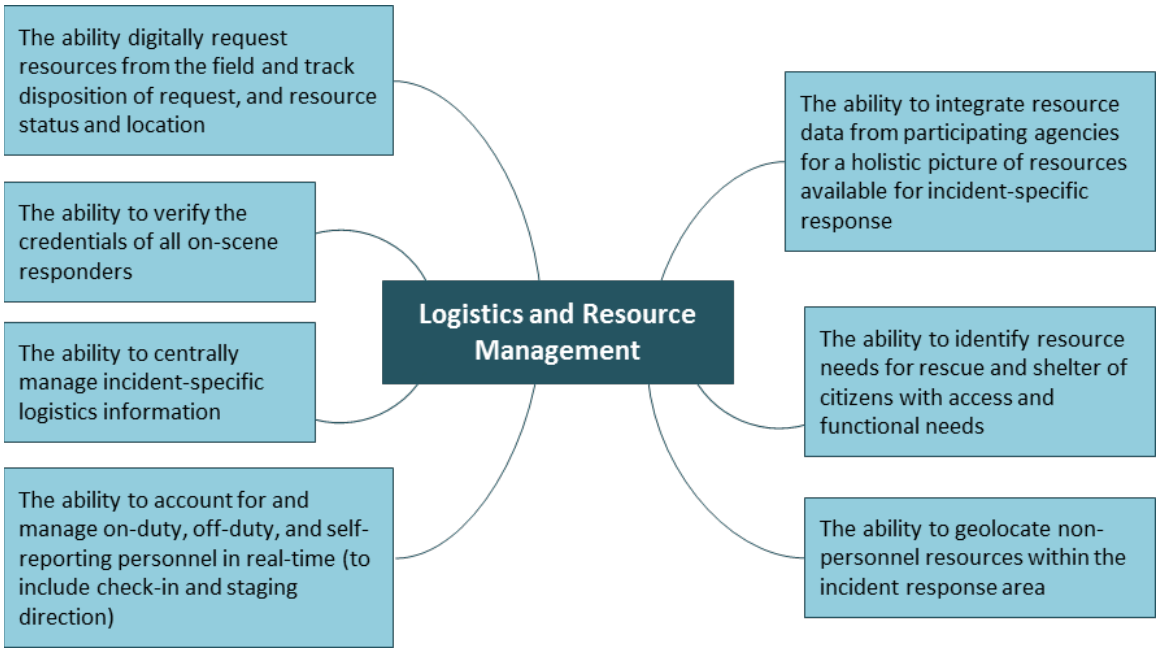

Figure 17. PR5 Logistics and Resource Management capability needs

Each of the Logistics and Resource Management capability needs is discussed below:

The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident-specific response

Large-scale incident response requires a coordinated effort across multiple agencies and jurisdictions. A key element in coordinating response actions is the ability to know, in real time, the availability, location and status of all resources. Currently, agencies rely on a number of techniques and tools to track their resources, from Excel spreadsheets and T-cards to more sophisticated software applications.[70] Therefore, while it might be clear what one agency has available, there is no ability to integrate the myriad data contained in the disparate tracking methods from multiple agencies and jurisdictions to create a holistic picture for incident command. Responders need the ability to integrate data from all responding agencies, including mutual aid partners, to identify which resources are available for a response and anticipated timelines for delivery.

Goals

- Creates integrated repository of all resources available for incident-specific response
- Provides graphic display of critical or selected resources on incident map
- Displays critical or selected resources as standardized icons
- Provides resource details (e.g., agency of origin, manufacturer and model number) on request
- Integrates with financial reporting and reimbursement systems
- Ingests data in multiple file formats
- Integrates with GIS coordinates
- Integrates with common electronic situational awareness tools
- Integrates with incident-specific maps
- Displays data in layers
- Ingests data sources in real time
- Maintains open format for outputs
- Designates resource owner for financial reporting
- Allows user queries of data
- Includes ability to filter data and customize filter criteria
- Allows off-line access
- Creates data layer for integration into incident management and situational awareness products
- Has customizable display settings

[70] Form 219 is the ICS standard Resource Status Card. They are "T" shaped cards printed on different color paper to differentiate different resource categories. Each card contains the status of one piece of equipment.

State of Technology

The field of data integration is well established and regularly applied to numerous industries. Data integration systems not only incorporate data from files in different formats, but also assemble the data to create a usable platform for users. Commercially available products integrate data residing in different operating systems, database formats and programming languages. Users are able to view outputs in graphical display and both search and filter the results. However, this capability has not been applied to the integration of public safety resource databases.

Data integration does not address the issue that many of the existing data repositories are frequently out of date. Contact information changes, or equipment goes out of service or is unavailable due to maintenance, but this information is not updated in agency spreadsheets or databases. Features that pull real-time data updates are critical to address this capability need.

There are also commercially available technologies that are hosted on a cloud-based server and accessed remotely that allow for the immediate input and updating of critical pieces of response information, such as resource location and availability. Based on a COP, these applications use color-coding and easy-to-identify icons to simplify the display of information. Further, they have the ability to overlay several additional data layers, including GIS data and sensor and live camera feeds to customize real-time information.

Related Standards and Guidelines

- EDXL-DE-V2.0: EDXL Distribution Element, v. 2.0
- Global JXDM
- NIEM

The ability to identify resource needs for rescue and shelter of citizens with access and functional needs

Individuals with access and functional needs include people with disabilities, those who live in institutionalized settings (e.g., prisons and mental health facilities), the elderly, children, people with limited or no English language skills and those with limited access to transportation. While providing rescue and shelter to the general population is resource intensive during response operations, doing so for those with access and functional needs further increases resources required. Addressing the rescue and shelter needs of these citizens requires specialized resources, such as medical equipment, power sources and a larger responder-to-civilian ratio. This capability gap is particularly an issue prior to and during natural disasters. While it is often desirable to evacuate some populations with access and functional needs before an incident, this is sometimes not possible due to competing priorities and limited transportation resources.

In general, there are three primary considerations when responding and sheltering populations with access and functional needs:

1. Identification of the individual with access and functional needs: who they are, where they are located and what their needs are
2. Identification of sheltering options: what shelters are available that can accommodate populations with access and functional needs
3. Identification of transportation needs: what the individual's needs are during transport

While not always possible, knowing the location of individuals with specialized needs prior to the incident would help responders plan for the unique transport and sheltering requirements. Large sheltering locations such as churches and schools simply may not provide the needed support for this population. Additionally, hospitals are not always an option because in large-scale emergencies, they become overwhelmed providing critical medical care.

Goals

- Incorporates a database of the local population with access and functional needs (including locations)
- Integrates jurisdiction- and incident-specific maps
- Creates data layer for integration into incident management and situational awareness products
- Identifies incident-specific resource needs for extraction
- Forecasts the appropriate resource needs for a given community
- Incorporates data regarding local businesses that provide equipment used during sheltering
- Stores pre-established purchasing agreements for ease of acquisition

State of Technology

The foundation for the capability goals described above is a database containing information on the population of persons with access and functional needs within a jurisdiction. For many jurisdictions, such a database does not exist. In places where information is collected, it is often incomplete and out of date. Responders believe that an opt-in database that includes information on primary residence, medical needs and person-specific guidance, and that is updated in real time, would be a beneficial first step in achieving this capability.

Several states have initiatives, such as the Pennsylvania Premise Alert System. This program began in 2004 in Chester County, Pennsylvania, and can now be accessed

through a federal website, www.disability.gov. The Premise Alert System is a tool to provide advance knowledge to emergency responders about persons with disabilities. It is a voluntary program that can be used by the person with the functional or access need, his or her parents, legal guardian, or those with power of attorney. The Premise Alert System provides a simple paper form that requests basic identifying information, as well as specific information about the individual's specialized needs. Once completed, the form is submitted to local police departments and can be used by dispatch during an emergency. It is advised that individuals update their forms annually.[71]

Another example is the State of Texas Emergency Assistance Registry (STEAR) program. This is a free, voluntary program that allows individuals with functional and access needs to register their information with the jurisdiction to be used in an emergency. The STEAR program provides several methods to register including a paper form, an online form and a telephone registry. Additionally, they have the ability for entire facilities, such as nursing homes, to register their information. [72]

The technology currently exists and is being used to create easily accessible, yet confidential, databases that store critical information for use by responders. This same technology supports the development of a database of local businesses that have specialized medical equipment that can be used for sheltering. Also, responders have commercially available options to create specialized maps with GIS data that display the location of individuals with access and functional needs.

Related Standards and Guidelines: None applicable

The ability to geolocate non-personnel resources within the incident response area

The scene of an incident may span large distances. Wildfires, for example, can extend hundreds of square miles. Even when the incident scene is smaller, infrastructure and debris can inhibit a line-of-sight view of the entirety of the scene. Managing resources in incidents during large-scale incidents can be especially challenging and responders do not have time to search for critical equipment across the incident scene. This problem is further exacerbated when roadways are covered with debris or destroyed by the incident or when roadways in remote areas are lacking. Responders need to know where critical equipment is located on the incident scene. This includes large items such as vehicles, but also smaller equipment such as generators, fuel supplies and portable toilets.

[71] "Premise Alert Request Form," Premise Alert Program, accessed October 24, 2016, http://papremisealert.com/us/wp-content/uploads/Microsoft-Word-Premise-Alert-Form-8-13.doc.pdf.

[72] "State of Texas Emergency Assistance Registry (STEAR) – Public," Texas Department of Public Safety, accessed October 24, 2016, https://www.txdps.state.tx.us/dem/stear/public.htm.

Goals

- Provides accurate geolocation of large or critical resources for x, y and z coordinates
- Provides graphic display of the location of all resources on the incident scene
- Operates in hazardous outdoor environments and in remote areas
- Provides real-time updates of resource movement
- Integrates with three-dimensional display of buildings and structures to identify the room or specific area in which the resource is located
- Incorporates terrain data
- Integrates with GIS coordinates
- Creates data layer for integration into common electronic situational awareness tools
- Provides location transmitters that are ruggedized, have a minimum of 24-hour battery life, and charge kinetically
- Incorporates a confidence level to indicate the accuracy of location
- Caches data when connectivity is offline and automatically forwards when connection is restored
- Functions across broad distances and remote places
- Functions in a communications-degraded environment
- Allows sharing of geolocation data across response agencies
- Includes ability to geofence selected areas to identify resources located in a specific area
- Alerts when resource leaves the area

State of Technology

Depending on the status of the communications infrastructure and the size of the incident area, a variety of widely available commercial technologies can be used to address this capability need. Simple and affordable tracking capability is widely used for industrial and consumer purposes. These tools and applications allow users to tag items and ping their location as needed. They also store the coordinates of the last known location and allow users to have this information updated in real time. However, this type of technology does have limitations relevant to use on an incident scene, particularly with proximity between the items being tracked and reader, frequency crossover and signal strength of the tag.

The most widely used technology that is commercially available to fully meet this need is radio frequency identification (RFID) chips. These chips can be attached or embedded in items of any size. They are ruggedized and rely on electromagnetic fields to store the tracking information. They are currently being used with success in many industries and applications, including the emergency responder field.

In a larger sense, geofencing can also help to manage the location of non-personnel resources. Geofencing using GPS or RFID can create a barrier or "fence" around any area desired. Therefore, responders instantly know when large items have entered or left a geofenced area. Geofencing can also be used in combination with the other afore-mentioned technologies.

Related Standards and Guidelines: None applicable

The ability to digitally request resources from the field and track disposition of request, resource status and location

In incidents where the need for resources is immediate, such as a call for backup or hazardous material response, it is readily apparent to the requestor if the need is not being fulfilled. However, in less urgent or protracted circumstances, responders may not have the ability to determine the status of the request. PR5 interviews and research found examples of commanders requesting needed items and awaiting delivery, only to find out later that the requests had been denied. For example, one interviewee indicated that only in analyses for an after-action report did he find that they never received multiple resource requests because of communications failures. This is specifically an issue for commanders or responders on-scene. Requests for resources are transmitted, but there is limited ability, other than repeated radio requests, to determine the status of the request, the estimated time of arrival or destination location.

Addressing this issue does not appear to be entirely a technology problem. During focus group discussions, some responders noted that better training and communications procedures from dispatch to the field could improve awareness of resource requests. However, responders stated that being able to quickly check the status of resource requests from the scene, without having to communicate over radio channels, would improve their capabilities.

Goals

- Allows user to digitally place resource requests and check status of existing requests from the field
- Provides acknowledgement of resource requests in real time
- Provides information about the status of requests (e.g., "pending" or "en route")
- Provides information about the position of request within the review process and the current approver

- Provides geolocation of delivered resources on the incident scene
- Integrates into resource management and situational awareness tools

State of Technology

There are several commercially available applications that currently provide the ability to digitally track resource requests. Features include real-time status updates; the ability to view, edit, search and filter requests; and visual display of the location of an asset. These technologies are capable of being integrated with incident management software systems that are widely used in the response community. The applications allow users to access request and resource information via mobile devices.

Figure 18. Uber graphical display

There are several technologies currently being used in other fields that provide the ability to digitally request resources and track the request. For example, Uber is a free application used in hundreds of cities in the United States. Using this application, riders request a driver and watch, in real time, as a driver acknowledges their request. The riders are provided with the driver's name, contact number, description of the car and the driver's pictures. Riders then watch on a map as the driver navigates to their location. The application also provides updated time estimates as the driver approaches the rider. The rider can customize a request to denote a specific type of car and add stops, as needed. This application can be used on a variety of mobile devices. While not specifically suited for use in emergency management situations, this type of technology could be transitioned to support emergency responders in requesting and tracking resource needs.

Related Standards and Guidelines

- NIEM

The ability to verify the credentials of all on-scene responders

Commanders are aware of the skill sets of their personnel within a local response. However, for a large-scale event, incident commanders or operational chiefs do not have records to verify the skill sets or qualifications of individuals that report through mutual aid or self-dispatch. There are a number of cases where responders claim to possess specialized skill sets when in fact they possess no verifiable credentials. Additionally, there have been instances where untrained civilians report and represent themselves as emergency responders.

In incident response, it is important to know the qualifications of the responding individuals. First and foremost, it ensures that only qualified personnel are on the incident scene, which in turn improves the safety of other responders and citizens. In addition, it can be challenging to quickly locate personnel who possess specialized skill sets.

Goals

- Provides electronic repository of all training records and certifications
- Allows user to search records by location, certification, type and name
- Allows electronic submission of records
- Provides templates and support for rostering decisions
- Functions for individuals and teams
- Incorporates standard resource type and kind designations
- Identifies absence of reciprocity agreements for specified resources
- Includes data for non-public-safety entities (e.g., construction and medical)

State of Technology

This capability has largely been addressed in other industries. Responders reported that culture and the lack of national-level system management play a notable role in why this technology has not been transitioned to public safety agencies.

There are several technologies currently available that store validated and secure data, such as personally identifiable information (PII) and credentials. For example, the DoD uses a common access card as the standard form of identification and access to controlled spaces for active duty and other select personnel. The card displays certain pieces of information, such as a photograph of the individual, badge expiration date, federal identifier, affiliation, service/agency, clearance level, pay grade and rank. There is also an integrated circuit chip and a magnetic strip. The magnetic strip is used only by the specific service or agency and has permission controls on the data that is stored on the card. For example, if the magnetic strip contains medical information, that information can only be accessed by medical personnel with the proper authority to view it. Each application on the magnetic strip is firewalled, and added encryption can selectively be applied. Also, the ability to view information and the ability to enter it are not always granted together. The technology that reads the cards is also widely available and ruggedized for use in a range of environments. The readers can be externally added to devices such as computers or can be fully embedded within devices such as tablets.

The foundation of these systems is the use of an identification card by all personnel wanting access to the facility, area or network. This is a potential barrier to adoption in the near term by public safety personnel. Each agency would need to issue cards to all staff members and maintain the currency of the data. Further, there is no national

repository of training or certification records, so it would be incumbent upon the agency to maintain the integrity of the training data.

Related Standards and Guidelines:

- NIEM

The ability to centrally manage incident-specific logistics information

Centralized management of logistics information is essential to an efficient and effective response. Resources of every shape and size, ranging from personnel to apparatus to generators to spark plugs, are needed to stabilize the scene, mitigate additional consequences, protect responders and the public, and restore the use of critical resources. The DHS Authorized Equipment List contains hundreds of *categories* of equipment that may be used in response operations.[73]

A centralized resource management system is more critical when multiple agencies and multiple jurisdictions are working together. In most areas, several systems, even within the same agency, are simultaneously used to address different aspects of resource and logistics management. For example, response agencies generally use spreadsheets, often outdated, to identify which resources are available and paper T-cards or checkout sheets to identify who is using the resource on the scene. These systems do not integrate, which creates gaps in information. This problem is further amplified when several agencies come together for a response.

Responders need a single system that can provide real-time data and information for the requesting, positioning and management of logistics functions for all classes of material. This system also needs to include the objectives for managing incident-specific responses and the data to ensure easy reimbursements and financial management post-incident.

Goals

- Integrates systems to aggregate resource information, process resource requests, track the logistics process and record necessary financial information
- Tracks inventory levels, available suppliers and resources and qualified response personnel in real time
- Provides visibility of resources at all levels (e.g., federal, state, local and private sector)
- Integrates transportation and distribution schedules
- Displays real-time resource status at the incident scene (e.g., fuel levels and battery life)

[73] *Authorized Equipment List*, (Washington: Federal Emergency Management Agency, May 8, 2015).

- Models burn rates on a range of resources
- Allows user to customize alert parameters
- Generates alerts when disposable supplies hit predetermined levels or automatic reordering of supplies given preset parameters
- Generates alerts for incompatibility of supply components
- Generates alerts when a resource is scarce on a local, regional or national basis
- Integrates with decision support and management systems and financial management requirements or systems
- Operates offline when network connectivity is absent
- Allows customization of data visualization
- Can be scaled for daily use and large-scale incident response
- Allows management team to review how resources are being managed
- Operates on multiple device platforms
- Functions on multiple operating systems (e.g., iOS, Android and Windows)
- Uses open data standards and APIs

State of Technology

Logistics management systems developed for the military and commercial entities provide most of the functionality requested by responders. One such system is the U.S. Army's Global Combat Support System (GCSS). GCSS is a portfolio of systems that supports the logistics elements of command and control, joint logistics interoperability and secure access to and visibility of logistics data. GCSS as a Web-based system that not only enables warfighters to see the status and track the movement of equipment in real time, but also assists them with the asset management and accountability of all items at multiple levels of visibility. However, these systems are very large, and affordability is an issue.

Commercially available logistics management or supply chain management systems allow users to direct inbound and outbound transportation, order fulfillment, inventory management and other related functions. These products exist as stand-alone systems or modules that can be integrated into incident management systems. Users can customize a repository of information that is used for everyday data storage and management, as well as for crisis situations. These systems integrate to provide extensive resource and task management functions and can allow responders access from the scene via mobile devices. At the conclusion of an incident, the system supports after-action reporting and the resolution of outstanding tasks.

Related Standards and Guidelines

- NIEM

The ability to account for and manage on-duty, off-duty and self-reporting personnel in real time (including check-in and staging direction)

Standard procedures in the fire service and emergency medical services dictate that responders do not report to the scene of an incident unless they are on duty and their unit is dispatched to the scene. Law enforcement procedures are slightly different; after dispatchers announce the location of a call, they will assign a specific officer or allow closest units to respond. However, in the case of a large-scale incident, off-duty personnel or responders from other jurisdictions will report to the incident scene without being dispatched. Once on-scene, all responders should report to the incident staging area to receive direction and tasking, but this does not always happen. Often, off-duty and self-reporting responders bypass staging and immediately become involved in response activities.

There is a significant safety issue directly connected to the ability to account for all incident personnel. Especially when responders bypass staging, there is simply no record of their presence at the incident scene. Therefore, command has no knowledge of their status and does not know to account for them at incident conclusion.

Additionally, during incident response, individuals who self-report or were off duty are often not in proper uniforms, so it is difficult to tell that they are part of the response. This can be problematic, especially in scenarios such as active shooters or riots. There are also examples of incidents where teams self-reported and began executing tactical actions that were in direct conflict with an operation already in progress. A scenario such as this could compromise responder safety and the ability to neutralize an imminent or ongoing threat.

The difficulty in accounting for all personnel is not always a direct result of unprompted self-reporting or off-duty personnel. There are examples of jurisdictions so overwhelmed by incident damage that they issued a wide solicitation for help. This caused a deluge of responders from surrounding geographic areas, creating traffic congestion and blocked ingress and egress routes.

Goals

- Includes features to dispatch, acknowledge dispatch
- Identifies emergency responders who enter the response area
- Directs responders to staging areas
- Provides information on restricted ingress and egress routes
- Provides arriving units with mission-critical information

- Allows for self-dispatched responders to notify command of their arrival on scene
- Integrates with responder geolocation data
- Integrates with navigation data to provide estimated time of arrival of dispatched responders

State of Technology

This is not entirely a technology issue. Participants in the PR5 focus group meeting discussed the need for better discipline to prevent personnel from self-dispatching to a scene. Some agencies have prohibited the practice, threatening punishment if a responder arrives at an incident without being dispatched. However, these controls are not common, and self-dispatching is a regular occurrence during large-scale incidents.

There are several types of applications used by the public that allow an individual to check in digitally at specific locations. Once they check in, their status is immediately known to anyone who has access to the application. These applications have even been tailored for use in emergency situations. For example, safety check is an option on the social media application Facebook. Safety check uses an individual's location to send a notification to that person if he or she is near a disaster area. The notification requests that the individual click a button to indicate that he or she is safe or not in the area. It also allows individuals to check on others and instantly see their status information.

There are other applications that allow event planners to manage onsite attendees. These applications allow individuals to easily and quickly enter their data at multiple kiosk locations or through their mobile devices. Once entered, the event managers can search the data by a number of customizable fields. This allows for real-time status of the number of people present as well as names and other required pieces of information. An expansion of this technology, currently in the experimental phase, applies facial recognition technology to the check-in process. The app accesses a list of stored facial images to automatically check people in as they arrive.

Additionally, some responders currently use an application that functions in reverse of what is being described by this capability gap. Essentially, this application helps responders know the location of incidents and increase their real-time situational awareness. This allows responders to self-dispatch to the incident. This technology could be augmented with a check-in feature as well as the ability to direct the responders to staging and/or provide other essential information to help manage their presence.

While the technology is available, it has yet to be customized and transitioned to the field of emergency management and response.

Related Standards and Guidelines: None applicable

Casualty Management

The Casualty Management domain is defined as the capability to provide rapid and effective search and rescue, medical response, prophylaxis and decontamination for large numbers of incident casualties and identify appropriate sheltering and transportation options. There are four capabilities in this domain:

- The ability to estimate or ascertain the number of persons in affected areas at the time of an incident
- The ability to identify the location of injured, trapped and deceased casualties on the incident scene
- The ability to track the status of known and potential casualties from site through reunification
- The ability to manage and track large numbers of fatalities through all phases of response

Figure 19. PR5 Casualty Management capability needs

Each of the Casualty Management capability needs is discussed below:

The ability to estimate or ascertain the number of persons in affected areas at the time of an incident

In many types of incidents, responders do not know the number of people in the affected area at the time of the incident. Having this knowledge can impact operational decisions. The Moore, Oklahoma, tornado of 2013 stayed on the ground for 47 minutes, destroying buildings and infrastructure in a path that was 17 miles long and 1.3 miles wide.[74] The timing of the event provides important context for this capability need. The tornado formed just before 3 p.m. on a Monday. Two elementary schools and one junior high school were in its path. Although the students had been released and many were away from the buildings, seven children died at the Plaza Towers Elementary School. Because

[74] "How big was the Moore, Oklahoma tornado," CNN, updated May 27, 2013, http://www.cnn.com/2013/05/27/us/infographic-moore-tornado/.

of their familiarity with the area, responders knew that schools were in the affected area, but did not know how bad the damage was or how many students might have been in the schools at the time they were hit. The tornado also hit residential areas. Given the time of day, many homeowners may have been out of the home. If responders know how many people are in an affected area at the time of an incident, they can better direct search and rescue operations. Several incident-specific factors impact how many people will be in a given area when an incident occurs: time of day, day of the week, population density and land-use zoning. For example, had the same tornado hit New York City, it would have covered a path from Battery Park to nearly Yonkers.[75] Significantly more people would have been injured or killed.

Goals

- Incorporates data to account for differences in population density for time of day, day of the week, tourism peaks, and special events
- Incorporates ownership records, student records, residence data for college students, hotel occupancy and venue capacity
- Integrates with GIS coordinates
- Integrates with incident-specific maps
- Integrates with resource management system to project resource needs
- Ingests data in multiple file formats
- Provides graphic display of numbers and locations of projected casualties
- Creates outputs including heat maps showing density of projected casualties, but also allows user to click through to get more specific information
- Displays projected casualty data in layers for integration into incident management and situational awareness products
- Allows user to zoom in or geofence selected areas
- Allows user to customize fields to search for specific information
- Integrates with social media and other platforms that provide disaster check-in
- Integrates with data from cellular telephones (i.e., pinging or interrogating phones within an area)
- Addresses privacy issues and guidelines

[75] Ibid.

State of Technology

Current methods to estimate populations affected by an incident include population density and crowd-counting models. Generally, these models are used after an incident and are not able to provide information that is operationally relevant for response. Advances in intelligent video surveillance systems are making it easier to estimate crowd size in real time, but this is only one element of the capability need. Research efforts for PR5 did not disclose any developmental or available technologies that provide real time estimates of population in a specific area.

Using GIS mapping technology with spatial, temporal and link analyses, the Vancouver, British Columbia, Police Department developed a sophisticated crime and analysis system that helped police make sense of location and event-related data. By tracking and mapping significant events, the department was able to identify and understand trends, and prepare resources and response tactics in advance. This system, which uses anonymous open-source data feeds, played an integral role in planning and preparation for the 2010 Winter Olympics in Vancouver, Canada. It demonstrated potential to assist responders in tracking and mapping significant events (e.g., large-scale sporting events, traffic and crowds related to school schedules) in their communities. Responders can use this data to identify trends in population density, providing them with usable information during emergency response operations.

Another example is the Connected Citizens Program, which is a free two-way data exchange between Waze, an interactive navigation application, and municipal partners. This technology analyzes municipal data (e.g., roads, school zones and school districts) with open-source anonymized information, crowdsourced by app users, to identify trends and map significant events for drivers. The trend information developed as a result of this technology could aid responders in determining population density and casualty estimates.

Related Standards and Guidelines:

- NIEM
- EDXL-DE-V2.0: EDXL Distribution Element, v. 2.0

The ability to identify the location of injured, trapped and deceased casualties on the incident scene

Large-scale incidents can directly impact many people, causing significant injury and death. Some incidents are confined to a small area, while others, such as the Moore, Oklahoma, tornado described above, have a much larger footprint. It is often difficult to identify where casualties (living and deceased) are located on the incident scene. During the 2014 landslide outside Oso, Washington, residents who were in their homes one minute were trapped under tens of feet of mud and debris the next. Responders and volunteers dug by shovel and by hand in areas where they suspected victims might be located or where search dogs alerted. Problems locating casualties are exacerbated when effects like flood waters or high-velocity winds move people and remains long distances

from where they were originally located. Although new technologies are in development, responders currently rely on canines and search-and-rescue tactics to locate casualties on the incident scene.

Goals

- Distinguishes between signs of life and signs of decomposition
- Provides graphic display of the location of signs of life or decomposition
- Integrates with GIS coordinates
- Integrates with digital blueprints and terrain data
- Integrates with incident-specific maps
- Integrates with historical, pre-incident maps
- Identifies the location of casualties, living and deceased, up to 100 feet below ground
- Identifies void spaces where casualties may be located
- Ingests data from geolocated transmissions and communications from persons trapped on the scene, to include social media posts, texts and voice communications and cellular phone communications with towers
- Ingests data from reported missing persons
- Ingests data from ownership records, lease agreements, student records and residence information, etc.
- Scalable and adjustable to meet the parameters of the incident scene
- Incorporates survival factors (e.g., exposure, dose and weather factors)
- Transmits data in real time

State of Technology

DHS S&T, in partnership with NASA's Jet Propulsion Laboratory (JPL), continues to develop the Finding of Individuals for Disaster and Emergency Response (FINDER) system. FINDER uses low-power microwave radar to detect small movements indicative of breathing and heartbeat of a buried victim. This allows rescuers to locate victims quickly, even those who are unconscious and unable to communicate. FINDER's signal can pass through several feet of rubble and building debris and is designed to distinguish between multiple victims. It can also distinguish between humans and animals.

Currently, technology exists that has potential to locate individuals using signals from cell phones. Some cell phone applications use a GPS signal to allow users to transmit their location so others can see it. Similarly, the Department of Justice (DOJ) uses cell-site simulators to locate cell phones via signal transmissions to a cell tower. When the simulator emits locator signals, cellular devices in close proximity transmit signals to the simulator, thereby identifying the cellular device(s) of interest. When the cell-site simulator identifies the specific cellular device of interest, it can retrieve signaling

information related to that particular phone. These capabilities can be used to locate cell phones of specific individuals determined to be missing or can be vectored to a specific area to determine the number of victims by the number of pings that are received.

UAS have also recently been applied to the search-and-rescue mission. A UAS videographer helped to rescue a man trapped by floodwaters in North Carolina in the aftermath of Hurricane Matthew. After posting a video on Twitter, he was contacted by relatives of a man trapped in the neighborhood shown in the video. The videographer was able to direct search and rescue teams to rescue the stranded man.[76] The concept of using UAS to go into inaccessible areas represents a significant advancement in search-and-rescue capability. Other conceptual ideas involving UAS include the ability to use the systems to deliver food, water or medical supplies to people trapped, but unreachable by searchers, or even using larger UAS to pick up victims from remote areas.

Related Standards and Guidelines:

- NIEM
- EDXL-DE-V2.0: EDXL Distribution Element, v. 2.0

The ability to track the status of known and potential casualties from site through reunification

"UPS can track a package halfway across the world but we can't track patients in the healthcare system to find out exactly where they are."[77] Patient tracking for large-scale incidents involves maintaining real-time knowledge of the location and status of patients from the incident scene through transport, treatment and reunification. Responders at the Boston Marathon bombing recounted how, because of the fear of a secondary device, victims were loaded quickly into ambulances for immediate removal from the scene. In some cases, multiple people were put into the same ambulance. The responders did not feel they had time to allocate patients and ambulances based on commonly used patient transportation practices. After the fact, it was unclear where patients were located or receiving treatment. This capability is distinct from the capability need discussed below, which is *the ability to manage and track large numbers of fatalities through all phases of response*, because of the time frame and the implications for response operations. This capability need is important because of the need to provide timely and accurate information to family members about the location and status of their loved ones. It is also important because characteristics of the incident can affect response operations. If it is determined that patients on the incident scene were exposed to radiological contaminants,

---

[76] "Stunning serendipity saves man and his dog from N.C. floodwaters," *Washington Post*, posted October 11, 2016, https://www.washingtonpost.com/news/morning-mix/wp/2016/10/11/insane-drone-photo-on-twitter-help-rescue-flood-victim-and-dog-halfway-across-country/.

[77] "Case Study: Revolutionizing Emergency Care: Setting A New Standard in Patient Triage, Tracking and Treatment," Motorola, 2010, https://www.zebra.com/content/dam/msi-new/assets/web/Business/_Documents/Case%20studies/_Static%20files/Electronic%20Patient%20Triage%20Case%20Study.pdf.

for example, command staff would need to know which responders, vehicles and facilities were also exposed.

Goals

- Tracks individual casualties from site through reunification
- Incorporates additional data (e.g., exposure, location and name)
- Integrates with facial recognition and other biometrics
- Integrates with other data sources (e.g., cellular phone records and communications, event data records)
- Provides graphic display of the location of all casualties in the system
- Integrates with GIS coordinates
- Integrates with incident-specific maps
- Allows user queries of data
- Includes ability to filter data and customize filter criteria
- Allows customization based on jurisdiction- and incident-based variables
- Generates resource estimates based on incident-specific data
- Addresses HIPAA issues and regulations

State of Technology

A number of jurisdictions are adopting patient tracking systems for use in mass casualty incidents. In Ohio, for example, a Web-based patient tracking system uses bar-coded triage tags to track patients from the scene. The tag is used for documentation and tracking purposes. Hospitals or medical centers then update the system with arrival status information.[78] Other new commercially available systems include many of the features described above. Responders use mobile devices to scan the bar code on triage tags or identification cards (e.g., driver's license). The initial scan records date, time and GPS coordinates. The interface allows the user to record patient information, vitals and injuries, as well as audio, video and still images. Data can be transmitted to medical facilities (e.g., vitals and images can be sent to the hospital in advance of arrival) or incident command and management staff. One system allows concurrent tracking of patient belongings.

---

[78] News Release, The Center for Health Affairs, "Patient Tracking System Now Available to Ohio Hospitals and Emergency Agencies," (May 27, 2016), http://www.chanet.org/TheCenterForHealthAffairs/MediaCenter/NewsReleases/2016/May/Patient-Tracking.aspx.

Advancements in the field of biographic and biometric services may also augment this capability. The FBI recently launched the Next Generation Identification (NGI) program, which "provides the criminal justice community with the world's largest, most efficient electronic repository of biometric and criminal history information."[79] The NGI System has a biometric identification repository that collects and analyzes biometric information to include fingerprints, palm prints, irises and facial recognition. With the use of compatible mobile devices, responders at the local, state and federal levels can connect to the FBI's NGI biometric system. There is ongoing discussion regarding how this technology, through adaptation, can assist responders in the unique challenges they face during a mass casualty incident by capturing and organizing casualty identifiers.

Related Standards and Guidelines

- HIPAA

The ability to manage and track large numbers of fatalities through all phases of response

None of the incidents studied for the PR5 effort resulted in the number of fatalities that could not be managed, albeit with some difficulty, by the local jurisdiction. However, multiple responders voiced concerns about how they would deal with a mass fatality incident of hundreds or thousands of casualties. Different jurisdictions have different levels of capability and resources in this area. This capability gap is not focused on the processes of fatality management, but on the ability of jurisdictions to administratively manage and track the deceased through the system. Responders need to know the precise location where remains or partial remains were found, status in the fatality management process and details of the release or disposition of those remains. These data are used to provide information to family members, as well as to support incident analysis and investigation functions.

Goals

- Tracks individual remains and partial remains from site through disposition
- Incorporates additional data (e.g., exposure, location and name)
- Provides graphic display of the location of all remains in the system
- Integrates with GIS coordinates
- Integrates with incident-specific maps
- Allows user queries of data

[79] "Next Generation Identification," Federal Bureau of Investigation, accessed October 19, 2016, https://www.fbi.gov/services/cjis/fingerprints-and-other-biometrics/ngi.

- Includes ability to filter data and customize filter criteria
- Allows customization based on jurisdiction- and incident-based variables
- Generates fatality management resource estimates based on incident-specific data

State of Technology

Many local- and state-level jurisdictions maintain fatality management plans that discuss the need for decedent tracking. Some plans also include example templates or cards, intended as a paper document that accompanies the remains through the process. However, research efforts for PR5 did not disclose any digital technologies focused on fatality tracking for incident response. Medical examiners' and coroners' facilities maintain electronic databases for management of remains, but these are not integrated with emergency response capabilities. Patient tracking technologies, such as those described above, have the potential to assist responders in the tracking of fatality information but need to be customized to this need.

Related Standards and Guidelines

- HIPAA

Training and Exercise

The *Training and Exercise* domain is defined as the ability to provide instruction on necessary skills for incident response and coordinate and practice implementation of plans and potential response prior to an incident. There are two capabilities in this domain:

- The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents
- The ability to maintain proficiency in disaster management training for all responders regardless of rank

Figure 20. PR5 Training and Exercise capability need

Each of the Training and Exercise capability needs is discussed below:

The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents

The wide spectrum of potential incidents that emergency responders may face, from natural disasters to man-made incidents, requires a level of preparedness to respond to many types of incidents. Training and exercises represent two of the best ways to prepare. However, both can be costly and time consuming. Many agencies cannot afford the training needed or mandated to qualify for grant funding. Exercises, when designed according to DHS guidelines and inclusive of partner agencies and jurisdictions, have a significantly higher cost burden. Responders throughout the interviews and data-gathering processes stated that they did not have the time or funding to do all of the training and exercises they believed necessary to properly prepare. Current training methods primarily include classroom and Web-based training, hands-on skills training, and immersive academy courses. Given existing budget constraints, many exercises are conducted in tabletop format instead of full-scale interactive events. Responders need a platform to train for multiple types of incidents without significant cost.

Goals

- Immerses users in numerous response scenarios

- Allows users to adopt and train in specific roles
- Incorporates specific knowledge, skills and abilities and specific training curricula
- Allows users to train solo, as part of a selected group or with users nationwide
- Provides multiple variations in scenarios and interactions within the scenario
- Functions on multiple operating systems (e.g., iOS, Android and Windows)
- Allows customization based on jurisdiction-, incident- and role-based variables
- Includes "instructor" role to assess tactics and alter inputs
- Allows user to train over multiple sessions of variable duration
- Provides user feedback, including action-based consequences and scoring
- Provides data for after-action reporting at individual or team level
- Ensures scenarios and roles are inclusive of traditional and non-traditional response agencies
- Allows user to access system from mobile devices and computers
- Incorporates scenarios that are tactics agnostic (e.g., the standard operating procedures of one agency may be different than those of another; the scenario should not fault users for using specific tactics)
- Ability for after-action reporting and observation
- Provides encryption of training sessions
- Functions as platform for agencies or jurisdictions to conduct virtual exercises
- Integrates with jurisdiction-specific maps
- Allows off-line access

State of Technology

In an effort to customize a virtual training environment that targets the unique needs of emergency responders, DHS S&T is continuing development of the Enhanced Dynamic Geo-Social Environment (EDGE). This effort evolved from the U.S. Army's EDGE prototype. The virtual training platform provides the option to train for a single or combined agency response. It gives responders access to various scenarios, and it allows responders to train as individuals or in teams. In future iterations, EDGE will be customizable so that response agencies will be able to tailor the platform to create geo-

specific 3D environments indicative of the infrastructure and resources available in their own environments.[80]

DARPA has several ongoing efforts exploring future technologies for training. DARPA created the ENGAGE program to develop education systems that are "better, faster, continuously optimized, and massively scalable."[81] ENGAGE is exploring software- and data-intensive education and training methods that use the power of large user populations to optimize instruction. ENGAGE has focused initially on interactive technologies for K-12 students. However, it is anticipated that the same techniques used in the ENGAGE program to optimize educational content and instruction in math and science can be applied to a wide variety of military and civilian training contexts.

DARPA is also investing in the development of a virtual test bed for the agency's Tactical Technology Office. The virtual test bed is intended to provide a realistic virtual training environment for the evaluation of squad-level technologies. Integration of first-person gaming engines would allow users to quickly and accurately build new virtual equipment and test capabilities and tactics. The combination of game-based, virtual and realistic training applications of the test bed would accurately model real military systems for easier adoption and engagement with military users at the squad combat level.[82]

Other commercial digital game-based learning platforms are available for responders to use for multi-user virtual training. These programs can provide a lifelike simulation of events and circumstances, such as those that responders are likely to encounter during an actual emergency. Recent advancements in virtual training options include the ability for users to record their sessions and to play them back on request.

Related Standards and Guidelines

- Federal Information Processing Standards (FIPS) Publication 197: Advanced Encryption Standard (AES)

The ability to maintain proficiency in disaster management training for all responders regardless of rank

The need for responders to maintain proficiency in disaster management training is embedded in ICS. The system is a nationwide approach to standardized and integrated incident management. Through its predecessor, FireScope, the fire service has a longer history with this form of incident management and generally uses ICS functions for daily

[80] "Virtual Training: Simulation Tool for First Responders, "DHS Science and Technology Directorate, last modified September 20, 2014, https://www.dhs.gov/sites/default/files/publications/Virtual%20Training-Simulation%20Tool%20for%20First%20Responders_0.pdf.

[81] "ENGAGE," Defense Advanced Research Projects Agency, accessed October 20, 2016, http://www.darpa.mil/program/engage.

[82] "Cubic's Intific Selected to Develop Infantry-Level Virtual Test Bed Technology for DARPA," Cubic, published July 6, 2015, https://www.cubic.com/News/Press-Releases/ID/1512/Cubics-Intific-Selected-to-Develop-Infantry-Level-Virtual-Test-Bed-Technology-for-DARPA.

response activities. Law enforcement was initially more reluctant to adopt the system, but is increasingly amenable to ICS and unified command. However, despite the discipline, there are still significant breakdowns in ICS during large-scale incident response, mainly at the command level. During one large response, the incident commander assumed multiple ICS roles, including that of active-duty responder. This caused significant breakdowns in incident management and negatively impacted response operations. Responders throughout the PR5 process stated the need for all responders, including those in leadership positions, to *maintain* disaster management training. New recruits receive ICS training in the academy. However, as responders become more experienced, this curriculum may be forgotten, leaving gaps in procedures and protocols as they rise to leadership positions. Responders stated there should be systems in place for each department wherein all individuals involved in emergency response efforts, regardless of rank or role, are required to demonstrate proficiency in current ICS protocols and procedures on a recurring basis.

As such, this is not a technology issue. Addressing this capability gap will likely require national-level mandates, evolving attitudes towards ICS and ICS training and expanded commitment within the public safety community to maintain proficiency.

Related Standards and Guidelines: None applicable

Risk Assessment and Planning

The Risk Assessment and Planning domain is defined as the capability to identify and manage likely vulnerabilities and threats and develop appropriate responses to potential incidents based on identified risk. There are two capabilities in this domain:

- The ability to accurately identify local and regional threats and risks and model potential consequences
- The ability to evaluate how evolving man-made incidents or natural disasters (e.g., civil unrest, active shooters and responder targeting) might impact an individual jurisdiction

Figure 21. PR5 Risk Assessment and Planning capability need

Each of the Risk Assessment and Planning capability needs is discussed below:

The ability to accurately identify local and regional threats and risks and model potential consequences

The focus of this capability need is on the ability for local jurisdictions to model threats, hazards and risks in advance of an incident. Many, but not all, jurisdictions complete the Federal Emergency Management Agency's (FEMA) Threat and Hazard Identification and Risk Assessment (THIRA).[83] Completing the THIRA helps communities understand what threats they need to prepare for and what resources they need to respond. State-level agencies and jurisdictions receiving funding under the Urban Area Securities Initiative are required to complete the THIRA, with others only encouraged to do so. Once a community has awareness of its potential threats and risks, whether through completing the THIRA or another assessment, they would like to determine how those threats and risks will affect the community should they occur. Responders specifically requested access to models that incorporate jurisdiction-specific data. To some extent, these models exist. Coastal communities, for example, use floodwater inundation models to visualize

[83] "Threat and Hazard Identification and Risk Assessment," Federal Emergency Management Agency, last updated March 19, 2015, https://www.fema.gov/threat-and-hazard-identification-and-risk-assessment.

on a map where flooding will occur (based on variables). Responders want to expand this type of modeling to other types of hazards.

Goals

- Models natural disasters, infrastructure and facility accidents and chemical, biological, radiological, nuclear, explosive (CBRNE) incidents
- Ingests THIRA and other threat risk-assessment data
- Ingests multiple types of models and layers (e.g., computational fluid dynamics data and remote sensing data)
- Ingests jurisdiction-specific data and maps
- Ingests specific facility data
- Integrates with GIS coordinates
- Provides graphic display of model outputs
- Allows user customization of data visualization
- Includes geographical representation of population, infrastructure and hazards
- Uses data-enabled icons and text data reports as part of graphic display
- Allows user to change variables and parameters to model multiple iterations or occurrences
- Allows user to share outputs with other agencies or jurisdictions
- Functions on multiple operating systems (e.g., iOS, Android and Windows)

State of Technology

There are a number of individual models available for communities to forecast the outcomes of specific threats and risks. These models include:

- Hazus (Hazards US): FEMA's standardized methodology and models to estimate physical, social and economic impacts for earthquakes, hurricanes and floods[84]
- Interagency Modeling and Atmospheric Assessment Center (IMAAC) products: includes dispersion modeling, plume model analysis and hazard prediction[85]

[84] "Hazus," Federal Emergency Management Agency, accessed October 18, 2016, https://www.fema.gov/hazus.

[85] "Interagency Modeling and Atmospheric Assessment Center (IMAAC)," DHS, published May 16, 2016, https://www.dhs.gov/imaac.

- Areal Locations of Hazardous Atmospheres (ALOHA): models chemical releases for emergency responders and planners[86]

The list above is only a selection of the models available from federal agencies. There are also commercially available threat and hazard modeling and simulation capabilities. This technology largely exists as described above by emergency responders. The current barriers include integrating multiple models into one platform, making the models easy to use and increasing the awareness of these models for the public safety community.

Related Standards and Guidelines: None applicable

The ability to evaluate how evolving manmade incidents or natural disasters (e.g., civil unrest, active shooters and responder targeting) might impact an individual jurisdiction

Public safety personnel generally understand the threats and hazards that are most likely to impact their jurisdiction and do their best to prepare for those events. Communities on the East Coast develop floodwater mitigation and evacuation plans in preparation for hurricanes. Likewise, communities with large chemical facilities stockpile appropriate materials for fire suppression. However, some incidents that can occur in any jurisdiction are difficult to plan for. These may include civil unrest with violent rioting, active shooters and other terrorist incidents, and violent targeting of public safety personnel. Moreover, it is difficult to anticipate responses to emerging types of threats. As discussed in the section on the evolving response environment, targeting of responders and violent riots are not new phenomena, but instances have been uncommon over the past several decades. The riots in Ferguson, Missouri, and Baltimore and the targeting and killing of law enforcement officers in Dallas and Baton Rouge, Louisiana, indicate that responders may encounter similar incidents in their jurisdictions and need to be prepared.

Multiple responders interviewed during the PR5 process stated that they had limited ability to plan potential responses if one of these incidents occurred in their jurisdiction. For example, in the case of a violent rioting incident, what jurisdiction-specific pre-plans, training and exercises can be put in place or conducted to prepare? What critical infra-structure needs to be protected? Which streets can be blocked to create a barrier? Which streets can be used to direct the crowd? Do local agencies have sufficient and appropriate equipment? Despite not knowing where, or if, these incidents will occur, it is still possi-ble to develop potential strategies and operations. Responders stated that they often fail to prepare for these types of incidents for several reasons: the thought that such incidents would not occur in their jurisdiction, limited training and exercise funds and limited awareness of best practices and lessons learned.

Responders agreed that there is not a technology solution for this capability need. Jurisdictions require templates and guidance for responding to incidents (similar to the active shooter guidance and strategy documents developed and disseminated by several

[86] "ALOHA Software," U.S. Environmental Protection Agency, last modified September 15, 2016, https://www.epa.gov/cameo/aloha-software.

organizations), as well as a focused effort on the part of their jurisdictions to evaluate how potential incidents might affect their jurisdiction.

Related Standards and Guidelines: None applicable

Intelligence and Investigation

The Intelligence and Investigation domain can be defined as the ability to collect, integrate and assess information to develop conclusions or courses of action prior to a criminal incident or to identify the cause or responsible persons following an event. There are four capabilities in this domain:

- The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation
- The ability to create actionable intelligence based on data and information from multiple sources
- The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence
- The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on scene during response operations

Figure 22. PR5 Intelligence and Investigation capability need

Each of the Intelligence and Investigation capability needs is discussed below:

The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation

An increasing amount of digital data is generated during response operations as well as during the investigation of an incident. This includes incident plans, image and video files, sensor data, witness statements, etc. Responders stated the amount of data generated often becomes too much to process and integrate into response operations. In addition, storage quickly becomes an issue. Responders from one incident reported that the amount of digital data and information uploaded caused their server to crash; subsequently none of the data were available until the issue was resolved. In many cases, however, there is no central repository to upload incident data until after the event, meaning critical data may not be accessible when needed. In cases where there is an incident-specific shared drive, the data are rarely organized, so the utility is diminished.

This capability gap is not focused on creating actionable information from data (see the discussion of *the ability to create actionable intelligence based on data and information from multiple sources* below), nor is it focused on having sufficient server space to store data. This capability gap addresses the need for the automated classification of raw data as they are uploaded or integrated into an incident-specific repository of data and information. For example, all images uploaded shall be geotagged to define location on the incident scene, or information from social media sources has a lower assigned confidence level than that derived from on-scene response personnel. The intent is to make the data more useful before they are turned into actionable intelligence.

Goals

- Provides automated suggested classification of data and information based on metadata (e.g., georeference, priority and data type)
- Uses standard platform of public safety metadata tags
- Allows customization of classification taxonomy and parameters
- Provides initial vetting of information for reliability (e.g., alerts when geotag from uploaded image is not in vicinity of the incident scene)
- Provides automated prioritization of data and information
- Allows user to customize parameters and algorithms
- Allows user to search raw data (e.g., “display all images originating from within set perimeter”)
- Establishes a link to historical database information (e.g., links to images of similar coordinates before and after incident)
- Classifies data in real time
- Allows access across disciplines
- Provides indication of data quality
- Functions to minimize storage space requirements (e.g., identifies duplicate files)

State of Technology

The field of data classification is focused on categorizing or tagging data so it can be used efficiently. The field is technically mature and data classification strategies and processes are used throughout public industry. Automated programs can assess a data repository and apply rules to categorize each data element. The programs filter new data and apply tags automatically. Most of the requirements listed above exist in commercially available programs.

However, one of the requirements listed above is a fundamental first step if data classification strategies will be applied effectively to the public safety arena. There is currently no standard classification taxonomy of public-safety-related metadata tags. Without this standard taxonomy, the categories, parameters and algorithms developed for one incident may not be the same as those developed for another, especially across jurisdictions. As such, it would not be possible to combine data repositories across different incidents.

Related Standards and Guidelines

- NIEM

The ability to create actionable intelligence based on data and information from multiple sources

Many of the data generated during an incident are raw data. For example, hazard sensors report readings, but often the format of those readings is not easy to understand or use. Responders are not able to easily identify critical information or implications of the information or patterns embedded in the data. Raw data are often useless data; only after they are transformed into actionable information or intelligence do they have utility. Adding context, validation and follow-on information provides value. An alert from a chemical sensor is insufficient to allow responders to act based on the alert. However, when the alert is combined with information on the chemical type, prevailing wind direction and recommended protective actions, responders can act purposefully to increase their level of safety. All pieces of information do not come from the same source—information needs to be combined from multiple sources and formats to create actionable intelligence. This process allows responders to understand the information in the context of the incident and plan future actions based on it. Currently, human analysts operating out of a fusion center are the primary developers of actionable intelligence. This limits the involvement of responders from all disciplines and is often not efficient given the increasing amount of data and information that need to be assessed.

Goals

- Provides user with contextual information, potential effects or consequences and suggested next steps
- Provides prediction, forecasts and models
- Provides decision-support prompts
- Alerts user to critical intelligence information
- Ingests data from multiple traditional and non-traditional sources (e.g., social media, public works and private industry)

- Integrates natural language processing for analysis of social media content and sentiment
- Ingests data sources in real time
- Generates outputs in real time
- Provides confidence level associated with outputs
- Includes pattern and trend analysis
- Ingests data in multiple file formats
- Transmits outputs based on role-based permissions
- Allows user to filter data and customize filter criteria
- Allows user to customize triggers and thresholds
- Requires low cognitive load for emergency responders
- Integrates metadata and classification taxonomy
- Provides updates as new data is available
- Ingests data and produces outputs in multiple languages
- Allows user to share outputs across agencies and jurisdictions

State of Technology

DoD currently has comprehensive systems to create actionable intelligence from any available data source. Existing systems provide multiple outputs and visualizations of the intelligence. To augment these capabilities, the DARPA initiated the Insight program to create an integrated system for the analysis of intelligence, surveillance and reconnaissance information. The system will receive, index and store incoming data from multiple sources. It would then analyze and correlate that information, and request and share other relevant information with analysts and data providers. Integrated behavioral learning and prediction algorithms will help analysts discover and identify potential threats and explore hypotheses about those threats' potential activities.[87]

There are also commercially available programs that create actionable intelligence, with some programs designed for use by law enforcement organizations. Available systems integrate data from structured and unstructured sources, including social media. Features of these systems include classification and processing of data, use of algorithms and engines to analyze the data, customizable visualization displays and provision of decision

[87] "Insight," Defense Advanced Research Projects Agency, accessed October 17, 2016, http://www.darpa.mil/program/insight.

support prompts. This technology currently exists and is being further refined; it needs to be more fully transitioned to meet the needs of public safety response operations.

Related Standards and Guidelines

- APCO ANS 1.112.1-2014: Best Practices for the Use of Social Media in Public Safety Communications
- NIEM

The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence

The growth of social media continues to have a profound influence on emergency response. Twitter, Facebook, Periscope and other platforms are used to share information, organize action and increase awareness of events. As evidenced by recent events, however, these platforms can be used to incite and direct violent actions.

- Facebook posts from Baton Rouge, Louisiana, in 2016 instigating violence against law enforcement officers: "Baton Rouge Purge Starts July 9th 12am ends 5am July 10th… Rule 1 Must Kill every Police!!!!"[88]
- Tweets from the 2015 Baltimore riots contained a gun emoji pointing at a policeman emoji[89]

In many recent incidents, responders monitored social media feeds to collect warnings and indications of violence. In some cases, however, the number of social media posts exceeded human capacity to review and assess the posts. Responders at one incident stated that the Twitter feed of related posts scrolled so quickly that it was impossible to read individual messages. Responders stated the need for tools to monitor multiple social media platforms and analyze current and historical posts to identify planned violent activities. Early use of this capability identified social media accounts used in Baltimore that were also tied to periods of peak violence during the riots in Ferguson, Missouri.[90] Analysts believe this suggested the presence of "professional protestors" who were inciting violent activities.[91] Expansion of this type of analysis would help responders identify and prepare for potential actions.

---

[88] "Officials concerned about 'virtual' war on cop," Fox News, July 12, 2016, http://www.foxnews.com/us/2016/07/12/officials-concerned-about-virtual-war-on-cops.html.

[89] "Officials combed social media for information as violence flared," *Baltimore Sun*, July 27, 2015, http://www.baltimoresun.com/news/maryland/freddie-gray/bs-md-ci-social-media-20150727-story.html.

[90] "Social media analysis suggests links between Baltimore and Ferguson violence," Fox News, published April 28, 2015, http://www.foxnews.com/tech/2015/04/28/social-media-analysis-suggests-links-between-baltimore-and-ferguson-violence.html.

[91] Ibid.

Goals

- Actively monitors non-traditional data sources and social media platforms
- Identifies feeds and posts from specific locations or users
- Distinguishes false information and erroneous content
- Monitors and evaluates postings for jurisdiction specificity
- Includes filter and search features
- Ingests information in real time
- Incorporates better means of getting structured alerts from the host company (e.g., public-private partnership)
- Allows access to social feeds on the dark web
- Identifies links between users, locations, activities or syntax

State of Technology

Technology in social media analysis to predict events is advancing quickly. Open Source Indicators Program, a project within the Intelligence Advanced Research Projects Activity, is developing methods to anticipate or detect significant societal events. As part of the project, three teams competed to see which could best predict events that created social disruptions. During the competition period, the teams successfully predicted public health outbreaks, riots, election results and other major events before they actually happened.[92]

The Open Source Indicators team led by Virginia Tech used Early Model Based Event Recognition using Surrogates (EMBERS) to build a forecasting model based on open-source indicators. EMBERS pulls data from publicly available sources, including Twitter, YouTube, Wikipedia, Tumblr, Tor, Facebook and others. It uses algorithms and applications to mine this "dense and complex" information for patterns that identify open-source pre-incident indicators.[93] Since its inception in April 2012, an average of 80 to 90 percent of the forecasts it generates have turned out to be accurate—and they arrive an average of seven days in advance of the predicted event.

A related study funded by the Office of Naval Intelligence assessed social media feeds, specifically posts referencing other users, to predict with 70 percent accuracy the

---

[92] "Open Source Indicators," Office of the Director of National Intelligence, Intelligence Advanced Research Project Activity, accessed on October 10, 2016, https://www.iarpa.gov/index.php/research-programs/osi.

[93] Leah McGrath Goodman. "The EMBERS Project Can Predict the Future with Twitter," *Newsweek*, March 7, 2015. http://www.newsweek.com/2015/03/20/embers-project-can-predict-future-twitter-312063.html.

likelihood that someone's next post will be part of a protest.[94] Researchers believe this technology can be used to predict how large a societal event may become.

This field is growing, and continued investments by the military and intelligence community may soon push the state of technology to meet responder requirements.

Related Standards and Guidelines

- APCO ANS 1.112.1-2014: Best Practices for the Use of Social Media in Public Safety Communications

The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on-scene during response operations

Minutes after the gunman started his shooting rampage in the Pulse Nightclub in Orlando, Florida, the nightclub posted a warning on its Facebook page: "Everyone get out of pulse and keep running."[95] Patrons of the club, including some trapped and some who escaped, posted updates on Facebook and Twitter during the shooting and the standoff between police and the gunman. Some patrons posted the location of where they were hiding in hopes of rescue. Others communicated via Facebook and text with family members. A witness positioned on a nearby rooftop shared live video from the scene.[96] In addition, the shooter pledged his allegiance to the so-called Islamic State on Facebook during his rampage. He also texted his wife from the scene, asking if she had seen the news.[97]

This incident clearly exemplifies the kind of information that responders would like to have access to in real time to support operations: accounts from persons trapped inside, images and video from eyewitnesses directly in sight of the events and communications from the perpetrator. These are all critical information sources that could improve the ability of responders to perform rescue operations, neutralize a suspect and obtain situational awareness. However, much of this information is currently unavailable to responders until after the incident.

---

[94] "Military Funded Study Predicts When You'll Protest on Twitter," Defense One, February 23, 2016, http://www.defenseone.com/technology/2016/02/military-funded-study-predicts-when-youll-protest-twitter/126156/.

[95] Twitter, Orlando Pulse, posted June 12, 2016.

[96] Twitter, Nic Hornstein, posted June 12, 2016 at 4:40 a.m.

[97] "Orlando shooter texted wife during attack, source says," CNN, posted June 17, 2016, http://www.cnn.com/2016/06/16/us/orlando-shooter-omar-mateen/.

Goals

- Captures social media posts and electronic communications in real time
- Allows geolocation of specific phones or devices being used to post or communicate on the incident scene, including those without battery power or those that are turned off
- Features ability for 3D geofencing of targeted areas
- Captures phone numbers and other user data
- Allows historical analysis, including geolocation of users prior to the incident
- Captures and translates social media posts and electronic communications in multiple languages and using "talk to you" (TTY) devices
- Includes search and filter features

State of Technology

There is currently limited capability to capture social media posts and electronic communications from on-scene casualties, eyewitnesses or suspects. Currently, the DOJ and other government agencies use cell-site simulators to capture electronic transmissions from smartphones and devices in a specific location. Cell-site simulators transmit locator signals to a cell tower. When the simulator emits the signals, cellular devices in close proximity transmit signals to the simulator, thereby identifying the cellular device(s) of interest. However, according to DOJ policies, the simulator may not be used to collect data on the phone itself.[98] This technology only addresses one of the requirements articulated by responders.

Related Standards and Guidelines

- APCO ANS 1.112.1-2014: Best Practices for the Use of Social Media in Public Safety Communications

[98] Press Release, DOJ, "Justice Department Announces Enhanced Policy for Use of Cell-Site Simulators" (September 3, 2015), https://www.justice.gov/opa/pr/justice-department-announces-enhanced-policy-use-cell-site-simulators.

(This page intentionally left blank.)

CONCLUSION

In this iteration of Project Responder, a multi-disciplinary group of responders from across the United States identified capabilities necessary to respond to the diverse threats, circumstances and issues that they currently face. As their response environment continues to evolve, so too do the capabilities needed to operate in that environment. This document describes 37 capability needs identified by emergency responders as necessary for improved response to large-scale incidents. All of the 37 needs can be considered to be priority needs; each describes a capability that is necessary for multiple types of incidents and is designed to improve responder or public safety. Many of these capabilities also improve efficiency of response, allowing responders to mitigate threats and carry out their mission more quickly.

Just as in previous iterations of Project Responder, responders also prioritized among the 37 capability needs to identify those that they determined to be the highest priorities. Over 100 responders from jurisdictions across the United States provided input to this prioritization. Based on those results, the following needs represent the highest priorities for improving response capabilities:

The ability to quickly establish joint command between jurisdictions and agencies

The ability to geolocate responders on the incident scene (indoors and outdoors) including latitude, longitude and altitude/depth

The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation

The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on the scene during response operations

The ability to share incident-related information among agencies and disciplines during response operations

The ability to merge and synthesize disparate data sources in real time to support situational awareness

The ability to create actionable intelligence based on data and information from multiple sources

The ability to access, integrate, share and display images and video pertinent to the incident scene for the responder and incident command

There are a number of observations that can be made in assessing these priorities and other data collected during the PR5 process. First, there remains continuity in the priority of many of these capability needs. The *ability to geolocate responders on the incident scene (indoors and outdoors) including latitude, longitude and altitude/depth* was first identified by responders as a high priority in the initial Project Responder report published in 2004 (originally described as “point location and identification”), and again in each subsequent report. This remains an elusive, but critical capability for the response community. The ability to know where responders are on the incident scene, including their proximity to threats and hazards, would provide significant advancements in responder safety. The criticality of this need is evidenced when

reviewing many of the incidents used as the foundation for this report. From riot events, law enforcement shootings and response to natural disasters, geolocation of responders on the incident scene would greatly improve responder safety.

Table 2 below depicts the highest priority capability needs in Project Responder over time. The needs are abbreviated for illustration purposes and shaded using the coloring schema used throughout this document for each domain. Only the capability needs that are identified across multiple iterations are shaded. Responder geolocation is the one capability need identified as a high priority in all iterations of Project Responder.

Table 2. Project Responder priorities across time

Capability Priorities Across Time				
2004 Priorities	2008 Priorities	2011 Priorities	2014 Priorities	2016 Priorities
Body protection from all hazards	Command & management	Virtual simulation training	All-environment communications	Joint command
On-scene detection	Communications (3)	Responder geolocation	Responder geolocation	Responder geolocation
Remote & standoff detection	Seamless data integration	All-environment communications	Threat detection & monitoring	Integration of digital information
Point location & identification	Full-body personal protection	Remote tactical monitoring	Hazard identification	Integration of social media feed data
Seamless connectivity & integration	Logistics support (2)	Body protection from all hazards	Remote tactical monitoring	Information sharing
Mass victim decontamination	Mass prophylaxis distribution	PPE integrated communications	Body protection from all hazards	Integration of disparate data sources
Risk awareness & assessment	Training & exercise programs	Threat detection & monitoring	PPE integrated communications	Creation of actionable intelligence
Mass medical prophylaxis	Mass victim decontamination	Resource availability	Resource availability	Integration of images and video
Mass casualty medical care management	Responder respiratory protection	Trend & pattern identification	Casualty location	
Individual & collective protection	Point location & identification	Hazard identification	Trend & pattern identification	
Surveillance & information integration	Prioritization & dissemination	On-scene resource status	On-scene resource status	
Logistics information systems	Credentialing	Casualty location	Virtual simulation training	
Threat assessment/data collection/analysis			All-source information integration	
			Software application assessment	

The table above also highlights the increasing priority in the need for integration of data from multiple sources. Half of the eight highest priority needs in PR5 describe the need to integrate data. Responders have access to increasing amounts of data. Being able to access the right data, in the right format and at the right time, could provide significant advancements in situational awareness, responder safety and the ability to conduct an investigation. Had the Orlando police department been able to access video and social media messages from those trapped inside the Pulse night club, or had the firefighters in West, Texas, had access to data about the materials produced in the fertilizer plant and the appropriate response activities, events may have

transpired differently. There are four different data integration capability needs listed among the highest priorities, but they all represent a distinct need and potentially different technology solutions. Being able to access, integrate and display images and video may require a different solution than being able to do the same with text data. This is especially problematic currently as the many land-mobile responder radios cannot display data, leaving emergency responders with access to a small fraction of the data available to the public on their smart phones. As evidenced by the priority given to these capability needs, responders are anxious to be able to integrate and access critical data feeds.

Responders in PR5 identified two non-technology needs among the highest priorities. Although this effort is sponsored by the S&T Directorate of DHS, the FRG recognizes that a number of the most critical needs cannot be solved by technology, but instead require advances or developments in policy, process, training or changes in culture and approach. The FRG encouraged the Project Responder team to identify the non-technology needs and it is not surprising that two of them are listed among the highest priorities. Review of multiple after action reports and other documentation provides evidence that the failure to establish joint command at the outset of an incident has negative consequences for response operations. Likewise, the inability or unwillingness to share information among agencies and jurisdictions can produce significant potential costs, both in dollars and lives lost. The materials to address these needs already exist, however, individual agencies and jurisdictions must remain committed to adopting and upholding the foundational policies. Although the FRG is able to provide support where technology can enable these capabilities, it is the responsibility of local, state and federal agencies to implement and adhere to policies that will address these needs. Federal agencies, inter-agency working groups and response associations could support this effort through the development of policy guidelines and templates, additional training materials or benchmarks to measure local capabilities.

A further observation based on the PR5 results is a relative decline in priority for interoperable communications, logistics tools and body protection garments and equipment. Each of these was a high priority in all previous iterations of Project Responder. However, this relative decline is not to say that these capability needs are no longer priorities at all. A review of the data from the focus groups illustrates that a responder safety need (*the ability to monitor the physiological signs of emergency responders*) and a logistics-related need (*the ability to geolocate non-personnel resources on the incident scene*) were rated as high priority among the responders that discussed the needs in detail.[99] Discussions during the focus group meetings can also shed some light on this relative decline. In some cases, responders believe that recent or anticipated advancements may address the issue. FirstNet, for example, is intended to address many of the issues involved with interoperable communications when the system becomes operational.

To close, it is important to discuss a path forward. The FRG fills a critical need in developing technologies, knowledge products and standards for the emergency response community. Unlike other constituencies in DHS, the FRG's customers are not federal employees. The FRG cannot develop technologies and mandate that they be used. The FRG is responsible for developing new

[99] These needs are not included among the list of the highest priority needs because they did not receive as high of ratings during the FRRG prioritization, and therefore are not universally recognized among the PR5 participants as being at the highest level of priority.

capabilities for responders in thousands of agencies throughout the United States, each with different priorities, challenges and budgets. It is critical that the FRG fulfill this mission. State and local agencies and jurisdictions cannot afford to develop new technology on their own and can rarely afford to impact the development of technology through private industry. Although industry often solicits input from the response community, it is often accomplished through liaison with the jurisdiction local to the manufacturer or with one large city as a representation for responders throughout the country. The PR5 results demonstrate that capability needs are not one-size-fits all. The equipment or configuration that is appropriate for the Northeast is not the same as needed in the Southwest. The ability of the FRG to access responders from across the country to identify emergency response capability needs is both unique and essential. The FRG has access to the responders, as well as the mission and resources to improve their capabilities. Project Responder provides value to the FRG because it a trusted forum where responders are willing and eager to discuss their needs, as well as independent analysis of the input, priorities and results.

The response environment continues to evolve, in terms of type and frequency of incidents, behavior of perpetrators and the public, and information and technology available to support operations. It is essential that the FRG continue to monitor that environment, and assess the type and priority of capability needs as necessary.

APPENDIX A. HISTORY OF PROJECT RESPONDER

Project Responder is an ongoing effort to identify the capability needs for response to large-scale incidents. The effort is distinctive because of its emphasis on conveying the voice of the emergency responder and its inclusion of traditional and non-traditional response agencies as part of data gathering. Project Responder outcomes are recognized for the methodology and the extent of end-user involvement. U.S. Department of Homeland Security (DHS) leadership referred to Project Responder 4 as "one of the best examples of how requirements are gathered, vetted, and a plan put together for their execution."[100] The Project Responder 4 results are being used by an international consortium of more than 16 countries as the basis for developing responder capabilities and are used by technology development agencies in foreign countries. The current Project Responder 5 (PR5) study is the fifth iteration.

The initial iteration, running from 2001 to 2004, was funded through a Department of Justice grant to the Oklahoma City National Memorial Institute for the Prevention of Terrorism. The original intent was to identify operational needs, shortfalls and priorities for response to catastrophic incidents and develop a technology investment plan to meet identified capability deficits. Shortly after inception, the focus of Project Responder was fundamentally shifted by the terrorist attacks of Sept. 11, 2001. During development in the initial iteration, emergency responders from multiple disciplines and a wide range of jurisdictions and locations participated in a series of interviews and responder workshops. The output of the data-gathering process was the development of 12 capability areas that defined and described the requirements for response to a catastrophic terrorist event. The capability areas were referred to as National Terrorism Response Objectives. Following the identification of capability requirements, a second series of workshops queried technologists from national laboratories, academia and private industry to inform a national agenda for research and development and a corresponding set of road maps detailing new initiatives designed to close gaps in emergency response capability. The output of the first iteration was the *Project Responder National Technology Plan for Emergency Response to Catastrophic Terrorism.*

DHS Science and Technology Directorate (S&T) initiated the second iteration of Project Responder in 2007. The focus was to examine changes in the emergency response environment since the 2004 report and identify new and enduring capability priorities. Despite the relatively short time frame between the first and second study efforts, significant shifts in the emergency response mission and needs occurred as a result of an increased focus on "all hazards" (due in part to events like Hurricanes Katrina and Rita, failure of large-scale infrastructure like the I-35 bridge collapse, pandemic influenza, etc.) and the evolution of national response policy and doctrine with the release of the National Incident Management System and the National Response Plan (which was later revised as the National Response Framework). As a result, the second Project Responder report found significant changes to responder capability needs and related priorities. Emergency responders from a wide range of disciplines, jurisdictions and agencies participated in the effort through a series of interviews and workshops. The findings from the 2008 report, *Project Responder: Review of Emergency Response Capability Needs,*

[100] Quotation attributed to Dr. Reginald Brothers, Deputy Under-Secretary of the DHS Science and Technology Directorate, as relayed by FRG staff.

included a set of 15 capability priorities and associated challenges in training, technology, management and policy that responders felt constrained the further development of respective capabilities.

In 2011, *Project Responder 3: Toward the First Responder of the Future,* examined capabilities needed to fill existing gaps and created a vision of emergency response in the future. DHS funded Project Responder 3 through a joint relationship between S&T's Support to the Homeland Security Enterprise and First Responders Group and the National Preparedness Directorate of the Federal Emergency Management Agency. Since the Project Responder 2 report, a number of economic, technological, infrastructural and societal developments—as well as a change in the number and type of major incidents facing the nation—combined to change the response environment. DHS believed these changes warranted a reevaluation of capability gaps and resulting investment priorities. As with the previous studies, Project Responder 3 used facilitated discussions with a diverse set of responders throughout the United States to identify existing response capability gaps. Through these discussions, participants identified 40 capabilities needed to fill existing gaps. Among these 40 capabilities, responders identified a subset of 12 capabilities as those of the highest importance. Project Responder 3 also produced a vision for potential capabilities that may be required in a future response environment, unconstrained by resource or technical considerations.

Project Responder 4 (PR4) built on previous efforts examining the state of science and technology for opportunities to address the most persistent and highest priority capability needs and developing a plan to address those needs. The results of PR4, *Project Responder 4: 2014 National Technology Plan for Emergency Response to Catastrophic Incidents,* identified 14 capability needs that responders believed represented the highest priorities for improving their ability to respond to catastrophic incidents. The capability needs included enduring needs that were identified across the previous phases of Project Responder and emerging needs that allow responders to use technological advances occurring in other fields. The plan further identified 42 response technology objectives (RTOs) that address the PR4 capability needs. The RTOs translated the capability statements into actionable, technology-centric objectives. Each identified a high-level technology solution (or part of a solution) designed to improve the capabilities of the response community. This plan also contains a series of technology road maps that illustrate the project timelines and resource requirements for each RTO.

PR5 examined emergency response capability needs for large-scale incidents in light of changes to the response environment, including the increase in incidence and severity of natural disasters and weather-related events, the growth of mass civil disturbance and riot events, and the introduction of violent targeting of emergency responders. PR5 identified capability needs for emergency response to large-scale incidents through review of after action reports and other documents, interviews with responders who participated in many recent large-scale incidents and a series of focus group meetings. The PR5 report describes 37 capability needs, responder-articulated goals for addressing those needs and related standards and technology programs.

APPENDIX B. INCIDENT SUMMARIES

This appendix contains summaries of the 20 incidents studied in Project Responder 5 (PR5). Where applicable and available, each summary identifies key findings that are related to the PR5 capability needs.

Century 16 Theater Shooting

Location: Aurora, Colorado

On 20 July 2012, a lone gunman shot moviegoers at the Century 16 Theater in Aurora, Colorado, shortly after midnight. Soon after the movie began, the shooter used an emergency exit to leave the theater. He returned shortly after, wearing tactical gear and armed with tear gas canisters and multiple firearms. Eighteen minutes into the movie, he began firing into the audience.[101] In total, 70 people were shot, 12 died and at least 12 were injured as they fled the building to the parking lot.

The shooter surrendered to police outside the movie theater minutes after he exited the building. The shooter also set booby-traps at his residence with improvised explosive devices. Responders discovered this when they went to search his apartment. Investigators used a robot to disarm the explosive devices, which included more than 30 homemade grenades and incendiary devices.

This incident is distinctive because of the method used to transport many of the injured to local hospitals. For numerous reasons (see capability gaps below), Aurora, Colorado, police officers used their vehicles for transport. Of the 60 patients brought to hospitals for treatment, 27 arrived in police cars, 20 in ambulances, 12 in private vehicles and one walked.

Selected areas of improvement identified by the *Aurora Century 16 Theater Shooting After Action Report for the city of Aurora, Colorado*:[102]

- Police and fire officials did not establish a unified command or a single overall commander until late in the first hour of the incident.
- In part due to the volume of radio traffic and dispatcher workload on police and fire frequencies, some critical messages were either not successfully relayed to recipients or not understood between police and fire incident commanders
- The level of risk in the theater was not discussed between police and fire commanders.
- Police and fire need to work out procedures for better access to victims in such logistically complex circumstances.
- Providing information to families on the status of loved ones was problematic.

---

[101] "Colorado Theater Shooting Fast Facts," CNN, last updated July 4, 2016, http://www.cnn.com/2013/07/19/us/colorado-theater-shooting-fast-facts/.

[102] *Aurora Century 16 Theater Shooting After Action Report for the City of Aurora, Colorado*, (Arlington: System Planning Corporation, TriData Division, April 2014).

Baltimore Riots

Location: Baltimore, Maryland

On 25 April 2015, the Baltimore Police Department (BPD) began to see a shift in the atmosphere among the protestors demonstrating against the death of Freddie Gray while in police custody on 19 April. As the crowd marched toward City Hall, BPD noticed increased agitation among a small faction of the group. This group moved off toward Camden Yards, where violence erupted against baseball fans, pedestrians and motorists in the area. BPD reported damage to police vehicles and some area businesses. Command ordered officers to not intervene or engage the rioters.[104]

Figure 23. Peaceful demonstrations following the Baltimore riots[103]

On 27 April, anonymous fliers were passed around at a local high school and via social media calling for a "purge" to begin after students were let out for the day.[105] At about 3:15 p.m., riots broke out in the area of Mondawmin Mall. The rioters began to attack BPD personnel with rocks, bricks and concrete, seriously injuring some officers. The rioting and looting of businesses in the area continued for hours. It is estimated that rioters looted, damaged or destroyed more than 300 businesses, with some businesses being set ablaze. [106]

A state of emergency was eventually declared in Baltimore, and the National Guard was deployed. The rioting ended with millions of dollars in property damage, injuries to citizens and injuries to more than 200 responders. Incidents of violence and looting diminished throughout the following days, with sporadic incidents occurring into early May.

Selected findings identified in the Recommendations for Enhancing Baltimore City's Preparedness and Response to Mass Demonstration Events:[107]

- The city had inadequate policy and guidelines for mass demonstration management and had not appropriately recognized the extent of the strategic and tactical distinction between routine operations and mass demonstration management.
- The city had no written policy and an unclear strategy on critical infrastructure protection.

---

[103] Photo by U.S. Army National Guard Sgt. Margaret Taylor, 29th Mobile Public Affairs Detachment.

[104] *After Action Review: A Review of the Management of the 2015 Baltimore Riots*, (Baltimore: Baltimore City Fraternal Order of Police, Lodge #3, 2015), http://www.fop3.org/wp-content/uploads/2015/07/AAR-Final.pdf.

[105] "After-Action Report: Learning From Baltimore's Response to Riots," In Public Safety, posted July 1, 2015, http://inpublicsafety.com/2015/07/after-action-report-learning-from-baltimores-response-to-riots/.

[106] Ibid.

[107] *Recommendations for Enhancing Baltimore City's Preparedness and Response to Mass Demonstration Events*, (Baltimore: Johns Hopkins University, December 2015), http://mayor.baltimorecity.gov/sites/default/files/Baltimore%20City%20Recommendations%20v120415_0.pdf.

- The city did not use an appropriate and well understood Incident Command System (ICS) for this incident and did not fully adhere to National Incident Management System (NIMS) principles.
- Critical information, including sensitive intelligence and basic operational data regarding the expected "purge" at Mondawmin Mall, was not communicated in a timely fashion to necessary stakeholders outside of BPD.
- Deficiencies in BPD communications were exacerbated by fragmented and inconsistent technical practices.
- The city in general, and BPD in particular, did not have the right equipment, in the right quantities and in proper condition, to respond to a mass demonstration, protest or riot.
- Processes for requesting resources were variable and not well documented, bypassed standard procedures and resulted in confusion during the resource request and fulfillment processes.
- Leadership from many city agencies identified that their personnel would benefit from improved services for critical incident stress management, mental wellness and trauma-specific care.

Boston Marathon Bombing

Location: Boston, Massachusetts

On the afternoon of 15 April 2013, two homemade improvised explosive devices (IEDs) detonated in separate locations near the finish line of the Boston Marathon. The IEDs were hidden in backpacks and placed on the ground level in viewing areas near the marathon finish line. The explosions killed three people and injured 264, many critically.[109]

Figure 24. Scene of Boston Marathon bombing[108]

It was quickly evident to many on-scene responders that the incident was an intentional act of violence and that there was a likelihood of secondary devices. Despite this threat,

[108] *After Action Report for the Response to the 2013 Boston Marathon Bombings,* (Boston, December 2014), http://www.mass.gov/eopss/docs/mema/after-action-report-for-the-response-to-the-2013-boston-marathon-bombings.pdf.

[109] Ibid.

emergency responders continued to provide medical treatment and transport patients away from the scene. Spectators, volunteers and runners also provided aid to the injured.[110]

Three days later, photographs of two suspects were released to the public. Soon after, the suspects carjacked an SUV in the Boston area. When the stolen vehicle was located, the suspects fired upon and launched homemade IEDs at responding officers. Police shot one of the suspects, who was subsequently struck by the stolen vehicle when the other suspect attempted to flee. In the shootout, a transit officer was shot and critically wounded. The injured suspect later died, but the other suspect fled on foot. Later, the suspect was located hiding in a winterized boat parked in a yard, and after a 24-hour standoff with officers, the suspect was arrested.

Selected findings identified in the after action report for the response to the 2013 Boston Marathon Bombings:[111]

- Boston's Emergency Operations Center (EOC) was not activated for the running of the 2013 marathon. This delayed the activation of Boston's WebEOC and sharing of situational awareness information through that portal.
- Once the bombings occurred, the existence of numerous operations centers created confusion about which city agencies were leads for which response efforts.
- Many law enforcement officials experienced post-traumatic stress associated with observing and responding to an incident of the magnitude of the bombings.
- There were approximately 5,000 runners on the course in Boston, Brookline and Newton, Massachusetts, when the bombings occurred and the race was stopped. The management of the evacuation of large numbers of runners off the course was not pre-planned and was therefore unsystematic.
- Some disciplines were unfamiliar with the marathon communication plan, had difficulty initially accessing the designated channels and quickly reverted to the internal systems that they felt most comfortable using.
- Although senior leadership and Unified Command were quickly advised that there were no chemical, biological, radiological or nuclear contaminants in the IEDs, this information was not widely relayed to other responders, mutual aid partners or the hospital community.
- A centralized source from which family members of victims and human services organizations could obtain patient information could not be established because of Health Insurance Affordability and Accountability Act (HIPAA) concerns.

Emanuel African Methodist Episcopal Church Shooting

Location: Charleston, South Carolina

[110] Ibid.

[111] Ibid.

On the evening of 17 June 2015, a shooter allegedly sat with parishioners during a Bible study group at Emanuel African Methodist Episcopal Church in Charleston for nearly an hour before he opened fire. He shot and killed nine attendees, and a 10th victim survived. Others survived unharmed, including one woman spared as a witness to recount the story. The gunman fled the scene after the attack. After spending 13 hours on the run, the shooter was arrested at a traffic stop in Shelby, North Carolina. He had in his possession a Glock .45 caliber semiautomatic handgun that he purchased the previous April. The incident was categorized as a racially motivated hate crime.

The shooter told authorities that he briefly reconsidered initiating his plan during the time he spent with the Bible study group, but eventually carried out the attack. The shooter claimed that he carried out the attack to start a race war.

Federal prosecution of the alleged shooter is underway, and limited information about response operations can be released until the case is concluded. No publicly available after-action reports have been released as of the date of this report.

Shooting of Dallas Police Department Officers

Location: Dallas, Texas

Over a period of several days in June and July 2016, videos showing two African-American men being shot by police in Louisiana and Minnesota spurred protests and debate over law enforcement's use of force. On 7 July 2016, peaceful protesters were marching in Dallas when a shooter ambushed officers, using an SKS semi-automatic rifle. He killed five officers and wounded seven. It was the deadliest incident for U.S. law enforcement since 11 September 2001. Initially, there was confusion as to the number of shooters involved in the police ambush due to the presence of protestors on scene carrying rifles and wearing ballistic vests who dispersed when the shooting began.[112] Much of the incident was documented by traditional media and social media posts from the crowds on scene.

In a lengthy standoff with police, the shooter told negotiators of his anger about the recent police shootings in Louisiana and Minnesota. He also stated that he wanted to kill white people, especially white officers. When negotiations failed to persuade the shooter to surrender, the Dallas police bomb squad placed an explosive device on a robot and detonated it near the shooter, killing him.

No publicly available after-action reports have been released for this incident as of the date of this report.

Ferguson Riots

Location: Ferguson, Missouri

[112] "Dallas sniper attack: 5 officers killed, suspect identified," CNN, last modified July 9, 2016, http://www.cnn.com/2016/07/08/us/philando-castile-alton-sterling-protests/.

On 9 August 2014, an officer shot and killed Michael Brown following an encounter with law enforcement. Witnesses and observers began to crowd around the scene, with the crowd growing increasingly hostile and threatening to the responding officers.[113] Due to the small size of the Ferguson Police Department, assistance from neighboring jurisdictions was requested as soon as the crowd began to encroach on the scene of the shooting. Those on scene reported that the arrival of a growing number of emergency vehicles appeared to fuel the crowd's anxiety. By 10 August 2014, crowds continued to grow in size and agitation, reaching nearly 1,000 protestors in front of the Ferguson Police Department, leading to requests for additional law enforcement from the state level. Protestors vandalized and looted more than 30 local businesses.[114]

Approximately 10 days after the shooting, daytime demonstrations were relatively peaceful. However at night, the demonstrations grew in size, and violence against law enforcement increased. Police reported that demonstrators were throwing rocks, bottles, frozen bottles of water, Molotov cocktails and other objects. The mass gatherings became more vocal and aggressive with burning of businesses and other property damage, including looting and breaking windows.[115] On the 17th, several hundred protesters tried to overrun the law enforcement command post. As a result, on the 18th, Missouri Governor Jay Nixon ordered the National Guard to the St. Louis area to provide additional assistance. After the grand jury inquiry into the death of Michael Brown began on 20 August, the protests and violence began to subside. The governor called for the withdrawal of the National Guard, and by 25 August, the protests were essentially over.

Selected findings identified in the After Action Assessment of the Police Response in Ferguson, Missouri:[116]

- While incident command was established, NIMS was not fully implemented, which inhibited coordination and response efforts.
- Limitations and variations in officer training on civil disobedience, deescalation and mutual aid negatively impacted the response to events in Ferguson.
- There was no evidence of comprehensive training or exercises involving all four agencies related to NIMS.
- Because of the lack of clear direction for unified operational policies, officers from more than 50 law enforcement agencies involved in the response to the mass gatherings typically relied on their parent agencies' policies to govern their actions.
- Incident command did not functionally incorporate available intelligence into the strategic decision-making process because NIMS was not fully implemented.

[113] *After Action Assessment of the Police Response in Ferguson, Missouri* (Washington: Department of Justice), 6.

[114] Ibid.

[115] Ibid, 16.

[116] Ibid.

- Limited intelligence was shared with incident commanders, despite intelligence personnel being assigned to the command post.
- Officers deployed for incident management received little intelligence about threats and protester strategies, which inhibited their ability to manage public interactions and make informed decisions.
- Radio interoperability challenges impeded communications among responding law enforcement agencies in the early days of the response.
- The four core law enforcement agencies underestimated the impact social media had on the demonstrations and the speed at which both facts and rumors were spread, and failed to have a social media strategy.

Hurricane Sandy

Location: East Coast of the United States, affecting states from Florida to Maine

Hurricane Sandy was the second-largest Atlantic storm on record, with effects that spanned 24 states. Sandy made landfall on 29 October 2012, inundating the densely populated New York and New Jersey region. As a result, this region experienced heavy rains, strong winds and record storm surges. Sandy also produced blizzard-like conditions in the Appalachian Mountains and severe winds and flooding in the coastal areas of the Great Lakes. The storm damaged or destroyed hundreds of thousands of homes, caused tens of billions of dollars in damages and killed at least 162 people in the United States.[118]

Figure 25. Aftermath of Hurricane Sandy[117]

Sandy caused water levels to rise along the entire East Coast of the United States. The highest storm surges and greatest inundation on land occurred in the states of New Jersey, New York and Connecticut, especially in and around the New York City metropolitan area. In many of these locations, especially along the coast of central and northern New Jersey, Staten Island, New York, and southward-facing shores of Long Island, New York, the surge was accompanied by powerful damaging waves.[119] Sandy's storm surge, in addition to large and battering waves, devastated large portions of the coasts of New Jersey and New York. In fact, the extent of

[117] Photo by Andrea Booher, FEMA.

[118] *Hurricane Sandy FEMA After-Action Report*, (Washington: Federal Emergency Management Agency, July 1, 2013), https://www.fema.gov/media-library-data/20130726-1923-25045-7442/sandy_fema_aar.pdf.

[119] *Tropical Cyclone Report: Hurricane Sandy*, AL182012, (Miami: National Hurricane Center, February 12, 2013), 8. http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

catastrophic damage along the New Jersey coast was unprecedented in the state's history. Whole communities were inundated by water and sand, houses were washed from their foundations, boardwalks were dismantled or destroyed and boats were pushed well inland from the coast.[120]

Selected findings identified in the *Hurricane Sandy After Action and the Hurricane Sandy FEMA After Action Report*:[121, 122]

- Many residential facilities, including nursing homes and adult care facilities, were not adequately prepared for the storm and its aftermath.
- Some of the most challenging issues during and after the storm arose in connection with providing care to evacuees with special medical needs.
- New York City did not immediately have access to accurate, timely data from power utilities, telecommunications companies, fuel providers, gas stations and other sectors that provide critical services.
- Sandy response operations in New York and New Jersey revealed inconsistencies in the way FEMA establishes incident management structures for large-scale incidents.
- Some FEMA planners struggled to effectively use "deliberate planning" developed pre-incident to then guide "incident planning" during Sandy.
- There was confusion regarding FEMA's role in the immediate lifesaving and life-sustaining needs of individuals with access and functional needs.

Joplin Tornado

Location: Joplin, Missouri

On 22 May 2011, an Enhanced Fujita-5 (EF-5) tornado, struck Joplin, Missouri, with winds at more than 200 mph. The National Weather Service (NWS) was able to issue severe weather warnings for the surrounding area and many residents were able to seek shelter. The tornado touched down at 6:41 p.m. on a Sunday, so many residents were at home when it struck. Even with prior warning, the tornado killed 161 and

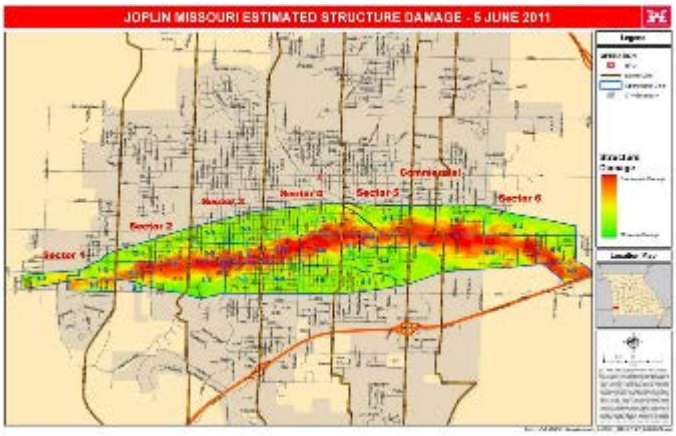

Figure 26. Map of Joplin structural damage[123]

[120] Ibid.

[121] *Hurricane Sandy After Action, Report and Recommendations to Mayor Michael R. Bloomberg*, (New York City: New York City Mayor's Office, May 2013).

[122] *Hurricane Sandy FEMA After-Action Report*, (Washington: Federal Emergency Management Agency, July 1, 2013), https://www.fema.gov/media-library-data/20130726-1923-25045-7442/sandy_fema_aar.pdf.

[123] U.S. Army Corps of Engineers assessment map

injured over 1,300.[124] At the time, it was the seventh-deadliest tornado on record and the deadliest tornado in the United States since 1950.

The tornado's path was 22 miles long and at times up to a mile wide. It caused widespread devastation in Joplin, leaving 7,500 residences and 500 businesses damaged or destroyed. The tornado damaged multiple health care facilities, including the St. John's Regional Medical Center, where five patients and one visitor were killed.[125] The tornado displaced an estimated 9,200 people, and generated 3 million cubic yards of debris.

Selected findings identified in the *Response to the 2011 Joplin, Missouri, Tornado Lessons Learned Study*:

- The thousands of mutual aid responders and volunteers who self-dispatched to Joplin, Missouri, immediately after the tornado enabled Joplin to conduct response operations, but presented challenges for incident management.
- The magnitude of the fatalities overwhelmed the capabilities of county coroners and presented challenges for the Disaster Mortuary Operational Response Team.
- Data and analyses from previous disasters were not available to inform Joint Field Office decision making.
- Unsolicited donations, and storage of those donations, caused significant logistical problems.

Kalamazoo Uber Shootings

Location: Kalamazoo, Michigan

On 20 February 2016, a driver for Uber went on a shooting rampage, killing six people and seriously wounding two others in three separate incidents across Kalamazoo, Michigan. The driver first shot a mother who was with her children at an apartment complex parking lot. He asked her if she called for a ride before he shot her multiple times. Four hours later, he killed a father and son at a car dealership. Minutes later, he drove to a Cracker Barrel restaurant, where he asked one of the victims "if she could spare a dollar to make America great again." He shot her when she declined his request. Though the driver indicated to police that he had planned to leave the Cracker Barrel after he shot the first victim, he heard others screaming and decided to shoot them, as well.

Between attacks, the shooter picked up several Uber passengers and drove them to their destinations. One passenger indicated the shooter drove erratically, causing him to repeatedly ask to be let out of the car. The passenger escaped and called police. Two hours after the final shootings at the Cracker Barrel, police arrested the driver without incident in downtown Kalamazoo, Michigan. They seized the semi-automatic pistol used in the attacks.

---

[124] *The Response to the 2011 Joplin, Missouri, Tornado Lessons Learned Study*, (Washington: Federal Emergency Management Agency, December 20, 2011), 3.

[125] Ibid.

Prosecution of the alleged shooter is underway and limited information about response operations can be released until the case is concluded. No after-action reports have been released as of the date of this report.

Moore Tornado

Location: Moore, Oklahoma

Figure 27. Destruction from Moore tornado[126]

Between 19 May and 31 May 2013, a severe weather pattern produced a series of devastating tornadoes across Oklahoma City and surrounding areas. On 20 May 2013, a supercell formed in central Oklahoma, spawning a single EF-5 tornado that touched down in Moore, Oklahoma, with winds in excess of 200 mph. The tornado remained on the ground for over 40 minutes—its path more than a mile wide and 17 miles long. The tornado was responsible for the deaths of 26 individuals, including seven children, and injuries to more than 387 others.[127] The tornado destroyed more than 1,000 homes, as well as causing major damage to a hospital and two elementary schools.

Selected findings from after-action meetings following the tornado include the following:[128]

- Because multiple agencies established their own mobile command and staging areas, incoming resources checked in at the wrong locations and, without clear communication between the various command posts and staging areas, were left with little instruction on where to go.
- Command staff quickly became overwhelmed with a large number of self-dispatched responders.
- Responders experienced difficulty trying to build ad hoc communications plans that could accommodate VHF, UHF, multiple 800 hybrids and patchwork systems.
- Before a structured check-in process was established, police officers from outside jurisdictions were given quick assignments and then forgotten.

[126] Photo by Jocelyn Augustino, FEMA.

[127] *FEMA's Initial Response to the Oklahoma Severe Storms and Tornadoes*, OIG-14-50-D, (Washington: Department of Homeland Security, March 2014), 3.

[128] "Disaster Response – Commanding from the Storm: Lessons Learned from Oklahoma Tornadoes – Part 3," Firehouse, posted April 1, 2014, http://www.firehouse.com/article/11290259/disaster-response-oklahoma-tornado.

Pulse Nightclub Shooting

Location: Orlando, Florida

On 12 June 2016, a shooter went to the Pulse nightclub in Orlando, Florida, armed with an assault rifle and pistol, and opened fire on club patrons. During the incident, the shooter called 911, pledged his allegiance to the Islamic State of Iraq and Syria (ISIS), and mentioned the Boston Marathon bombers.[129] Additionally, the shooter called his wife to ask if she had seen the news footage of the shooting.

When police arrived and surrounded the building, the shooter hid inside the club with the trapped patrons. After a three-hour standoff, police entered the building using an armored vehicle, and shot and killed the perpetrator. The shooter killed 49 people and wounded 53.

Social media played a key role in this event. At the start of the shooter's rampage, the nightclub sent out an urgent warning via Facebook telling patrons to flee the building and stay away. During the initial assault on the nightclub and the subsequent standoff with police, some of the victims inside communicated with police, relatives and friends via cell phones and social media,

[129] "Orlando Shooting: 49 Killed, Shooter Pledged ISIS allegiance," CNN, posted 13 June 2016, http://www.cnn.com/2016/06/12/us/orlando-nightclub-shooting/.

such as Twitter and Facebook. Also during the event, Orlando police posted warnings to Twitter to stay away from the area.[130]

No publicly available after-action reports have been released for this incident as of the date of this report.

State Route 530 Landslide

Location: Oso, Washington

On Saturday, 22 March 2014, at 10:37 a.m., a massive landslide occurred near Oso in Snohomish County, Washington. Heavy rains caused an unstable hill in the North Fork Stillaguamish River valley to collapse. In less than one minute, mud and debris slid into the valley, covering one square mile of terrain. The landslide engulfed 49 homes, caused extensive flooding upstream and blocked State Route (SR) 530. The Oso slide is the deadliest single landslide event in U.S. history. Forty-three people died and 15 were rescued during the incident.[132]

Figure 28. Scene from the Oso landslide[131]

Rescue operations began immediately. On 22 March, the governor declared a state of emergency. The state EOC was activated for a total of 38 days during the response and recovery activities. More than 900 local, state and federal personnel, trained and untrained volunteers, contractors, families and community members were involved in all parts of the response operations.[133]

Selected findings as identified in the SR 530 Landslide Commission Final Report:

- Despite the adoption and broad implementation of ICS and NIMS in the state, there is still need for substantially stronger funding in some areas and both vertical and horizontal linkage across agencies and entities.

[130] Timeline of Orlando Nightclub Shooting," CNN, posted June 17, 2016, http://www.cnn.com/2016/06/12/us/orlando-shooting-timeline/index.html.

[131] Photo by U.S. Army Staff Sgt. Rory Featherston.

[132] *SR 530 Landslide Commission Final Report,* (Olympia: SR 530 Landslide Commission, December 15, 2014), 1.

[133] Ibid.

- Washington lacks sufficient accurate geological information, Light Detection and Ranging (LIDAR) and robust geological databases for cities, counties, state agencies and the public to make important permitting, land-use and other critical regulatory decisions.
- There were no clear parameters for activation of statewide resources, such as the state fire service.
- Significant challenges emerged in establishing the most appropriate level of command and control as quickly as possible, due to geographically separated communities and command structures.
- Responders reported that the process for ordering resources (equipment, personnel, etc.) was antiquated, confusing, slow and, in some cases, redundant.
- The Snohomish County Medical Examiner's Office was not staffed to handle a mass fatality event.
- There was confusion regarding which agency had the responsibility of maintaining missing person lists, resulting in a number of responding organizations and volunteers making their own lists.
- Different operational frequencies used by some of the responding organizations created communication challenges.
- There is a lack of statewide geologic and geohazard mapping.

Planned Parenthood Shooting

Location: Colorado Springs, Colorado

On 27 November 2015, a lone gunman attacked the Planned Parenthood Clinic in Colorado Springs, Colorado, at 11:38 a.m. For five hours, police reported shots fired from the gunman. During this time, police, fire, SWAT and Bureau of Alcohol, Tobacco and Firearms agents surrounded the building and adjacent shopping center. Finally, police SWAT teams crashed armored vehicles into the clinic being occupied by the shooter forcing him to surrender. A police officer and two civilians were killed. Five additional police officers and four civilians were injured. The motive for the attack was the shooter's opposition to Planned Parenthood's abortion services.

In August 2016, a judge found that the shooter in the Planned Parenthood attack remains incompetent to stand trial. No after-action reports have been released for this incident as of the date of this report.

Inland Regional Center Shooting

Location: San Bernardino, California

On the morning of 2 December 2015, a county health inspector attended his office holiday party at Inland Region Center (IRC) in San Bernardino, California. He reportedly left the party

abruptly, described as "angry," and returned later that morning with his wife. Both wore tactical gear. The couple fired on party attendees, killing 14 and wounding 22, then escaped in a rented vehicle. After taking witness accounts, officers were able to determine the identity and address of one of the shooters. San Bernardino police located the suspects' vehicle in a residential area leading to a shootout when one of the shooters began firing at officers. Officers shot and killed both gunmen.

Investigation revealed the shooters had become radicalized by ISIS years prior to the shooting and that they engaged in significant planning before the attack. They had more than 1,500 rounds of ammunition on their bodies or in their vehicle.[134] A bag belonging to the shooters was found in the room where the party was held containing explosive devices packed with black powder and rigged to a remote-controlled toy car.[135] A search of their home revealed over 4,500 rounds of ammunition and what was described as a "bomb making workshop" in their home. The number and type of weapons found suggested the shooters had plans for an even larger attack.

Selected findings identified in the *Bringing Calm to Chaos* critical incident review:[136]

- An initial command structure was established within eight minutes, but it was not until the arrival of other public safety leaders with enhanced experience in incident command that the formalized unified incident command leadership structure emerged.
- While the number of officers who initially responded to the IRC was necessary, the manner in which they responded lacked coordination, adding to an already chaotic scene. Many officers were not in uniform, and many were driving unmarked vehicles.
- There was limited appreciation of the consequences of unattended police vehicles blocking access routes to critical responding personnel such as tactical units, fire and emergency medical services.
- Numerous officers took independent actions in an attempt to locate the suspects. Some officers left preassigned positions at or near the IRC without notifying incident command and responded without adequate situational awareness.
- The uncontrolled numbers of officers responding and lack of parking discipline again caused roads to be blocked and resulted in a delay of critical tactical assets being available during the officer-involved shooting.
- As the number of law enforcement personnel grew, so did the volume of police radio traffic, thereby limiting the availability of radio broadcast time.
- Many law enforcement responders reported difficulty in determining the best radio channel to monitor to get the most accurate information about the situation.

---

[134] "Mass Shooting at Inland Regional Center: What We Know," CNN, posted December 5, 2015 http://www.cnn.com/2015/12/03/us/what-we-know-san-bernardino-mass-shooting/index.html.

[135] Ibid.

[136] Rick Braziel, Frank Straub, George Watson, and Rod Hoops, *Bringing Calm to Chaos,* (Washington: U.S. Department of Justice, Community Oriented Policing Service, 2016).

- Many responders reported that their departments immediately provided and continued to provide considerable mental health trauma support, while others struggled with identifying how to get the help they needed.

Sandy Hook Shooting

Location: Newtown, Connecticut

On the morning of 14 December 2012, a man fatally shot his mother with a .22-caliber rifle while she slept in her bed. He then drove to Sandy Hook Elementary School in Newtown. He walked to the front entrance of the school, armed with a Bushmaster Model XM15-E2S rifle, a Glock 20 pistol, a Sig Sauer P226 pistol and a large supply of ammunition.

The gunman shot through the plate glass window to gain entry to the school lobby. He subsequently shot and killed the school principal and psychologist and wounded two other staff members. He eventually proceeded to two first-grade classrooms, where he shot and killed an additional four adults and 20 children with the Bushmaster rifle. The incident ended when the shooter killed himself with one gunshot to his head.

Subsequent investigations concluded that the shooter engaged in a significant amount of planning for the incident, intentionally committing these crimes with the intention of killing even more people.

The report by the State's Attorney on this incident is a document of factual details and does not contain analysis of capability gaps.[137] Other reports likewise do not contain findings pertinent to emergency response operations.

Freight Train Collision and Bridge Collapse

Location: Chaffee, Missouri

On 25 May 2013, near Chaffee, a Union Pacific (UP) Railroad freight train collided with a Burlington Northern Santa Fe (BNSF) Railroad freight train at Rockview Interlocking, where the tracks of the two railroads intersect. At 2:30 a.m., as the BNSF train was passing through the interlocking, the UP train struck the 12th freight car behind the locomotives. Thirteen cars of the BNSF train derailed due to the impact of the collision. In addition, two locomotives and 11 cars on the UP train also derailed. As a result of the collision, the UP train locomotives spilled diesel, which subsequently caught on fire. The UP train engineer and conductor were seriously injured. The total damage was estimated to exceed $11 million.

The train collision occurred directly below the Missouri State Highway Route M bridge over Rockview Interlocking. Derailed train cars caused further damage by crashing into bridge supports, which caused portions of the bridge to collapse. Although there were no cars on the

[137] *State's Attorney, Report of the State's Attorney for the Judicial District of Danbury on the Shootings at Sandy Hook Elementary School and 36 Yogandanda Street on December 14, 2012,* (Danbury: Office of the State's Attorney Judicial District of Danbury, 25 November 2013), http://www.ct.gov/csao/lib/csao/Sandy_Hook_Final_Report.pdf.

bridge when it collapsed, two vehicles drove into the void created by the bridge collapse when they were unable to stop in time. Five occupants of those vehicles were injured and transported to a local hospital.

No after-action reports have been released for this incident as of the date of this report.

South Carolina Statewide Flooding 2015

Location: South Carolina

During 1-5 October 2015, the combination of low-pressure systems along the East Coast and tropical moisture associated with Hurricane Joaquin in the Atlantic Ocean resulted in record rainfall over portions of central to coastal South Carolina.

This record rainfall resulted in a major flooding event. Some affected areas received nearly 19 inches of rainfall in a 24-hour period.[139] Much of the precipitation fell over urban areas with severe runoff rates and soil previously saturated by recent storms.

Figure 29. South Carolina flooding aftermath[138]

Flooding from this event resulted in 19 fatalities, produced tons of debris and damage losses estimated at $1.5 billion. Infrastructure such as roadways, the electric grid, local and regional dams, water and sewage systems and communications were severely damaged or destroyed by the floodwaters. During the floods, there were 36 dam failures across South Carolina.[140] While some residents received warnings about evacuating flood-prone areas, others were caught by surprise when they suddenly realized that they were surrounded by water in areas that did not normally flood.

Local and state law enforcement from multiple jurisdictions, along with fire and EMS, worked together to perform numerous swift- and high-water rescues of people trapped in homes and vehicles surrounded by flood waters.

---

[138] Photo by Bill Koplitz, FEMA.

[139] "South Carolina's Catastrophic Floods Caused by One of the Most Prolific Rainfall Events in Modern U.S. History," Weather.com, posted October 11, 2015, https://weather.com/news/news/south-carolina-historic-flood-rainfall-record-extreme.

[140] *Service Assessment: The Historic South Carolina Floods of October 1–5, 2015*, (Silver Spring: National Weather Service, July 2016), http://www.nws.noaa.gov/os/assessments/pdfs/SCFlooding_072216_Signed_Final.pdf.

Selected findings identified in *Understanding the October 2015 Charleston Floods* and the National Weather Service's *Service Assessment*:[141,142]

- The modeling used during this event did not accurately predict where the worst rainfall amounts would occur.
- Models did not address key variables that would have helped determine the range of severity for the flooding (e.g., additional hydrologic forecasts beyond the deterministic river forecasts, tide gages and associated forecasts).
- Many models were out of date or data inputs were unavailable.
- There were shortfalls in alternate resource requirements necessary for rescue and shelter of citizens with disabilities, pets, etc.

South Central Texas Flooding 2015

Location: Texas

Heavy rains throughout May 2015 saturated the soil across south-central Texas. Rain in many locations was several inches above normal heading into Memorial Day weekend. Starting on the afternoon of Saturday, 23 May, several rounds of heavy rain hit the area, including more than 12 inches of additional rain in six hours in the Blanco River watershed. The Blanco River at Wimberley rose from nearly five feet at 9 p.m. on 23 May to nearly 41 feet by 1 a.m. on 24 May.[144] The flooding was responsible for 12 deaths and the destruction of over 350 homes.

Figure 30. Brownsville, TX flooding[143]

On 30 October 2015, another historic and catastrophic flooding event occurred in the same region. Again, a large volume of precipitation fell in a short period, causing destructive floods. Rivers overflowed and property damage was extensive.

---

[141] *Understanding the October 2015 Charleston Floods: A Symposium Report*, (Charleston: Charleston Resilience Network, February 2016), http://www.charlestonresilience.net/wp-content/uploads/2016/06/CRN_Flood_Symposium_Report-_FINAL.pdf.

[142] *Service Assessment: The Historic South Carolina Floods of October 1–5, 2015*, (Silver Spring: National Weather Service, July 2016), http://www.nws.noaa.gov/os/assessments/pdfs/SCFlooding_072216_Signed_Final.pdf.

[143] Photo by Jacinta Quesada, FEMA.

[144] *Hays County 2015 Flooding Events After Action Reports.* Hays County/San Marcos Joint EOC Operations, 2015. http://www.co.hays.tx.us/data/sites/1/pdf/press-releases/2016/hays-county-may-october-2015-flooding-aar.pdf

Selected findings identified in the Hays County and Blanco County after-action reports:[145]

- Collaboration between Hays County and the state teams needed better coordination.
- Jurisdictions need to establish a future training effort that will involve more ICS implementation across multiple disciplines.
- Initial radio operations in May were noted as inefficient due to overwhelming calls for assistance and a lack of coordination among multiple dispatch centers.
- Some responders had questions about the primary channel in use for the event.
- Appropriate channel allocation was lacking, and responders noted a lack of direct channels to conduct operations.
- Out-of-area responding agencies used radios that were not all equipped with the frequencies identified for the event.
- There was inconsistent communication and documentation between various search groups and Operations Section leadership.

Umpqua Community College Shooting

Location: Roseburg, Oregon

On 1 October 2015, a student at Umpqua Community College in Roseburg entered classrooms on campus and began shooting. Investigators reported that the shooter killed some people at random, but also targeted some of Christian and other faiths. The gunman wore protective clothing and used six weapons during the shooting. Officers arrived within six minutes of the first emergency call and engaged the shooter within minutes. After two additional minutes of firing at the officers, the gunman died of a self-inflicted gunshot wound. The gunman killed eight students and one professor, injuring nine others.

No after-action reports for this incident have been publicly released as of the date of this report.

[145] *Memorial Day 2015 Rain Event After Action Report*, (Johnson City: Blanco County Office of Emergency Management, June 11, 2015).

West Fertilizer Plant Explosion

Location: West, Texas

On 17 April 2013, a fire at the West Fertilizer Company plant in West, Texas, was reported at 7:29 p.m. The West Police Department was first on the scene and the West Volunteer Fire Department (VFD) requested that they block traffic from going near the plant. By the time West VFD reached the scene, the fire in the plant's structures was heavily involved. The fire involved the seed and fertilizer building at the plant, which housed large quantities of chemicals and materials used by the local farming community.

Figure 31. McLennan County, Texas Emergency Manager briefing the media on the West Fertilizer Company plant explosion[146]

At 7:51 p.m., the building's roof collapsed, triggering an explosion of the estimated 40-60 tons of ammonium nitrate stored at the north end of the seed and fertilizer building. The blast killed 10 firefighters, two civilians assisting in fighting the blaze and three residents who lived nearby. More than 200 residents were injured. The blast created a 90-foot-wide and 10-foot-deep crater and damaged or destroyed 500 structures in a 37-block area.[147] Officials later determined that the cause of the explosion was arson.

Selected findings identified in the *Firefighter Fatality Investigation:*[148]

- The strategy and tactics used by the West VFD were not appropriate for the rapidly developing and extremely volatile situation, and exposed the firefighters to extreme risks.
- There was no ICS, and the senior ranking members did not perform supervisory roles.
- The failure to create and communicate an incident action plan resulted in uncoordinated and unmanaged fire ground operation.
- There were no pre-fire or pre-incident plans for the high-risk structure containing hazardous materials.
- The state of Texas has not adopted minimum training standards for volunteer fire departments.

[146] Photo by Cynthia Hunter, FEMA

[147] *Firefighter Fatality Investigation, Investigation FFF FY 13-06*, (Texas State Fire Marshal's Office, April 2013), https://www.tdi.texas.gov/reports/fire/documents/fmloddwest.pdf.

[148] Ibid.

(This page intentionally left blank.)

APPENDIX C. PRE-INTERVIEW QUESTIONNAIRE

This questionnaire is part of Project Responder 5 (PR5), an initiative of the U.S. Department of Homeland Security (DHS) Science and Technology (S&T) Directorate. The purpose of the project is to provide the DHS S&T First Responders Group with analytic support and subject matter expertise regarding the operational requirements and priorities of the public safety community. Your input to this process is very important and will help assure that the needs and priorities of emergency responders are represented accurately.

We look forward to talking with you in person about your incident response capabilities and needs as part of PR5. Ahead of our meeting, we would like to get a general sense of what you think about your jurisdiction's needs and preparedness.

Please take a few minutes to answer this short survey. It should take you about 10 minutes. Just print it, fill it out and give it to the PR5 team when they visit for your interview.

Your individual responses to these questions will not be shared without your permission.

Please answer the following questions about your jurisdiction's needs.

1. What is the *most significant* threat or hazard your jurisdiction must be prepared for? Please provide a very brief description:

2. How well prepared do you think your jurisdiction is to respond to this threat or hazard today?

   - ☐ Extremely well prepared
   - ☐ Very well prepared
   - ☐ Somewhat prepared
   - ☐ Not very well prepared
   - ☐ Not prepared at all

3. Thinking back, would you say your jurisdiction is better prepared or not as prepared to respond to this threat or hazard than it was 5 years ago?

   - ☐ Much better prepared than 5 years ago
   - ☐ Somewhat better prepared than 5 years ago
   - ☐ About as prepared as 5 years ago
   - ☐ Somewhat less prepared than 5 years ago
   - ☐ Much less prepared than 5 years ago

Still thinking about the same threat or hazard, how big of a need is each of the following to improve your jurisdiction's preparedness level for this?

4. Specialized training

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

5. Specialized equipment

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

6. New technology

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

7. Better access to existing technology

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

8. Additional personnel

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

9. New policies and procedures

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

For the next several questions, please tell us about your jurisdiction's current status and need for each capability.

10. The ability to know the location of responders and their proximity to risks and hazards in real time.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

11. The ability to detect, monitor and analyze passive and active threats and hazards at the incident scene in real time.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

12. The ability to rapidly identify hazardous agents and contaminants.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

13. The ability to incorporate information from multiple and nontraditional sources (for example, crowdsourcing and social media) into incident command operations.

Our ability to do this now is:

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

Our need for this capability is:

- ☐ Extremely urgent
- ☐ Very urgent
- ☐ Somewhat urgent
- ☐ Not very urgent
- ☐ Not urgent at all

14. The ability to communicate with responders in any environmental conditions (including through barriers, inside buildings and underground).

Our ability to do this now is:

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

Our need for this capability is:

- ☐ Extremely urgent
- ☐ Very urgent
- ☐ Somewhat urgent
- ☐ Not very urgent
- ☐ Not urgent at all

15. Communications systems that are hands free, ergonomically optimized and can be integrated into Personal Protective Equipment (PPE).

The availability of this now is:

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

Our need for this capability is:

- ☐ Extremely urgent
- ☐ Very urgent
- ☐ Somewhat urgent
- ☐ Not very urgent
- ☐ Not urgent at all

16. The ability to remotely monitor the tactical actions and progress of all responders involved in the incident in real time.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

17. The ability to identify trends, patterns and urgent content from large volumes of information from multiple sources (including nontraditional sources) to support incident decision-making.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

18. The ability to identify, assess and validate emergency-response-related software applications.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

19. Protective clothing and equipment for all responders that protects against multiple hazards.

The availability of this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

20. The ability to identify what resources are available to support a response (including resources not traditionally involved in response), what their capabilities are and where they are, in real time.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

21. The ability to monitor, in real time, the status of resources and their functionality in current conditions.

Our ability to do this now is:	Our need for this capability is:
☐ Excellent	☐ Extremely urgent
☐ Very good	☐ Very urgent
☐ Good	☐ Somewhat urgent
☐ Fair	☐ Not very urgent
☐ Poor	☐ Not urgent at all

22. The ability to remotely scan an incident scene for signs of life and decomposition to identify and locate casualties and fatalities.

Our ability to do this now is:

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

Our need for this capability is:

- ☐ Extremely urgent
- ☐ Very urgent
- ☐ Somewhat urgent
- ☐ Not very urgent
- ☐ Not urgent at all

23. Readily-accessible, high-fidelity simulation tools to support training and exercises in incident management and response.

The availability of this now is:

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

Our need for this capability is:

- ☐ Extremely urgent
- ☐ Very urgent
- ☐ Somewhat urgent
- ☐ Not very urgent
- ☐ Not urgent at all

So we can better understand how needs vary across the country, please give us some information about your jurisdiction, agency and role.

(This information will not be shared without your permission.)

What agency do you work for?

What jurisdiction does this agency protect?

What is your primary functional role on a daily basis?

What is your primary functional role during a major incident response?

May we contact you if we have follow-up questions about the information you have provided here? If so, please provide your contact information:

Name: _____

Title: _____

Email address: _____

Contact telephone number: _____

THANK YOU FOR PARTICIPATING IN PROJECT RESPONDER 5.

APPENDIX D. PROJECT RESPONDER 5 INTERVIEW PROTOCOL

As described in the "Methodology" section of this report, the study team conducted in-person interviews with 40 emergency responders as part of the data gathering effort for Project Responder 5 (PR5). Below is the protocol used during those interviews.

Research Objectives

The first phase of PR5 is focused on developing a draft set of capability needs that will be validated, described and prioritized in subsequent focus group meetings. As part of this phase, the study team identified a set of natural disasters and man-made incidents from the past three to five years. These include complex, multi-jurisdictional, large-scale, high-risk, high-probability or high-consequence incidents, or those that had important social or economic impacts. As part of the effort to identify the draft capability needs, researchers will be conducting research through interviews with emergency responders that participated in many of these incidents. The study team identified the following objectives as part of the interview process:

1. Initial characterization of the current operating environment of emergency responders, including identification of the most important factors that drive capability needs.
2. Identification of areas where prior technology development efforts have produced capabilities that are now successfully deployed, resulting in improved response.
3. Identification of the most salient operational challenges or problems responders face.
4. Initial assessment of the continuing relevance of previously identified capability needs.
5. Identification of a tentative list of current capability needs.

Interview Design

These research objectives will be met through a series of semi-structured interviews with state and local emergency responders who had leadership roles in a set of recent incidents across the United States. The incidents on which the interviews will focus represent the spectrum of current experience with prevalent threats and hazards of three important types: natural disasters, willful acts and large-scale civil unrest. All incidents occurred within the past five years. Querying responders with direct leadership experience on these incidents allows their assessments of current operational challenges and capability needs to be grounded in a recent opportunity to witness in detail what is working and what is not working in the field today.

To help focus each interview quickly on the research objectives, the research team will become very familiar with each incident in advance by reviewing available after-action and lessons-learned reports, including those completed by the participating agencies and by third parties, as well as media reports and any other documentation that reveals: what caused the incident, how the response proceeded, which aspects of the response were strong and which were weak, and what lessons have been identified that suggest the need for changes in the future.

Interviews will take place in or near the jurisdiction where the incident occurred. They will ideally involve as few as one and no more than three interviewees in any given session. They are

expected to last approximately two hours. They will be semi-structured to allow the research team to judge during the interview which areas are most salient to the particular incident at hand and probe these, but they will be guided by the procedure below to assure thorough coverage of the topics related to capability need.

At a minimum, each interview will be staffed by two researchers. One will lead the discussion and ask questions. The other will be dedicated to taking detailed notes. This allows the interviewer to focus on what the participants are saying, rather than being distracted by having to document the conversation in real time.

Interview Procedure

Introduction

The interviewer will open the session by explaining the purpose of Project Responder and the purpose of the interview. She will make clear that the objective is to develop a detailed understanding of capability needs, not to evaluate the quality of the response. She will also explain that the team has already reviewed available documentation about the incident and so is already familiar with the incident and the response.

The interviewer will explain that this will be an informal conversation guided by a series of questions designed to gain the insight relevant to the project's goals and objectives. She will explain the role and purpose of the note-taker, how the notes will be used and generally what the final project report will include. The interviewer will confirm that, with this understanding, the participants are ready and willing to proceed with the interview.

Primary Questions

Fundamentally, the success or failure of a response rests on capability, both technological and non-technological. The primary focus of the interview is therefore to understand how each capability functioned on the incident. This will reveal what capabilities exist and are working, what capabilities are available but underdeveloped and what capabilities are needed but absent.

- As you think about this incident and the response to it, what do you think went well? What would you consider the main successes of the response?
- To what do you attribute these successes? Why exactly did these things go well?
- Are there specific capabilities your jurisdiction has that generated this success?
- As you think about this incident and the response to it, what do you think went badly or wrong? What would you consider the biggest problems of the response?
- To what do you attribute these problems? Why exactly did these things go badly?
- Are there specific capabilities your jurisdiction lacks that would have improved the response?
- Are these capabilities available elsewhere? If so, why do you not have access to them?

- Have you have changed your preparedness or response operations based on the response to this particular incident? In what ways?
- Now I would like you to think back 10 or 15 years. If this same incident had happened then, how would the response have gone? Do you think it would have gone better than it did now, worse than it did now or would it have been about the same? Why do you think so?
- How have your jurisdictions response capabilities changed over the past 10-15 years?
- In what way have they gotten stronger? Why? What new capabilities do you have now that you did not have before?
- In what ways have they gotten weaker? Why?
- How likely is it that you will face a similar incident again? Why?
- If something similar happens, do you think the response will go better or worse or about the same? Why?
- In general, what are the biggest challenges to successful response to critical incidents your jurisdiction faces?

Probes

Appendix A contains a list of questions that may be used as appropriate to delve into particular aspects of an incident that are revealed to be especially relevant to identifying capability gaps. They can be used at any appropriate point during the interview to gather more details. They are organized according to major functional requirements typical of any major incident. The specific language of the question should be adjusted as appropriate to reflect the particular circumstances of the incident.

In addition, the following questions may be used to explore aspects of the incident that are more contextual:

- Please tell us how the news media supported or hindered response to this incident.
- What was the role of social media during this incident? Did you use it or data from it? Did members of the community use it? Did these activities help or hinder the response?
- What were the community's expectations about this incident? How did these evolve over the course of the incident? Do you think these expectations were reasonable and appropriate? Why or why not? What impact did they have?
- Please tell us how volunteers (trained and/or untrained) supported or hindered operations during this incident.
- Is there anything you think is special or unusual about this incident? Why? What impact do these things have?

Concluding Questions

- Is there anything else you think is relevant that we have not discussed?
- Are you willing to be contacted if we have follow-up questions?
- Do you have any questions of us?

The interviewer will thank the participants and provide contact information in case they have any additional questions or would like to provide further information in the future.

APPENDIX A: Probes

These questions may be used as appropriate to delve into particular aspects of an incident that are revealed to be especially relevant to identifying capability gaps. They are organized according to major functional requirements typical of any major incident. The specific language of the question should be adjusted as appropriate to reflect the particular circumstances of the incident.

Situational awareness *(defined as the capability to provide and distill specific knowledge concerning emerging threats, hazards and conditions in a timely fashion to support incident management decisions across all phases of catastrophic incident response)*

1. Tell us about the extent of your situational awareness on the incident scene.
2. What were the specific threats and hazards facing responders on-scene?
3. What information did you need to understand those threats and hazards?
4. Did you have access to all of the information that you needed to understand those threats and hazards and their impact on responder safety?
    a. Did you have access to timely weather-related data and projections?
    b. Did you have access to traffic data and projections?
    c. Did you have access to third-party images or video streams?
    d. Did you have access to sensor data?
    e. Did you have access to blueprints or map data?
    f. Did you have access to model projections?
    g. Did you have access to social media data feeds?
5. Did you know the location of responders on the incident scene?
6. Did you use any decision-support tools during the response? Do you consider the tools you used effective?
7. Can you envision any technology improvements or developments with regard to situational awareness that could make future operations more safe, effective or efficient?
8. Are you aware of any technology improvements with regard to situational awareness that are currently being developed or piloted?
9. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your situational awareness capabilities?
10. Are there policy or process changes with regard to situational awareness that would make future operations more safe, effective or efficient?
11. Are there training opportunities with regard to situational awareness that would make future operations more safe, effective or efficient?

12. Are there standards or guidelines that impact your situational awareness activities and/or use of decision-support tools?
13. Are there specific capability gaps with regard to situational awareness that you want to mention?

Communications *(defined as the capability to seamlessly and dynamically connect multiple persons/entities and convey meaningful and actionable information to all relevant parties)*

1. Please tell us about your on-scene communications.
    a. Were you able to communicate with other responders from your agency or jurisdiction while on scene?
    b. Were you able to communicate with responders from other agencies or jurisdictions while on scene?
    c. Were you able to communicate with Incident Command (IC) while on scene?
    d. Were you able to communicate with victims while on scene? What about witnesses?
    e. Did you have voice communications while on scene?
    f. Did you have video communications while on scene?
2. Can you envision any technology improvements or developments with regard to communications that could make future operations more safe, effective or efficient?
3. Are you aware of any technology improvements with regard to communications that are currently being developed or piloted?
4. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your communications capabilities?
5. Are there policy or process changes with regard to communications that would make future operations more safe, effective or efficient?
6. Are there training opportunities with regard to communications that would make future operations more safe, effective or efficient?
7. Are there standards or guidelines that impact your use or purchase of communications equipment?
8. Are there specific capability gaps with regard to communications that you want to mention?

Command, control and coordination (C3) *(defined as the ability to identify incident priorities, allocate scarce resources and exchange relevant information to make effective decisions in a stressful environment)*

1. Please tell us about your command and control experiences during the incident.
2. Did IC have access to all of the information they needed to make incident action plans?
3. Can you envision any technology improvements or developments with regard to C3 that could make future operations more safe, effective, or efficient?
4. Are you aware of any technology improvements with regard to C3 that are currently being developed or piloted?
5. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your C3 capabilities?

6. Are there policy or process changes with regard to C3 that would make future operations more safe, effective or efficient?
7. Are there training opportunities with regard to C3 that would make future operations more safe, effective or efficient?
8. Are there standards or guidelines that impact your use or purchase of C3 tools or equipment?
9. Are there specific capability gaps with regard to C3 that you want to mention?

Responder health and safety *(defined as the ability to identify hazards to public safety personnel and develop appropriate mitigations to reduce morbidity and mortality associated with response activities)*

1. Please tell us about any issues or shortfalls with personal protective equipment (PPE) during the incident.
    a. Were responder garments suitable for the response activities?
    b. Were gloves/boots/headgear suitable for response activities?
    c. Was breathing apparatus suitable for response activities?
2. Did the incident present specific threats to responder safety based on insufficient PPE?
3. Did responders experience physical or mental health issues following the incident?
4. Can you envision any technology improvements or developments with regard to PPE that could make future operations more safe, effective or efficient?
5. Can you envision any technology improvements or developments with regard to responder physical or mental health that could make future operations more safe, effective or efficient?
6. Are you aware of any technology improvements with regard to PPE or responder physical or mental health that are currently being developed or piloted?
7. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance responder physical or mental health?
8. Are there policy or process changes with regard to PPE that would make future operations more safe, effective or efficient?
9. Are there policy or process changes with regard to responder physical or mental health that would make future operations more safe, effective or efficient?
10. Are there training opportunities with regard to PPE that would make future operations more safe, effective or efficient?
11. Are there training opportunities with regard to responder physical or mental health that would make future operations more safe, effective or efficient?
12. Are there standards or guidelines that impact your use or purchase of PPE?
13. Are there specific capability gaps with regard to responder health and safety that you want to mention?

Logistics and resource management *(defined as the capability to identify, acquire, track and distribute available equipment, supplies and personnel in support of catastrophic incident response)*

1. Please tell us about your experiences with logistics and resource management during the incident.
2. Was IC able to identify all resources needed for the response in a timely manner?

3. Was IC able to request all resources needed for the response?
4. Was IC able to obtain all resources needed for the response?
5. What methods were used to track resources on scene?
6. Can you envision any technology improvements or developments with regard to logistics that could make future operations more safe, effective or efficient?
7. Are you aware of any technology improvements with regard to logistics that are currently being developed or piloted?
8. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your logistics capabilities?
9. Are there policy or process changes with regard to logistics that would make future operations more safe, effective or efficient?
10. Are there training opportunities with regard to logistics that would make future operations more safe, effective or efficient?
11. Are there standards or guidelines that impact your use or purchase of logistics tools or equipment?
12. Are there specific capability gaps with regard to logistics and resource management that you want to mention?

Casualty management *(defined as the capability to provide rapid and effective search and rescue, medical response, prophylaxis and decontamination for large numbers of incident casualties and identify appropriate sheltering and transportation options)*

1. Please tell us about your experiences managing casualties (living and deceased) during the incident.
    a. Were you able to locate all casualties?
    b. What methods did you use to locate casualties?
    c. Were you able to retrieve all casualties?
2. Were you able to convey pertinent information to casualties, families and the public?
3. Can you envision any technology improvements or developments with regard to casualty management that could make future operations more safe, effective or efficient?
4. Are you aware of any technology improvements with regard to casualty management that are currently being developed or piloted?
5. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your casualty management capabilities?
6. Are there policy or process changes with regard to casualty management that would make future operations more safe, effective or efficient?
7. Are there training opportunities with regard to casualty management that would make future operations more safe, effective or efficient?
8. Are there standards or guidelines that impact your use or purchase of casualty management tools or equipment?
9. Are there specific capability gaps with regard to casualty management that you want to mention?

Training and exercise *(defined as the ability to provide instruction on necessary skills for catastrophic incident response and coordinate and practice implementation of plans and potential response prior to an incident)*

1. Do you feel that you had sufficient or specific training prior to the incident to prepare you for the response?
2. Has your jurisdiction planned or held exercises focused on response to a similar incident?
3. Can you envision any technology improvements or developments with regard to training and exercise that could make future operations more safe, effective or efficient?
4. Are you aware of any technology improvements with regard to training and exercise that are currently being developed or piloted?
5. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your training and exercise capabilities?
6. Are there policy or process changes with regard to training and exercise that would make future operations more safe, effective or efficient?
7. Are there additional training opportunities that would make future operations more safe, effective or efficient?
8. Are there standards or guidelines that impact your training and exercises for this type of incident?
9. Are there specific capability gaps with regard to training and exercise that you want to mention?

Risk assessment and planning *(defined as the capability to identify and manage likely vulnerabilities and threats and develop appropriate responses to potential catastrophic incidents based on identified risk)*

1. Please tell us about any related risk assessment or planning activities conducted prior to this incident.
2. Can you envision any technology improvements or developments with regard to risk assessment and planning that could make future operations more safe, effective or efficient?
3. Are you aware of any technology improvements with regard to risk assessment and planning that are currently being developed or piloted?
4. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your risk assessment and planning capabilities?
5. Are there policy or process changes with regard to risk assessment and planning that would make future operations more safe, effective, or efficient?
6. Are there training opportunities with regard to risk assessment and planning that would make future operations more safe, effective, or efficient?
7. Are there standards or guidelines that impact your risk assessment and planning for this type of incident?
8. Are there specific capability gaps with regard to risk assessment and planning that you want to mention?

Intelligence and investigation *(defined as the ability to collect, integrate and assess information to develop conclusions or courses of action prior to a criminal incident or to identify the cause or responsible persons following an event)*

1. Please tell us about information sharing during this incident.
2. Did you have access to the information needed for investigation or causation purposes?
3. Were you able to integrate information from multiple sources to support investigation or causation activities?
4. Can you envision any technology improvements or developments with regard to intelligence and investigation that could make future operations more safe, effective or efficient?
5. Are you aware of any technology improvements with regard to intelligence and investigation that are currently being developed or piloted?
6. Are you aware of tools or capabilities used elsewhere (inside or outside of the public safety community) that could either be used in their current form or slightly altered to enhance your intelligence and investigation capabilities?
7. Are there policy or process changes with regard to intelligence and investigation that would make future operations more safe, effective or efficient?
8. Are there training opportunities with regard to intelligence and investigation that would make future operations more safe, effective or efficient?
9. Are there standards or guidelines that impact your intelligence and investigation for this type of incident?
10. Are there specific capability gaps with regard to intelligence and investigation that you want to mention?

(This page intentionally left blank.)

APPENDIX E. PROVISIONAL CAPABILITY NEEDS

This appendix contains the list of 42 provisional capability needs identified based on information from the Project Responder 5 documentation, questionnaires and interview notes.

Situational Awareness

- The ability to access, integrate and display images and video from the incident scene (for the on-scene responder and incident command)
- The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth
- The ability to detect and identify threats and hazards on the incident scene
- The ability to generate incident-specific maps tied to GIS coordinates for indoor and outdoor locations on the incident scene
- The ability to merge disparate data sources in real time (e.g., known hazards, building blueprints, ownership records) to support situational awareness
- The ability to identify ideal sites and implement procedures to establish staging, command posts and ingress/egress routes
- The ability to identify secondary incidents and effects during response operations (e.g., after-effects and devices) and project consequences
- The ability to obtain and maintain a bird's-eye view of the incident scene

Communications and Information Sharing

- The ability to effectively communicate incident-specific hazards to the public and business community in advance of known threats
- The ability to manage communications channels and frequencies among multiple disciplines and agencies
- The ability to effectively communicate in the presence of loud ambient noise
- The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations
- The ability to share incident-related information among agencies and disciplines during response operations

Command, Control and Coordination

- The ability to provide decision-support templates and prompts during incident operations

- The ability to electronically document and track command decisions, actions and assignments during response operations
- The ability to quickly establish joint command between jurisdictions and agencies

Responder Health and Safety

- The ability to provide basic protection from threats (e.g., fire, puncture, slash and ballistic hazards) without donning specialized garments or compromising comfort and maneuverability
- The ability to provide personalized mental health services following incident response
- The ability to monitor the physiological signs of on-duty and rehabbing responders
- The ability for responders to ascertain exposure type and level

Logistics and Resource Management

- The ability to integrate resource data from participating agencies for a holistic picture of resources available for incident response
- The ability to identify resource needs for rescue and shelter of citizens with disabilities
- The ability to identify available resources and track inbound location in real time
- The ability to geolocate non-personnel resources on the incident scene
- The ability to digitally request resources from the field and track disposition of request, resource status and location
- The ability to verify the credentials of all on-scene responders
- The ability to centrally manage incident-specific logistics information
- The ability to account for and manage on-duty, off-duty and self-reporting personnel in real time (including check-in and staging direction)

Casualty Management

- The ability to estimate or identify the number of persons in affected areas at the time of an incident
- The ability to identify the location of injured, trapped and deceased casualties on the incident scene
- The ability to manage large numbers of fatalities
- The ability to manage and track the status of known and potential casualties from site through reunification

- The ability to conduct multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents

Training and Exercise

- The ability to maintain ICS and disaster management training for all responders regardless of rank
- The ability to provide training via multiple modalities

Risk Assessment and Planning

- The ability to accurately model local and regional threats and risks
- The ability to assess how evolving threats and hazards (e.g., civil unrest, active shooters and responder targeting) affect an individual jurisdiction

Intelligence and Investigation

- The ability to integrate and manage digital content related to response operations or an investigation
- The ability to integrate and assess data and information from multiple sources
- The ability to automatically determine patterns and trends from multiple information sources
- The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence
- The ability to isolate and extract critical information from social media feeds (of bystanders and casualties) and other non-traditional sources during response operations

(This page intentionally left blank.)

APPENDIX F. PRIORITIZATION FRAMEWORK

As described in the "Methodology" section of this report, the study team facilitated four focus group meetings in different regions of the United States as part of the validation and prioritization phase of Project Responder 5 (PR5). The prioritization process during those meetings had three distinct components: a pre-meeting questionnaire, a voting exercise that took place after discussions to validate the capability needs and a post-meeting capability assessment. Below is a description of each of those components.

Research Objectives

As a key element of the larger PR5 study, the focus group meetings are intended to meet three primary research objectives:

1. Understand the major challenges, threats and hazards that jurisdictions currently face and about which they are most concerned.
2. Understand how priorities have remained stable or changed from previous Project Responder efforts, and why.
3. Identify current "top" priorities, as held by a group of expert emergency responders.

Prioritization Components

Pre-meeting questionnaire

Before the main discussions about capability needs begin, focus group participants will be asked to complete a brief written questionnaire (attached appendix A). This questionnaire will provide insights into each participant's jurisdiction and his or her function as an emergency responder within that jurisdiction. This information will be coded and correlated with other information each participant provides throughout the focus group to yield insights about the context for capability requirements. When this questionnaire is distributed, a facilitator will explain to participants that their responses will be kept confidential and will not be shared without their permission, except as de-identified, aggregated data. The facilitator will also explain that all questionnaires will ask them to provide their name simply so that their responses can be linked together. If anyone is uncomfortable providing a name, they should be directed to speak to a facilitator privately to make accommodations for this.

Multi-Voting

The focus group participants will also be asked to reach consensus about which needs are most urgent to help inform technology development investment choices by U.S. Department of Homeland Security and others. To prioritize needs, the focus groups will employ a multi-voting approach. Multi-voting is a group decision-making technique that allows the group to select a defined number of priorities from a larger set of items using an iterative form of approval voting.

A “top” priority can be viewed as a need that is deemed most important by the most people. This would be revealed through typical majority or plurality single-winner voting methods, which generate “winners” (those that get the most votes) and “losers” (those that do not). This approach to voting can mask broadly held consensus support for something that is not at the very top for enough people. In other words, multi-voting reveals underlying agreement about a popular or favored option among group members by identifying options that may not be anyone’s top choice (or may only be the very top choice of a few), but that is seen as important by many. Additional advantages of the technique are that it permits prioritization of an extensive set of options, and that it is simple to understand and quick to use.

The prioritization process will take place at the end of the focus group meeting day, and will consider all capability requirements developed during the facilitated group discussion. The steps to the multi-voting procedure that will be used during the focus groups are as follows:

1. Show the list of capability needs to all participants by projecting them so everyone can see them. The needs should be in random order, and identified by a letter (A, B, C, etc.). Explain to participants that the letters are only for identification purposes, and that they do not signify any particular order. This list can be of any length, but is anticipated to include 10 to12 requirements. If it is not possible to project the list so they can all be easily seen and clearly read at once, write the list on flip chart pages and post them on the wall, or print the list and give each participant a copy.

2. Ask participants to identify all of the capability needs on the list they see as high priorities by writing down the corresponding letters on a blank ballot. They can select as many of the capability needs as they like, up to and including the full list, as long as they see them as high priorities.

3. Tally the votes for each capability need.

4. Generate a new, more limited list of capability needs. All needs that got votes from at least four of the participants will remain on the list for further consideration by the participants. All others will be eliminated. If the new list contains three or fewer needs, the process is finished. If not, go to Step 5.

5. Show the refined list of capability needs to all participants by projecting them so everyone can see them. The needs should be in random order, and identified by a letter (A, B, C, etc.). Remind participants that the letters are only for identification purposes, and that they do not signify any particular order.

6. Ask participants to select half of the capabilities from the list as high priorities by writing down the letters of their choices on a blank ballot.

7. Tally the votes for each capability need.

8. Generate a new, more limited list of capability needs. All needs that got votes from at least four of the participants will remain on the list for further consideration by the participants. All others will be eliminated. If the new list contains three or fewer needs, the process is finished. If not, go to Step 9.

9. Show the refined list of capability needs to all participants by projecting them so everyone can see them.
10. Ask participants to select half of the capabilities from the list as priorities by writing down the letters of their choices on a blank ballot.
11. Tally the votes for each capability need.
12. Generate a new, more limited list of capability needs. All needs that got votes from at least four of the participants will remain on the list for further consideration by the participants. All others will be eliminated. If the new list contains three or fewer needs, the process is finished. If not, go to Step 13.
13. Show the refined list of capability needs to all participants by projecting them so everyone can see them.
14. Ask participants to select one-third of the capabilities from the list as priorities by writing down the letters of their choices on a blank ballot.
15. Tally the votes for each capability need.
16. Generate a new, more limited list of capability needs. All needs that got votes from at least four of the participants will remain on the list for further consideration by the participants. All others will be eliminated. If the new list contains three or fewer needs, the process is finished. If not, go to Step 17.
17. Show the refined list of capability needs to all participants by projecting them so everyone can see them.
18. Ask people to rank order the remaining capability needs by writing down the letters of those needs in priority order from highest to lowest.
19. Assign a score that corresponds to how a capability need is ranked, depending on the number of needs being ranked. (So, for example, if there are five needs being ranked, the highest priority would be scored a 5, the next highest a 4, and so on.) For each ballot, note the score that each capability received.
20. Tally the scores. The top three scoring capabilities are the group's top priorities.

At the conclusion of the process, show the top three capability needs to the participants. To check the validity of the result, the facilitator will confirm with the group that these seem reasonable and appropriate as the highest priorities.

Post-meeting capability assessment

After the main discussions of the focus group and the prioritization process concludes, participants will be asked to complete a written questionnaire (attached appendix B below). This questionnaire will enable participants to rate each of the capability priorities according to a set of criteria relevant to their utility and urgency. The data from these responses will allow the priorities to be rank ordered in aggregate or against any particular criterion, giving DHS more insight into why each priority is deemed important, and how important they are

relative to each other. The post-meeting questionnaire can be finalized and printed while the prioritization process is going on.

APPENDICES: Prioritization Instruments

Appendix A: Pre-meeting questionnaire

Appendix B: Post-meeting capability assessment

NGT, Delphi, and Voting Theory references:

Brown, Bernice B. 1968. “Delphi Process: A Methodology Used for the Elicitation of Opinions of Experts.” RAND (Document No: P-3925).

Brown, Thomas. 1972. “An Experiment in Probabilistic Forecasting.” R-944-ARPA.

Colomer, Josep M., ed. 2004. Handbook of Electoral System Choice. London and New York: Palgrave Macmillan.

Cranor, Lorrie. “Vote Aggregation Methods.” Declared-Strategy Voting: An Instrument for Group Decision-Making.

Dalkey, Norman and Olaf Helmer. 1963. “An Experimental Application of the Delphi Method to the use of experts.” *Management Science* 9(3): 458–467.

Delbecq, A. L. and A. H. VandeVen. 1971. “A Group Process Model for Problem Identification and Program Planning.” *Journal Of Applied Behavioral Science* 7: 466–91.

Delbecq, A. L. and A. H. VandeVen. 1975. Group techniques for program planning: A guide to nominal group and Delphi processes. Glenview, Illinois: Scott Foresman and Company.

Farrell, David M. 2001. Electoral Systems: A Comparative Introduction. New York: St. Martin's Press.

Harold A. Linstone and Murray Turoff. 1975. The Delphi Method: Techniques and Applications. Reading, Mass.: Addison-Wesley.

Rescher. 1998. Predicting the Future. Albany, NY: State University of New York Press.

Sackman, H. 1974. “Delphi Assessment: Expert Opinion, Forecasting and Group Process.” R-1283-PR.

Tague, Nancy R. 2004. The Quality Toolbox. 2nd Ed. ASQ Quality Press. pp 359-361.

Project Responder 5
Pre-Meeting Questionnaire

This survey is part of Project Responder 5, an initiative of the Department of Homeland Security (DHS) Science and Technology (S&T) Directorate. The purpose of the Project is to provide the First Responders Group with analytic support and subject matter expertise regarding the operational requirements and priorities of the public safety community. Your input to this process is very important and will help assure the needs and priorities of first responders are represented accurately.

We look forward to today's discussion about your incident response capabilities and needs as part of Project Responder 5. Before we start the discussion, we would like to get a general sense of what you think about your jurisdiction's needs and preparedness.

Please take a few minutes to answer some questions using this short questionnaire. It should take you about 5-10 minutes.

Your individual responses to these questions will not be shared without your permission.

If you have any questions about Project Responder or this survey, please contact the project lead, Michelle Royal, at Michelle.Royal@hsi.dhs.gov.

Please answer the following questions about your jurisdiction's needs.

1. What is the *most significant* threat or hazard your jurisdiction must be prepared for? Please provide a very brief description.

2. How well prepared do you think your jurisdiction is to respond to this threat or hazard today?

   - ☐ Extremely well prepared
   - ☐ Very well prepared
   - ☐ Somewhat prepared
   - ☐ Not very well prepared
   - ☐ Not prepared at all

3. Thinking back, would you say your jurisdiction is better prepared or not as prepared to respond to this threat or hazard as it was 5 years ago?

   - ☐ Much better prepared than 5 years ago
   - ☐ Somewhat better prepared than 5 years ago
   - ☐ About as prepared as 5 years ago
   - ☐ Somewhat less prepared than 5 years ago
   - ☐ Much less prepared than 5 years ago

Still thinking about the same threat or hazard, how big a need is each of the following to improve your jurisdiction's preparedness level for this?

4. Specialized training

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

5. Specialized equipment

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

6. New technology

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

7. Better access to existing technology

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

8. Additional personnel

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

9. New policies and procedures

- ☐ Extremely necessary
- ☐ Very necessary
- ☐ Somewhat necessary
- ☐ Not very necessary
- ☐ Not necessary at all

For coding purposes and so we can better understand how needs vary across the country, please give us some information about your jurisdiction and role.

(This information will not be shared without your permission.)

Name: _____

Title: _____

What agency do you work for?

What jurisdiction does this agency protect?

What is your primary functional role on a daily basis?

What is your primary functional role during a major incident response?

May we contact you if we have follow-up questions about the information you have provided?

- ☐ Yes, you may contact me at:
  Email address: _____
  Contact telephone number: _____

- ☐ No, please do not contact me.

THANK YOU FOR PARTICIPATING IN PROJECT RESPONDER 5.

Project Responder 5
Post-Meeting Capabilities Assessment

This questionnaire is part of Project Responder 5, an initiative of the Department of Homeland Security (DHS) Science and Technology (S&T) Directorate. The purpose of the Project is to provide the First Responders Group with analytic support and subject matter expertise regarding the operational requirements and priorities of the public safety community. Your input to this process is very important and will help assure the needs and priorities of first responders are represented accurately.

Thank you for participating in today's meeting about your incident response capabilities and needs as part of Project Responder 5. We would like to understand more about how important the capabilities we discussed are for your particular jurisdiction.

Please take a few minutes to answer this short questionnaire. It should take you about fifteen minutes.

Your individual responses to these questions will not be shared without your permission.

If you have any questions about Project Responder or this survey, please contact the project lead, Michelle Royal, at Michelle.Royal@hsi.dhs.gov.

Beginning on the next page, please answer the questions about your jurisdiction's current status and need for each capability. →→→

1. [Insert text describing capability priority X here]

How strong is your jurisdiction's ability to do this now?

☐	☐	☐	☐	☐
Not at all Strong	Not Very Strong	Somewhat Strong	Very Strong	Extremely Strong

How useful will this capability be for major incidents in your jurisdiction?

☐	☐	☐	☐	☐
Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful	Extremely Useful

How useful will this capability be for day-to-day operations in your jurisdiction?

☐	☐	☐	☐	☐
Not at all Necessary	Not Very Necessary	Somewhat Necessary	Very Necessary	Extremely Necessary

How urgent is your jurisdiction's need for this capability?

☐	☐	☐	☐	☐
Not at all Urgent	Not Very Urgent	Somewhat Urgent	Very Urgent	Extremely Urgent

How likely is it that your jurisdiction would invest resources in this capability?

☐	☐	☐	☐	☐
Not at all Likely	Not Very Likely	Somewhat Likely	Very Likely	Extremely Likely

(This page is repeated as necessary for each capability need discussed during the Project Responder 5 focus group meetings.)

Capability Rating Sheet

Look at each of the capabilities listed below. Circle the number corresponding how important you think each one is, where 1 = very low priority, 2 = low priority, 3 = medium priority, 4 = high priority, and 5 = very high priority.

	Very Low Priority	Low Priority	Medium Priority	High Priority	Very High Priority
[capability need statements here]	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

For coding purposes and so we can better understand how needs vary across the country, please give us some information about your agency and role.

(This information will not be shared without your permission.)

Name: _____

Title: _____

Agency: _____

May we contact you if we have follow-up questions about the information you have provided?

☐ Yes, you may contact me at:

Email address: _____

Contact telephone number: _____

☐ No, please do not contact me.

THANK YOU FOR PARTICIPATING IN PROJECT RESPONDER 5.

APPENDIX G. PRIORITIZATION DATA AND ANALYSIS

This appendix contains the outputs of the data from the pre-interview questionnaire, pre- and post-meeting questionnaires, multi-voting exercises, and the priority survey completed by members of the First Responders Resource Group (FRRG).

Current Preparedness for Most Significant Threat

The study team asked 39 interview and focus group participants a series of survey questions about their current preparedness environment. The team first asked about the threats and hazards they are most concerned about. The results are shown in Table 3, below.

Table 3. Significant threats[149]

What is the most significant threat or hazard your jurisdiction must be prepared for?	**Number of respondents who listed this first**
Terrorism (including active shooter, IED, multiple attacks)	16
Natural disaster (including wildfire, earthquake, hurricane, etc.)	13
Infrastructure or transportation disaster	3
Civil unrest, riots	3
Mass casualty incident	2
Other (routine emergencies, environmental issues)	2

When asked how well prepared respondents think their jurisdiction is to respond to this threat or hazard today, the mean response was 3.3 (standard deviation [s.d.] = 0.73) on a five-point scale where 5 = extremely well prepared and 1 = not prepared at all. The median and modal responses are both 3. Thus, respondents generally see their jurisdictions as somewhat prepared for the most significant threat they face.

The study team asked respondents to reflect on how their jurisdiction's preparedness has changed over time by asking, "Thinking back, would you say your jurisdiction is better prepared or not as prepared to respond to this threat or hazard as it was 5 years ago?" The mean response was 3.9 (s.d. = 1.06) on a five-point scale where 5 = much better prepared and 1 = much less prepared. The median and modal responses are both 4. Thus, respondents generally see their jurisdictions as somewhat better prepared than they were five years ago.

The team then asked the 39 respondents to tell us what their jurisdiction needs to improve its level of preparedness for the most significant threat it faces. The results are shown in Table 4, below.

[149] Note: Of the 39 survey respondents, 31 listed both terrorism and natural disasters as the most significant threat to their jurisdiction.

Table 4. General preparedness needs

How big a need is…	Mean	S.D.
Better access to existing technology	4.18	0.76
Specialized training	4.18	0.82
Additional personnel	4.18	1.02
New technology	4.13	0.86
New policies and procedures	3.90	0.94
Specialized equipment	3.85	0.87

Focus Group Capability Prioritization

As a result of the interview process, a set of 37 capability needs was identified. To explore these in detail, four focus groups were convened. Each of the focus groups was asked to discuss a set of approximately eight capabilities within a particular response domain or domains.

Through a multi-voting process, described in the methodology, the focus group participants identified the top capability priorities from those they discussed. The results of this process are the group's consensus about which capabilities are most important. The highest priority capabilities by focus group are shown in Table 5, below.

Table 5. Top capability priorities based on focus group consensus

Focus Group 1

- The ability to capture, process, integrate and manage raw and digital information related to incident, response operations or an investigation
- The ability to isolate and extract critical information from social media feeds and electronic communications (of individuals on the scene) during response operations

Focus Group 2

- The ability to quickly establish joint command between jurisdictions and agencies
- The ability to geolocate non-personnel resources within the incident response area

Focus Group 3

- The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth

Focus Group 4

- The ability to estimate or identify the number of persons in affected areas at the time of an incident
- The ability to monitor the physiological signs of emergency responders
- The ability to maintain proficiency in disaster management training for all responders regardless of rank

In addition, the study team surveyed the participants in each focus group to understand their individual perspectives of the importance of each of the capability needs their group discussed. Specifically, participants were asked to assess:

- the strength of their jurisdiction's ability with respect to each capability now
- how useful each capability will be for major incidents in their jurisdiction
- how useful each capability will be for day-to-day operations in their jurisdiction
- how urgent their jurisdiction's need is for each capability
- how likely is it that their jurisdiction would invest resources in each capability
- how high a priority each capability is to their jurisdiction

Responses employed a five-point scale, where 5 = extremely (strong, useful, urgent, likely or very high, respectively) and 1 = not at all (strong, useful, urgent, likely or very low, respectively).

Tables 5 through 8 below summarize the results of each focus group for each of the capabilities that group discussed. The tables report mean responses on the five-point scale. The tables are ordered from highest priority capability to lowest, based on the

individual ratings of focus group participants. The capabilities that the group selected through the multi-voting process as highest priorities are shown in bold.

Table 6. Focus group 1 results

Domains: Communications and Information Sharing and Intelligence and Investigation
(10 participants)

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to isolate and extract critical information from social media feeds and electronic communications during response operations	2.9	4.4	3.7	3.7	3.7	4.9
The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation	3.2	4.6	3.6	4.0	3.9	4.8
The ability to share incident-related information among agencies and disciplines during response operations	3.0	4.2	3.7	3.9	3.8	4.3
The ability to create actionable intelligence based on data and information from multiple sources	3.2	4.4	3.9	3.7	3.7	4.1
The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence	2.9	4.5	3.4	3.9	3.5	4.1
The ability to effectively communicate in the presence of loud ambient noise	2.0	4.0	3.5	3.1	2.8	3.5
The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations	3.4	4.4	3.7	3.6	3.3	3.4
The ability to facilitate the management of communications channels and frequencies among multiple disciplines and agencies	3.0	3.7	2.9	3.1	3.2	3.1

Table 7. Focus group 2 results

Domains: Command, Control and Coordination and Logistics and Resource Management
10 participants

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to quickly establish joint command between jurisdictions and agencies	4.0	4.6	4.3	3.6	4.0	4.5
The ability to geolocate non-personnel resources within the incident response area	2.4	4.5	3.1	3.5	3.5	4.0
The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident-specific response	2.1	4.0	3.0	3.1	3.3	3.9
The ability to electronically document and track command decisions, actions and assignments during response operations	3.1	4.1	3.3	2.6	3.8	3.5
The ability to centrally manage incident-specific logistics information	3.3	4.3	3.3	2.9	3.1	3.3
The ability to digitally request resources from the field and track disposition of request, resource status and location	2.0	3.8	2.6	2.6	3.0	3.3
The ability to account for and manage on-duty, off-duty and self-reporting personnel in real-time (including check-in and staging direction)	1.8	3.8	2.4	2.6	3.1	3.1
The ability to identify resource needs for rescue and shelter of citizens with access and functional needs	2.3	3.9	2.8	2.8	2.9	3.0
The ability to verify the credentials of all on-scene responders	2.1	3.8	2.3	2.5	2.6	2.9
The ability to provide decision-support templates and prompts during incident operations	2.5	3.6	3.3	2.9	3.1	2.8

Table 8. Focus group 3 results

Domains: Situational Awareness and Risk Assessment and Planning
10 participants

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth	1.3	4.5	4.7	4.1	3.1	4.5
The ability to merge and synthesize disparate data sources in real time to support situational awareness	1.5	4.0	3.8	3.5	2.9	4.5
The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command	1.8	4.7	3.7	3.8	3.1	4.4
The ability to obtain and maintain a bird's-eye view of the incident scene	2.0	4.9	4.5	3.6	2.6	4.1
The ability to generate maps for indoor and outdoor locations integrating incident data with existing GIS data	2.0	4.4	3.9	3.6	2.9	3.9
The ability to detect and identify threats and hazards on the incident scene	2.3	4.0	3.9	3.2	2.6	3.6
The ability to identify cascading effects of the incident that impact the response and/or the surrounding community	2.1	3.8	3.1	3.0	2.2	3.4
The ability to evaluate how evolving manmade incidents or natural disasters might impact an individual jurisdiction	2.6	4.1	3.4	3.4	2.7	2.9
The ability to accurately identify local and regional threats and risks and model potential consequences	2.7	4.0	3.3	2.9	2.7	2.9

Table 9. Focus group 4 results

Domains: Responder Health and Safety; Casualty Management; and Training and Exercise
5 participants

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to monitor the physiological signs of emergency responders	2.0	4.6	3.4	3.2	3.2	4.4
The ability to estimate or identify the number of persons in affected areas at the time of an incident	2.6	3.8	2.6	2.8	2.6	3.4
The ability to maintain proficiency in disaster management training for all responders regardless of rank	2.8	3.6	3.2	3.0	3.0	3.4
The ability for responders to ascertain exposure type and level	2.6	4.0	3.4	2.8	3.2	3.8
The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability	2.0	3.8	3.2	2.6	3.0	3.6
The ability to identify the location of injured, trapped and deceased casualties on the incident scene	2.2	3.6	2.4	2.4	2.6	3.4
The ability to manage and track the status of known and potential casualties from site through reunification	2.4	4.0	2.4	2.6	2.4	3.4
The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents	2.4	3.6	3.6	3.0	3.0	3.2
The ability to provide individually appropriate mental health services following incident response	3.0	4.2	3.2	3.0	3.2	3.0
The ability to manage the process and track large numbers of fatalities through all phases of response	2.2	3.8	2.2	2.4	2.2	2.6

Table 10, below, shows the results for all 37 capability needs across all four focus groups, ordered by how high a priority individual focus group participants assessed each of those capabilities that their group discussed (means on a five-point scale, highest to lowest). Those capabilities that were identified through the multi-voting process as top priorities by consensus of the focus group that discussed them are shown in bold. Individual assessments typically differ from consensus choices, as they do here, but both individuals and groups concur about the very top capability needs. The table reports mean responses on the five-point scale.

Table 10. Individual assessments of capability needs

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to isolate and extract critical information from social media feeds and electronic communications during response operations	2.9	4.4	3.7	3.7	3.7	4.9
The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation	3.2	4.6	3.6	4.0	3.9	4.8
The ability to quickly establish joint command between jurisdictions and agencies	4.0	4.6	4.3	3.6	4.0	4.5
The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth	1.3	4.5	4.7	4.1	3.1	4.5
The ability to merge and synthesize disparate data sources in real time to support situational awareness	1.5	4.0	3.8	3.5	2.9	4.5
The ability to access, integrate, share and display images and video pertinent to the incident scene for the responder and incident command	1.8	4.7	3.7	3.8	3.1	4.4
The ability to monitor the physiological signs of emergency responders	2.0	4.6	3.4	3.2	3.2	4.4
The ability to share incident-related information among agencies and disciplines during response operations	3.0	4.2	3.7	3.9	3.8	4.3
The ability to create actionable intelligence based on data and information from multiple sources	3.2	4.4	3.9	3.7	3.7	4.1
The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence	2.9	4.5	3.4	3.9	3.5	4.1
The ability to obtain and maintain a bird’s-eye view of the incident scene	2.0	4.9	4.5	3.6	2.6	4.1

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to geolocate non-personnel resources within the incident response area	2.4	4.5	3.1	3.5	3.5	4.0
The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident response	2.1	4.0	3.0	3.1	3.3	3.9
The ability to generate maps for indoor and outdoor locations integrating incident data with existing GIS data	2.0	4.4	3.9	3.6	2.9	3.9
The ability for responders to ascertain exposure type and level	2.6	4.0	3.4	2.8	3.2	3.8
The ability to detect and identify threats and hazards on the incident scene	2.3	4.0	3.9	3.2	2.6	3.6
The ability to provide enhanced protection from threats without specialized garments or compromising comfort and maneuverability	2.0	3.8	3.2	2.6	3.0	3.6
The ability to effectively communicate in the presence of loud ambient noise	2.0	4.0	3.5	3.1	2.8	3.5
The ability to electronically document and track command decisions, actions and assignments during response operations	3.1	4.1	3.3	2.6	3.8	3.5
The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations	3.4	4.4	3.7	3.6	3.3	3.4
The ability to identify cascading effects of the incident that impact the response and/or the surrounding community	2.1	3.8	3.1	3.0	2.2	3.4
The ability to estimate or identify the number of persons in affected areas at the time of an incident	2.6	3.8	2.6	2.8	2.6	3.4
The ability to identify the location of injured, trapped and deceased casualties on the incident scene	2.2	3.6	2.4	2.4	2.6	3.4
The ability to maintain proficiency in disaster management training for all responders regardless of rank	2.8	3.6	3.2	3.0	3.0	3.4
The ability to manage and track the status of known and potential casualties from site through reunification	2.4	4.0	2.4	2.6	2.4	3.4
The ability to centrally manage incident-specific logistics information	3.3	4.3	3.3	2.9	3.1	3.3

Capability need	Ability now	Usefulness for major incidents	Usefulness day-to-day	Urgency of need	Likeliness of investment	Level of priority
The ability to digitally request resources from the field and track disposition of request, resource status and location	2.0	3.8	2.6	2.6	3.0	3.3
The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents	2.4	3.6	3.6	3.0	3.0	3.2
The ability to facilitate the management of communications channels and frequencies among multiple disciplines and agencies	3.0	3.7	2.9	3.1	3.2	3.1
The ability to account for and manage on-duty, off-duty and self-reporting personnel in real-time (including check-in and staging)	1.8	3.8	2.4	2.6	3.1	3.1
The ability to identify resource needs for rescue and shelter of citizens with access and functional needs	2.3	3.9	2.8	2.8	2.9	3.0
The ability to provide individually appropriate mental health services following incident response	3.0	4.2	3.2	3.0	3.2	3.0
The ability to verify the credentials of all on-scene responders	2.1	3.8	2.3	2.5	2.6	2.9
The ability to evaluate how evolving manmade incidents or natural disasters might impact an individual jurisdiction	2.6	4.1	3.4	3.4	2.7	2.9
The ability to accurately identify local and regional threats and risks and model potential consequences	2.7	4.0	3.3	2.9	2.7	2.9
The ability to provide decision-support templates and prompts during incident operations	2.5	3.6	3.3	2.9	3.1	2.8
The ability to manage the process and track large numbers of fatalities through all phases of response	2.2	3.8	2.2	2.4	2.2	2.6

First Responders Resource Group Survey

To gain additional and broader perspective on the capability needs, the study team asked members of the FRRG to also assess the 37 capability needs. Sixty-six members of the FRRG responded to a survey that asked them how high a priority each of the 37 capability needs is on a five point scale where 5 = very high priority and 1 = very low priority. The results are shown in Table 9, below, sorted from highest to lowest priority.

Table 11. FRRG assessments of capability needs

Capability need	Mean	S.D.
The ability to detect and identify threats and hazards on the incident scene	4.47	0.71
The ability to identify the location of injured, trapped and deceased casualties on the incident scene	4.32	0.79
The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth	4.30	0.82
The ability to quickly establish joint command between jurisdictions and agencies	4.29	0.72
The ability to merge and synthesize disparate data sources in real time to support situational awareness	4.21	0.79
The ability to facilitate the management of communications channels and frequencies among multiple disciplines and agencies	4.21	0.81
The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command	4.20	0.85
The ability to share incident-related information among agencies and disciplines during response operations	4.20	0.86
The ability to create actionable intelligence based on data and information from multiple sources	4.05	0.83
The ability to generate maps for indoor and outdoor locations integrating incident data with existing GIS data	4.02	0.87
The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability	3.98	0.79
The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations	3.97	1.01
The ability to account for and manage on-duty, off-duty and self-reporting personnel in real-time (including check-in and staging direction)	3.95	0.95
The ability to effectively communicate in the presence of loud ambient noise	3.95	0.97
The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence	3.94	0.84
The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents	3.92	0.88
The ability for responders to ascertain exposure type and level	3.86	0.86
The ability to verify the credentials of all on-scene responders	3.85	0.9
The ability to isolate and extract critical information from social media feeds and electronic communications during response operations	3.85	0.95
The ability to maintain proficiency in disaster management training for all responders regardless of rank	3.82	0.84
The ability to electronically document and track command decisions, actions and assignments during response operations	3.79	0.87
The ability to obtain and maintain a bird’s-eye view of the incident scene	3.79	0.83
The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident-specific response	3.76	0.86
The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation	3.76	0.86

Capability need	Mean	S.D.
The ability to identify cascading effects of the incident that impact the response and/or the surrounding community	3.73	0.87
The ability to estimate or identify the number of persons in affected areas at the time of an incident	3.73	0.83
The ability to monitor the physiological signs of emergency responders	3.68	0.88
The ability to accurately identify local and regional threats and risks and model potential consequences	3.64	0.89
The ability to provide individually appropriate mental health services following incident response	3.61	1.02
The ability to manage and track the status of known and potential casualties from site through reunification	3.61	0.82
The ability to provide decision-support templates and prompts during incident operations	3.56	0.77
The ability to evaluate how evolving manmade incidents or natural disasters might impact an individual jurisdiction	3.55	0.86
The ability to geolocate non-personnel resources within the incident response area	3.52	0.81
The ability to manage the process and track large numbers of fatalities through all phases of response	3.50	0.9
The ability to centrally manage incident-specific logistics information	3.48	0.68
The ability to identify resource needs for rescue and shelter of citizens with access and functional needs	3.48	0.96
The ability to digitally request resources from the field and track disposition of request, and resource status and location	3.47	0.81

The study team also asked the FRRG members to examine 16 capabilities that were viewed as a high priority, either by individual assessments by project participants or through the multi-voting process, or both. The FRRG members were asked to choose their top three priorities in order from the list of 16. Table 12, below, shows the number of FRRG members that ranked each capability need first, second or third, or in the top three. (Sample size for this rating is 56 useable responses.)

Table 12. FRRG ranking of top priorities identified by project participants

Capability	Top	Second	Third	In top 3
The ability to share incident-related information among agencies and disciplines during response operations	9	7	6	22
The ability to geolocate responders on the incident scene (indoors and outdoors), including latitude, longitude and altitude/depth	10	5	6	21
The ability to quickly establish unified command between jurisdictions and agencies	11	4	2	17
The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on the scene during response operations	1	4	9	14
The ability to integrate resource data from participating agencies for a holistic picture of resources available for incident-specific response	2	6	4	12

Capability	Top	Second	Third	In top 3
The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command	3	6	2	11
The ability to create actionable intelligence based on data and information from multiple sources	3	8	0	11
The ability to merge and synthesize disparate data sources in real time (e.g., known hazards, building blueprints, ownership records) to support situational awareness	1	4	5	10
The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation	4	1	4	9
The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence	4	1	4	9
The ability to account for and manage on-duty, off-duty and self-reporting personnel in real-time (including check-in and staging direction)	0	3	5	8
The ability to obtain and maintain a bird's-eye view of the incident scene	2	1	4	7
The ability to monitor the physiological signs of emergency responders	3	1	2	6
The ability to geolocate non-personnel resources within the incident response area	1	2	0	3
The ability to estimate or ascertain the number of persons in affected areas at the time of an incident	0	1	0	1
The ability to manage and track large numbers of fatalities through all phases of response	0	0	1	1

APPENDIX H. STANDARDS RELATED TO PROJECT RESPONDER 5 CAPABILITY NEEDS

This appendix contains brief descriptions of standards and guidelines that may impact development of solutions to address the Project Responder 5 (PR5) capability needs. Relevance is based on the goals articulated by responders in the focus group meeting. Therefore, it is likely that other standards might pertain as requirements are developed and refined.

ANSI/ISEA 107-2015: American National Standard for High-Visibility Safety Apparel and Accessories[150]

Authorizing Body: American National Standards Institute (ANSI) and International Safety Equipment Association (ISEA)

ANSI/ISEA 107-2015 combines the requirements from the 2010 edition with those of ANSI/ISEA 207, American National Standard for High-Visibility Public Safety Vests, which was a standard for high-visibility safety apparel (HVSA) used by emergency responders. The standard specifies the performance requirements for the materials used to make HVSA and labelling requirements by type, class and flame-resistance features based on the minimum amount of background and retroflective material, and the specific placement of the latter. It also specifies three new type designations for high visibility safety apparel, based on the expected work environment.

ANSI/ISEA 107-2015 includes new design criteria for smaller garments to address the needs of smaller workers who are 5’6” and under and specifies new labeling requirements for flame resistant garments. HVSA must be labeled as flame resistant, along with the appropriate standard used in testing, or indicate that the garment is not flame resistant.

Correlation with PR5 capability needs:

- The ability to geolocate responders on the incident scene (indoors and outdoors) to include latitude, longitude and altitude/depth

APCO ANS 1.112.1-2014: Best Practices for the Use of Social Media in Public Safety Communications[151]

Authorizing Body: Association of Public-Safety Communications Officials (APCO)

Social media sites, such as Facebook, Twitter, Instagram and Google+, can be an effective communication tool for agencies to provide information to, and receive information from, the general public. Response agencies have used social media before,

[150] American National Standard for HVSA and Accessories, ANSI/ISEA 107-2015, ANSI International, 2015.

[151] Best Practices for the Use of Social Media in Public Safety Communications, APCO ANS 1.112.1-2014, APCO International, 2014.

during, and after incidents to communicate with the public and to maintain situational awareness. APCO ANS 1.112.1-2014 provides guidance to agencies for the development of operational procedures and competencies for the use of social media, while recognizing the need for each to customize specific procedures to their local environment. The standard directs that agencies should establish policies for social media use during and after active incidents, including the circumstances under which it will be used to communicate with the public, who is responsible for those communications, and the chain of command for approval of that information.

APCO ANS 1.112.1-2014 outlines the need for procedures concerning the use of social media information and validation of sources if agencies are going to use social media for research and investigation during an active incident. These activities include validating, logging and archiving information collected. The standard recommends that policies should be developed for monitoring and responding to social media posts from the general public during major events and for emergency management and that these policies should be posted on social media sites so the general public is aware of the frequency and circumstances under which they will be used to communicate emergency information.

Correlation with PR5 capability needs:

- The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command
- The ability to create actionable intelligence based on data and information from multiple sources
- The ability to monitor social media and other non-traditional intelligence sources for warnings and indications of planned activities or violence
- The ability to isolate and extract critical information from social media feeds and electronic communications (e.g., texts) of individuals on the scene during response operations

ASTM F1671/F1671M-13: Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System[152]

Authorizing Body: American Society of Testing Materials (ASTM)

ASTM F1671/F1671M-13 is used to measure the resistance of materials used in protective clothing to penetration by blood-borne pathogens. Pass/fail determinations are based on the detection of penetration by the surrogate liquids. This test is not always effective in testing protective materials with thick, inner liners that readily absorb the

[152] Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System, ASTM F1671/F1671M-13, ASTM International, 2013.

assay fluid. ASTM F1671/F1671M-13 addresses only the performance of materials, including specific material constructions such as seams, used in protective clothing. This test method does not address the design, overall construction and components or other factors that may affect the overall protection offered by the clothing.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

ASTM F2413: Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear[153]

Authorizing Body: ASTM

ASTM F2413 specifies the minimum requirements for design, performance, testing and classification of footwear designed for protection against workplace hazards that could cause injury. Performance requirements are included for:

- Toe area impact resistance
- Toe area compression resistance
- Metatarsal impact protection
- Conductive properties that reduce hazards due to static electricity buildup
- Protection from electric hazards
- Static dissipative properties
- Footwear bottom puncture resistance

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

Common Alerting Protocol (CAP), Version 1.2[154]

Authorizing Body: Organization for the Advancement of Structured Information Standards (OASIS)

The CAP is an open, non-proprietary digital message format for exchanging all-hazard emergency alerts and public warnings over various types of networks. It allows a

[153] Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear, ASTM F2413, ASTM International, 2011.

[154] Common Alerting Protocol (CAP), Version 1.2, Organization for the Advancement of Structured Information Standards, 2010.

consistent message to be disseminated simultaneously over many different warning systems such as Internet services and the Emergency Alert System, thus increasing the warning's effectiveness. CAP provides a template for effective warning messages based on best practices. Template messaging using the CAP format offers enhanced capabilities that include:

- Flexible geographic targeting using latitude/longitude shapes and other geospatial representations in three dimensions
- Multilingual and multi-audience messaging
- Phased and delayed effective times and expirations
- Enhanced message update and cancellation features
- Template support for framing complete and effective warning messages
- Compatible with digital encryption and signature capability
- Facility for digital images and audio

Correlation with PR5 capability needs:

- The ability to share incident-related information among agencies and disciplines during response operations

EDXL-DE-V2.0: Emergency Data Exchange Language (EDXL) Distribution Element, v. 2.0[155]

Authorizing Body: OASIS

The primary purpose of EDXL-DE-V2.0 is to facilitate the routing of any properly formatted extensible markup language (XML) emergency message to its intended recipients. The format described in the standard may be thought of as a "container" that provides the information to specifically route message sets (e.g., alerts or resource messages), by including key routing information such as distribution type, geography, incident and sender/recipient identifiers. EDXL-DE-V2.0 describes a standard message distribution framework for data sharing between emergency information systems via XML-based EDXL. This EDXL format can be used over any data transmission system.

Correlation with PR5 capability needs:

- The ability to merge and synthesize disparate data sources in real time (e.g., known hazards, building blueprints and ownership records) to support situational awareness

[155] EDXL Distribution Element, v. 2.0, EDXL-DE-V2.0, Organization for the Advancement of Structured Information Standards, 2013.

- The ability to share incident-related information among agencies and disciplines during response operations
- The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident specific response
- The ability to generate maps for indoor and outdoor locations integrating incident data with existing maps
- The ability to estimate or ascertain the number of persons in affected areas at the time of an incident
- The ability to track the status of known and potential casualties from site to reunifaction

Federal Information Processing Standards (FIPS) Publication 197: Advanced Encryption Standard (AES)[156]

Authorizing Body: FIPS

FIPS 197 specifies a FIPS-approved cryptographic algorithm used to protect electronic data. The algorithm can encrypt (encipher) and decrypt (decipher) information. The AES standard may be used when an agency determines that sensitive (unclassified) information requires cryptographic protection.

Correlation with PR5 capability needs:

- The ability to conduct multi-modal, multi-agency and multi-jurisdictional training and exercises across a wide spectrum of incidents
- The ability to create actionable intelligence based on data and information from multiple sources
- The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command
- The ability to obtain and maintain a bird's-eye view of the incident scene
- The ability to share incident-related information among agencies and disciplines during response operations

Global Justice XML Data Model (GJXDM)[157]

Authorizing Body: U.S. Department of Justice

[156] Advanced Encryption Standard (AES), Publication 197, Federal Information Processing Standards, 2001.

[157] Global Justice XML Data Model (Washington: Department of Justice).

The GJXDM represents a common way to develop information sharing systems through the use of a common vocabulary that is understood system to system. The GJXDM enables access to information from multiple sources and the ability to reuse the information in multiple applications thus allowing justice and public safety disciplines to effectively exchange information at all levels.

The GJXDM is a reference model, meaning it is not a rigid standard that must be used exactly as it is in its entirety. It was designed as a core set of building blocks to be used as a consistent baseline for creating exchange documents and transactions.

NOTE: The GJXDM is the predecessor of the National Information Exchange Model (NIEM). Based on information available, it appears that the GJXDM is still supported, although adoption of NIEM is encouraged.

Correlation with PR5 capability needs:

- The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident specific response
- The ability to share incident-related information among agencies and disciplines during response operations
- The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command
- The ability to merge and synthesize disparate data sources in real time (e.g., known hazards, building blueprints and ownership records) to support situational awareness
- The ability to create actionable intelligence based on data and information from multiple sources

HIPAA: Health Insurance Portability and Accountability Act[158]

Authorizing Body: Pub.L. 104–191, 110 Stat. 1936

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) was passed by the U.S. Congress in August 1996 and regulated the following areas within the health care industry:

- Provides the ability to transfer and continue health insurance coverage after a change in or loss of employment
- Reduces the potential for health care fraud and abuse
- Mandates standards for health care information on electronic billing and other processes

[158] Health Insurance Portability and Accountability Act of 1996, Pub. L. 104–191, 110 Stat. 1936 (1996).

- Requires the protection and confidential handling of health information

The HIPAA regulations require health care providers and organizations develop and follow procedures that guarantee the confidentiality and security of protected health information (PHI) when it is transferred, received, handled or shared. These regulations apply to all forms of PHI (e.g., paper, oral and electronic). HIPAA also states that only the minimum health information necessary to conduct business is to be used or shared.

Correlation with PR5 capability needs:

- The ability to provide individually appropriate mental health services following incident response
- The ability to monitor the physiological signs of emergency responders
- The ability to track the status of known and potential casualties from site through reunification
- The ability to manage and track large numbers of fatalities through all phases of the response

ISO/IEC DIS 18305: Real-time locating systems—Test and evaluation of localization and tracking systems[159]

Authorizing Body: International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC)

Identifying the precise location of responders on an incident scene is critical to responder safety. Responders need to know their location and that of other responders. Incident commanders need to know the location of their responders to communicate instructions and locations of hazards. They also need to know location information in case an evacuation or rescue of trapped workers is needed. Global positioning systems do not work in indoor environments. Indoor responder geolocation systems are needed. This standard addresses test and evaluation of localization and tracking systems designed for indoor environments.

The standard does not set minimum performance requirements because one test and evaluation standard may apply to several localization and tracking systems applications, but the minimum performance requirements usually vary.

Correlation with PR5 capability needs:

- The ability to geolocate responders on the incident scene (indoors and outdoors) to include latitude, longitude and altitude/depth

[159] Real-time locating systems--Test and evaluation of localization and tracking systems, ISO/IEC DIS 18305, International Organization for Standardization, 2016.

NFPA 1851: Standard on Selection, Care and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting[160]

Authorizing Body: National Fire Protection Association (NFPA)

NFPA 1851 was developed to be a companion document to NFPA 1971, *Standard on Protective Ensembles for Structural Fire Fighting*, which specifies product design, performance, testing and certification for manufacturers and certification organizations. NFPA 1851 specifies the minimum requirements for the selection, care and maintenance of structural and proximity firefighting protective ensembles and their individual elements, including those with optional CBRN protection. These requirements apply to garments, helmets, gloves, footwear and interface components, to reduce health and safety risks associated with improper maintenance, contamination or damage. The standard is written for the individual firefighter who uses the protective ensemble, as well as the staff members trained for more advanced maintenance, decontamination, inspection and repair. NFPA 1851 also addresses administrative responsibilities and the review of the structural firefighting protective ensemble program to ensure it is working as designed and achieving its goals. Responsibilities for garment element inspection, cleaning and repair are specified. The standard does not address respiratory protection.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1951: Standard on Protective Ensembles for Technical Rescue Incidents[161]

Authorizing Body: NFPA

NFPA 1951 specifies the minimum requirements for the design, performance, testing and certification of protective ensembles and ensemble elements for responders involved in technical rescue incidents, including search, rescue, treatment, decontamination and recovery and site stabilization. Different types of technical rescue scenarios require different types of protective ensembles. To cover the various incident types to which responders may respond, the standard sets the requirements for three types of ensembles (garments, interface, gloves, footwear, helmets and eye and face protection): utility, rescue and recovery and Chemical, biological, radiological and nuclear (CBRN). Utility technical rescue protective ensembles and element requirements provide limited protection at incident scenes at which physical and thermal hazards are likely. Rescue and recovery technical rescue protective ensembles and element requirements provide limited protection in settings for which exposure to physical, thermal, liquid and bodily fluid-borne pathogen hazards are expected. CBRN technical rescue protective ensembles and

[160] Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, NFPA 1851, NFPA, 2014.

[161] Standard on Protective Ensembles for Technical Rescue Incidents, NFPA 1951, NFPA, 2013.

element requirements establish limited protection for incidents in which exposure to physical, thermal, liquid, bodily fluid-borne pathogens and CBRN agents in vapor, liquid-splash and particulate forms are likely. NFPA 1951 specifies the minimum requirements for respiratory protection for CBRN technical rescue protective ensembles only and does not include requirements for protective ensembles used in water or wilderness incidents.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting[162]

Authorizing Body: NFPA

NFPA 1971 was written with the goal of safeguarding firefighting personnel by establishing minimum levels of protection from thermal, physical, environmental and blood-borne pathogen hazards during structural fires and intense heat operations. The standard specifies the minimum design, performance, testing and certification requirements for structural firefighting protective ensembles and elements (e.g., coats, trousers, coveralls, helmets, gloves, footwear and interface components). The standard also specifies additional optional requirements for complete structural firefighting and proximity firefighting protective ensembles that provide some protection from specified chemicals, biological agents and radiological particulates.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1975: Standard on Emergency Services Work Clothing Elements, 2014 Edition[163]

Authorizing Body: NFPA

NFPA 1975 was established in 1985 on the premise that the uniform itself should not contribute to firefighter or responder injury under adverse conditions. Its evolution has allowed uniforms to adapt to fire service needs while allowing uniform elements to potentially provide different performance characteristics. The standard applies to labeling, design, performance, testing and certification of non-primary protective work clothing elements and apparel. NFPA 1975 specifies criteria for textiles that will not rapidly deteriorate, melt, shrink, or adhere to the skin. Additionally, the standard provides

[162] Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, NFPA 1971, NFPA, 2013.

[163] Standard on Emergency Services Work Clothing Elements, NFPA 1975, NFPA, 2014.

optional requirements and tests for verification of resistance to flame, odor and water, as well as insect repellency.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1992: Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies[164]

Authorizing Body: NFPA

NFPA 1992 specifies the minimum requirements for the design, performance, testing, documentation and certification of liquid-splash protective ensembles and their elements as well as protective clothing for responders during hazardous materials emergencies. According to the standard, protective ensembles must encapsulate the torso, head, arms, legs, hands, feet and self-contained breathing apparatus. NFPA 1992 also includes optional requirements for protection from chemical flash fires to provide escape time for responders. The standard does not apply to hazardous chemicals that are suspected or known carcinogens or toxic chemical vapors. The 2012 edition of the standard contains a new requirement on thermal heat loss.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1994: Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents[165]

Authorizing Body: NFPA

There is no protective ensemble that can protect responders from all hazards. Selection of the appropriate protective ensemble is based on an assessment of the hazards present at an incident scene. NFPA 1994 sets the minimum requirements for new protective ensembles and their elements to protect responders against CBRN terrorism agents. The standard includes the design, performance, testing, documentation and certification of three classes of CBRN ensembles for different types of hazards in response to non-firefighting terrorist incidents. NFPA 1994 includes requirements for Classes 2, 3 and 4 ensembles. Class 2 ensembles protect against vapor or liquid chemical hazards with concentrations at or above Immediately Dangerous to Life and Health (IDLH), which require the use of self-contained breathing apparatus. Class 3 ensembles protect against

[164] Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies, NFPA 1992, NFPA, 2012.

[165] Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents, NFPA 1994, NFPA, 2012.

vapor or liquid chemical hazards with levels below IDLH, allowing for the use of air purifying respirators (APR). Class 4 ensembles are used for incidents that involve biological hazards or radiological particulate hazards with concentrations less than IDLH, permitting for the use of APR. All three classes of protective ensembles described in this standard are single-use.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

NFPA 1999: Standard on Protective Clothing and Ensembles for Emergency Medical Operations[166]

Authorizing Body: NFPA

NFPA 1999 specifies the documentation, design, performance, testing and certification requirements for protective clothing to shield EMS workers from blood- and body fluid-borne pathogens while caring for patients during emergency medical operations prior to transportation to medical facilities. The standard also applies to protective clothing for medical first receivers at those facilities. The minimum performance requirements for protective clothing are specified by the Occupational Safety and Health Administration. The standard also specifies requirements for limited protection from specified chemical, biological, radiological and nuclear agents.

Due to the 2014 Ebola outbreak in Africa and the subsequent cases of Ebola in the United States, particularly in Dallas, Texas, a Tentative Interim Amendment to NFPA 1999 was issued to prepare responders for future cases of highly infectious diseases. The standard specifies the minimum design, performance, testing, documentation and certification requirements for single-use and multiple-use PPE ensembles that provide full-body protection against airborne and liquid-borne pathogens and includes the requirements, precautions and sequence for donning and removal for each ensemble element.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

National Information Exchange Model (NIEM) v. 3.2[167]

Authorizing Body: National Information Exchange Model

NIEM is a standards-based approach to exchanging information that can be used by diverse communities to increase efficiency in information sharing and improve decision making. Through a collaborative effort between the justice and homeland security

[166] Standard on Protective Clothing and Ensembles for Emergency Medical Operations, NFPA 1999, NFPA, 2013.

[167] National Information Exchange Model, U.S. Department of Justice, 2014.

communities, a set of common, well-defined data elements for data exchange development were developed. NIEM built upon the success and lessons learned of the Global JXDM to develop and deploy a national model for information sharing and the organizational structure to govern it.

To date, all 50 states and the majority of federal agencies are using or are considered to be using the model. NIEM exchanges are currently under development to allow for a more efficient and consistent method of sharing important public safety information.

Correlation with PR5 capability needs:

- The ability to access, integrate, share and display images and video pertinent to the incident scene for the on-scene responder and incident command
- The ability to coordinate dispatch functions from multiple jurisdictions and agencies during response operations
- The ability to share incident-related information among agencies and disciplines during response operations
- The ability to integrate resource data from participating agencies for a holistic picture of resources available on scene for incident specific response
- The ability to centrally manage incident-specific logistics information
- The ability to digitally request resources from the field and track disposition of request, resource status and location
- The ability to capture, process, integrate and manage raw and digital information related to incident response, operations or an investigation
- The ability to create actionable intelligence based on data and information from multiple sources
- The ability to generate maps for indoor and outdoor locations integrating incident data with existing maps
- The ability to estimate or ascertain the number of persons in affected areas at the time of an incident
- The ability to track the status of known and potential casualties from site to reunifaction
- The ability to verify the credentials of all on-scene responders

NIJ Standard 0108.01: Ballistic Resistant Protective Materials[168]

Authorizing Body: U.S. Department of Justice, National Institute of Justice

[168] Ballistic Resistant Protective Materials, NIJ Standard 0108.01, National Institute of Justice, 1985.

NIJ Standard 0108.01 establishes minimum performance requirements and methods of testing for ballistic resistant protective materials. The standard is applicable to all ballistic resistant materials intended to provide protection against gunfire, with the exception of police body armor and ballistic helmets. Ballistic resistant materials used include metals, ceramics, transparent glazing, fabric and fabric-reinforced plastics. These are used separately or in combination, depending upon the intended threat protection. The test ammunitions specified in NIJ Standard 0108.01 represent common threats to law enforcement.

Correlation with PR5 capability needs:

- The ability to provide enhanced protection from threats without donning specialized garments or compromising comfort and maneuverability

Project 25 (P25) Technology Interest Group Standards[169]

Authorizing Body: The Project 25 Technology Interest Group (PTIG), administered by the Telecommunications Industry Association (TIA Mobile and Personal Private Radio Standards Committee TR-8)

Established in 1989, Project 25 (P25) is a collection of standards developed to ensure interoperability of digital two-way wireless communications products, which include the push-to-talk land-mobile radio systems used by federal, state and local response agencies throughout the country. Interoperability of radio systems allows communication between different agencies and jurisdictions, a critical requirement for a coordinated response during emergency situations.

The P25 standardization process is user driven. That is, the public safety community contributes to the development of the P25 Technology Interest Group Standards. P25 requires that products are user friendly, allowing for ease of operation with minimal training. The standard establishes Phase 1 and Phase 2 equipment, both of which are compatible with existing analog systems. This allows existing bandwidth and frequency allocations to be used, easing systems and equipment migration from old technology to new. P25 ensures reliable intra- and inter-agency communications, which are essential to multiple jurisdiction and joint operations. To comply with P25, products must meet a minimum set of requirements.

Correlation with PR5 capability needs:

- The ability to facilitate the management of communications channels and frequencies among multiple disciplines.

Small Unmanned Aircraft Rule (Part 107)[170]

Authorizing Body: Federal Aviation Administration (FAA)

---

[169] P25 Technology Interest Group Standards, 2016, http://www.project25.org/.

[170] Small Unmanned Aircraft Rule (Part 107), (Washington: Federal Aviation Administration, June 2016).

As of 26 August 2016, the FAA has amended its regulations to allow the operation of small unmanned aircraft systems in the National Airspace System (NAS) when registered by the owner. 14 C.F.R. Part 107 allows for routine civil operation of small UAS in the NAS when following the safety rules set forth for those operations. The rule defines a small UAS as one that weighs between 0.55 and 55 pounds. To mitigate risk, the rule limits small UAS to daylight and twilight operations with appropriate lighting, confined areas and visual-line-of-sight operations. Part 107 also addresses airspace restrictions, remote pilot certification and operational limits to maintain safety and ensure that small UAS do not pose a threat to national security. A key provision of the rule is a waiver to allow individual operations to deviate from the operational restrictions detailed in the rule if the FAA Administrator determines that the proposed operation can be safely conducted under a certificate of waiver.

Correlation with PR5 capability needs:

- The ability to obtain and maintain a bird's-eye view of the incident scene

---

The following standards do not pertain directly to the PR5 capability needs as defined by the associated goals. However, they may affect development of new solutions as requirements are developed and refined.

ANSI/ISEA Z89.1-2014: American National Standard for Industrial Head Protection[171]

Authorizing Bodies: ANSI and ISEA

ANSI/ISEA Z89.1 specifies performance and labeling requirements for industrial protective helmets or hard hats. This standard establishes both types (based on location of impact force) and classes (based on electrical insulation) of protective helmets for different types of hazards. ANSI/ISEA Z89.1 also specifies minimum performance requirements for protective helmets that reduce the forces of impact and penetration and that may provide protection from electric shock.

NFPA 1982: Standard on Personal Alert Safety Systems (PASS)[172]

Authorizing Body: NFPA

Emergency responders often work in unsafe conditions with a lot of noise. NFPA 1982 sets the requirements for performance of personal alert safety systems (PASS) that allow responders to signal for help in the event they are lost, disoriented, trapped, injured or run out of breathing air when responding to an incident. This standard also includes the minimum requirements for radiofrequency (RF) PASS, which can both transmit a signal for help and receive a signal to evacuate. NFPA 1982 includes design, testing, and

[171] American National Standard for Industrial Head Protection, ANSI/ISEA Z89.1-2014, ANSI International, 2014.

[172] Standard on Personal Alert Safety Systems (PASS), NFPA 1982, NFPA, 2013.

certification of PASS for monitoring a responder's motion and requires PASS to automatically emit an audible signal to call for help if the user becomes incapacitated or needs assistance. The standard addresses corrosion, heat, flame, impact and vibration resistance. NFPA 1982 also lists criteria for mode selection, motion sensing, radio system tests and signal frequency tests.

(This page intentionally left blank.)

APPENDIX I. PROJECT RESPONDER 5 PARTICIPANTS

Name	Agency
Brian Ambrose	Charleston (South Carolina) Police Department
Knox Andress	Louisiana Region 7 Hospital Coalition
Jose Archila	Boston Emergency Medical Services
Bruce Arvizu	Los Angeles County Fire Department (Retired)
April Bassett	San Francisco Fire Department
Rick Bekemeier	Michigan State Police
Randal Bittinger	Fairfax County (Virginia) Fire and Rescue Department
Daniel Bout	California Governor's Office of Emergency Services
Ashland Bray	Michigan State Police
Joseph Brooks	Boston Fire Department
Kevin Buckley	Boston Police Department
Alan Butsch	Montgomery County (Maryland) Fire & Rescue Service
Jay Cassout	Scott City (Missouri) Fire and Rescue
John Clark	Charleston County (South Carolina) Sheriff's Office
Paul Cresci	Fire Department of New York City
Carol Cunningham	Ohio Department of Public Safety, Division of EMS
Michael Dailey	Aurora Police Department
D. Jeremy DeMar	City of Rochester (New York) Emergency Communications Department
Josh Dennis	Chicago Fire Department
Robert Doke	Oklahoma State Fire Marshal's Office
Daniel Dooley	New York City Police Department
Tim Dorsey	West County (Missouri) EMS & Fire
Brian Drake	Cook County (Illinois) Office of Homeland Security & Emergency Management
Patricia J. Dukes	Area Support Group – Kuwait Emergency Medical Services
Craig Dyer	Seattle Fire Department
Sophia Dyer	Boston Emergency Medical Services
Michael Eby	San Bernardino (California) Police Department

Name	Agency
Robert Ehrlich	Central Islip – Hauppauge (New York) Volunteer Ambulance Service
Greg Encinas	Tohono O'odham Nation Fire Department
Errol Etting	Baltimore Police Department
Andrew Fitch	Charleston County Sheriff's Office
Paul Fitzgerald	Story County (Iowa) Sheriff's Office
Ryan Flerlage	Riley County (Kansas) Police Department
Gerard Fontana	Boston Fire Department
Margaret Fowke	Silver Spring (Maryland) Fire Department
Jeff Friedland	Saint Clair County (Michigan) Office of Homeland Security/Emergency Management
Tracy Frazzano	Montclair (New Jersey)Police Department
Max Geron	Dallas Police Department
Mark Ghilarducci	California Governor's Office of Emergency Services
Xenophon Gikas	Los Angeles Fire Department
Ralph Gonzalez	United States Forest Service
Ryan Guinn	Baltimore Police Department
Jay Hagen	Seattle Fire Department
Troy Hagen	Care Ambulance Service
Edmund Hassan	Boston Emergency Medical Services
Laurel Havens	Muskogee County (Oklahoma) Emergency Medical Services
Phillip Henderson	State of Alabama Law Enforcement Agency
Chris Heppel	Lane Fire Authority (Oregon)
Greg Herbster	Moore (Oklahoma) Fire Department
John Herrmann	Montclair (New Jersey) Fire Department
George Hough	Fire Department of New York City
Leonard Jackson	Essex County (New Jersey) Sheriff's Office
Sue Jacobus	Schuyler Fire Department (New York)
Anne Jensen	San Diego Fire-Rescue Department
Charlie Johnson	City of Houston
Chris Johnson	GEO Huntsville (Alabama)

Name	Agency
Mark Jones	Boston Fire Department
Dennis Keeley	Boston Fire Department
Michael Knox	Charleston County Sheriff's Office
Jad Lanigan	Aurora Police Department
Michael Larranaga	Ramboll Environ, Inc.
Matt Lavanchy	Pattonville (Missouri) Fire Department
Dustin Lewis	City of South Jordan (Utah)
Chris Lombard	Seattle Fire Department
Frederick Lorenz	Boston Fire Department
Colm Lydon	Boston Police Department
Carl Makins	Charleston County (South Carolina) Sheriff's Office
Steve Mason	Snohomish County (Washington) Fire District 1
Al Mattox	State of Alabama Law Enforcement Agency
Paul McDonagh	Seattle Police Department
Philip McGovern	Boston Emergency Medical Services
Kirk McKinzie	Cosumnes Fire Department (California)
Robert McLafferty	Herman (Pennsylvania) Volunteer Fire Company
Arturo Mendez	Port Authority of New York & New Jersey
Adam Miller	Huntingdon County (Pennsylvania) Sheriff's Office
Joe Namm	Plantation (Florida) Fire Department
Anthony Natale	Con Edison of New York
Kenneth Neafcy	Seattle Office of Emergency Management
Joseph O'Hare	Boston Emergency Medical Services
Kevin Oden	City of Dallas Office of Emergency Management
Richard Patrick	Department of Homeland Security
Brian Paulsen	Yankton (South Dakota) Police Department
Matthew Paulus	Saint Clair County (Michigan) Sheriff's Office
Jack Pearsull, Jr.	Boston Emergency Medical Services
James Plourde	Boston Fire Department
Jim Puscian	Aurora (Colorado) Police Department
Jeff Race	Pineville-Morrow (North Carolina) Volunteer Fire Department

Name	Agency
Rodney Reed	Harris County (Texas) Fire Marshal's Office
Cory Richter	Indian River County (Florida) Fire Rescue
James Riley	Boston Fire Department
Jeff Rubin	Tualatin Valley (Oregon) Fire & Rescue
Martin Ryczek	Chicago Police Department
David Saitta	Calumet City (Illinois) Fire Department
Susan Schiller	Boston Emergency Medical Services
Gordon Schluderberg	Baltimore Police Department (Retired)
Jim Schwartz	Arlington County (Virginia)
Ray Silva	Fort Bliss Fire & Emergency Services
David Smith	Salve Regina University
Eugene Smith	Boise Police Department
Jason Smith	Montgomery County (Maryland) Fire & Rescue Service
Thomas Smith	Saint Paul (Minnesota) Police Department (Retired)
Frank Soto, Jr.	Albuquerque (New Mexico) Fire Department
Steve Standridge	South Metro Fire Rescue (Colorado)
Randall Sterett	Orange County (California) Sheriff's Office
Brad Stoddard	Michigan's Public Safety Communications System
John Sudnik	New York City Fire Department
Lawrence Tan	New Castle County (Delaware) Emergency Medical Services
Mike Touchstone	Philadelphia Regional Emergency Medical Services
Steve Townsend	Carrollton (Texas) Fire Rescue
William Troup	United States Fire Administration
Steve Vandewalle	San Diego Fire-Rescue Department
Cloe Vincent	United States Immigration and Customs Enforcement
Eric Watson	Charleston County (South Carolina) Sheriff's Office
Mark Wilbert	Charleston County (South Carolina) Emergency Management Department
Rich Wilson	Dallas Police Department
Bill Wirtz	Snohomish County (Washington) Fire District 7
Andrew Wordin	Los Angeles Fire Department

APPENDIX J. ACRONYMS

Acronym	Definition
3D	Three-dimensional
AES	Advanced Encryption Standard
ALOHA	Areal Locations of Hazardous Atmospheres
AME	African Methodist Episcopal
ANS	Adaptable Navigation Systems
ANSI	American National Standards Institute
APCO	Association of Public Safety Communications Officials
API	Application program interface
APR	Air purifying respirators
ASTM	American Society of Testing Materials
BNSF	Burlington Northern Santa Fe
C3	Command, control, and coordination
CAD	Computer-aided dispatch
CAP	Common Alerting Protocol
CBRN	Chemical, biological, radiological and nuclear
CBRNE	Chemical, biological, radiological, nuclear and explosive
COA	Certificate of Waiver or Authorization
COP	Common Operating Picture
DARPA	Defense Advanced Research Projects Agency
DHS	Department of Homeland Security
DoD	Department of Defense
DOJ	Department of Justice
EDGE	Enhanced Dynamic Geo-Social Environment
EF-5	Enhanced Fujita Scale Level 5
EMBERS	Early Model Based Event Recognition using Surrogates
EMS	Emergency medical services
EOC	Emergency Operations Center
ERHMS	Emergency Responder Health Monitoring and Surveillance
EXDL	Emergency Data Exchange Language
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FDS	Fire Dynamics Simulator

Acronym	Definition
FEMA	Federal Emergency Management Agency
FINDER	Finding Individuals for Disaster and Emergency Response
FIPS	Federal Information Processing Standard
FRG	Support to the Homeland Security Enterprise and First Responders Group
FRRG	First Responders Resource Group
GCSS	Global Command Support System
GIS	Geographic information system
GPS	Global positioning system
Hazus	Hazards U.S.
HIPAA	Health Insurance Portability and Accountability Act
HSIN	Homeland Security Information Network
HVSA	High visibility safety apparel
IARPA	Intelligence Advanced Research Projects Activity
IC	Incident command/Incident commander
ICS	Incident Command System
IDLH	Immediately dangerous to life and health
IEC	International Electrotechnical Commission
IED	Improvised explosive device
IMAAC	Interagency Modeling and Atmospheric Assessment Center
iOS	Operating system used by Apple
IP	Internet protocol
IRC	Inland Regional Center
ISEA	International Safety Equipment Association
ISIS	Islamic State of Iraq and Syria
ISO	International Organization of Standards
IVN	In vivo nanoplatforms
JPL	Jet Propulsion Laboratory
JXDM	Global Justice XML Data Model
LLNL	Lawrence Livermore National Laboratory
LMR	Land mobile radio
MIPT	Memorial Institute for the Prevention of Terrorism
mHZ	Megahertz
NAS	National Airspace System
NASA	National Aeronautics and Space Administration

Acronym	Definition
NFPA	National Fire Protection Association
NGI	Next Generation Identification
NHC	National Hurricane Center
NICS	Next-Generation Incident Command System
NIEM	National Information Exchange Model
NIJ	National Institute of Justice
NIMS	National Incident Management System
NLP	Natural language processing
NOAA	National Oceanic and Atmospheric Administration
NPD	Newton Police Department
NWS	National Weather Service
OASIS	Organization for the Advancement of Structured Information Standards
OSI	Open Source Indicators (Program)
P25	Project 25 (Technology Standard)
PASS	Personal Alert Safety System
PD	Police department
PEL	Permissible Exposure Limits
PHI	Protected Health Information
PII	Personally identifiable information
PIO	Public information officer
POINTER	Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders
PPE	Personal protective equipment
PR4	Project Responder 4
PR5	Project Responder 5
PRD	Personal radiation detector
PSCR	Public Safety Communications Research
PTSD	Posttraumatic Stress Disorder
RIC-M	Radio Internet-Protocol Communications Module
RF	Radio frequency
RFID	Radio frequency identification
RSPACE	Resilient Synchronized Planning and Assessment for the Contested Environment
RTO	Response technology objective
SCBA	Self-contained breathing apparatus

Acronym	Definition
SBCSD	San Bernardino County Sheriff's Office
SBPD	San Bernardino Police Department
S.D.	Standard deviation
SOP	Standard operating procedure
SR	State Route
STEAR	State of Texas Emergency Assistance Registry
SUV	Sport utility vehicle
SWAT	Special weapons and tactics
SWP	Size, weight, and power
S&T	Science and Technology
T&E	Test and evaluation
THIRA	Threat and Hazard Identification and Risk Assessment
TTO	Tactical Technology Office
TTY	Talk to you
UAS	Unmanned aircraft systems
UASI	Urban Area Security Initiative
UHF	Ultra-high frequency
UP	Union Pacific
UPS	United Parcel Service
US&R	Urban Search and Rescue
USGS	United States Geological Survey
VFD	Volunteer Fire Department
VHF	Very high frequency
VMS	Video Management Systems
VoIP	Voice-over-Internet Protocol
WMD	Weapons of mass destruction
WTC	World Trade Center
XML	Extensible markup language

(This page intentionally left blank.)

APPENDIX K. BIBLIOGRAPHY

Active911. "Active911." Accessed Oct. 12, 2016. http://active911.com/assets/active911_overview.pdf.

Advanced Textiles Source. "Success in smart textiles – now and in the future." Posted Oct. 9, 2015. http://advancedtextilessource.com/2015/10/09/success-in-smart-textiles-now-and-in-the-future/.

After Action Report for the Response to the 2013 Boston Marathon Bombings. December 2014. http://www.mass.gov/eopss/docs/mema/after-action-report-for-the-response-to-the-2013-boston-marathon-bombings.pdf.

Ahmed, Saeed, and Ralph Ellis. "Mass Shooting at Inland Regional Center: What We Know." CNN, Dec. 5, 2015. http://www.cnn.com/2015/12/03/us/what-we-know-san-bernardino-mass-shooting/index.html.

Aisch, Gregor, Ford Fessenden, Josh Keller, Haeyoun Park, Alicia Parlapiono, Julie Shaver, Tim Wallace, Derek Watkins, Jeremy White and Karen Yourish. "What Investigators Know About the San Bernardino Shooting." *New York Times*, Dec. 10, 2015. http://www.nytimes.com/interactive/2015/12/02/us/california-mass-shooting-san-bernardino.html?_r=0.

ANSI International, *American National Standard for High-Visibility Safety Apparel and Accessories, ANSI/ISEA 107-2015*, 2015.

ANSI International, *American National Standard for Industrial Head Protection, ANSI/ISEA Z89.1-2014*, 2014.

APCO International, *Best Practices for the Use of Social Media in Public Safety Communications, APCO ANS 1.112.1-2014*, 2014.

ASTM International, *Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System, ASTM F1671/F1671M-13*, 2013.

ASTM International, *Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear, ASTM F2413*, 2011.

Balakrishnan, Anita. "The hospital held hostage by hackers." CNBC, Feb. 16, 2016. http://www.cnbc.com/2016/02/16/the-hospital-held-hostage-by-hackers.html.

Baltimore City Fraternal Order of Police Lodge #3. After Action Review. *A Review of the Management of the 2015 Baltimore Riots*. July 2015. http://www.fop3.org/wp-content/uploads/2015/07/AAR-Final.pdf.

Baltimore City Mayor's Office. Timeline of Events. 2015. http://mayor.baltimorecity.gov/sites/default/files/Timeline%20Highlights%20%28Final%29_0.pdf

Baltimore Sun. "About 130 officers injured during Baltimore riots released from hospital." May 6, 2015. http://www.baltimoresun.com/news/maryland/crime/bs-md-ci-officer-injuries-20150505-story.html.

Barajas, Joshua. "What we know- and don't know- about the Oregon shooting." PBS, Oct. 3, 2015. http://www.pbs.org/newshour/rundown/know-dont-know-oregon-shooting/.

Bergen, Peter. "What explains the biggest U.S. terror attack since 9/11?" CNN, Dec. 5, 2015. http://www.cnn.com/2015/12/04/opinions/bergen-san-bernardino-terror-attack-explain/index.html.

Blanco County Office of Emergency Management. *Memorial Day 2015 Rain Event After Action Report.* June 11, 2015.

Bradner, Eric. "Dallas Police Chief: Shooter Had Larger Plans." CNN, July 10, 2016. http://www.cnn.com/2016/07/10/politics/dallas-shooting-police-chief-david brown/.

Braziel, Rick, Frank Straub, George Watson, and Rod Hoops. *Bringing Calm to Chaos.* Community Oriented Policing Service, 2016.

Brennan, A., G. Carbone, K. Dow, L. Fly, P. Gao, C. Konrad, K. Lackstrom, and D. Tufford. *The South Carolina Floods of October 2015*. South Carolina: Carolinas Integrated Sciences and Assessments, University of South Carolina, Oct. 30, 2015.

Brenner, Philip S., Jessica L. LeBlanc, Anthony M. Roman and Naa Oyo A. Kwate. "Safety and Solidarity After the Boston Marathon Bombing: A Comparison of Three Diverse Boston Neighborhoods." *Journalist's Resource*, March 2015. http://journalistsresource.org/studies/government/criminal-justice/boston-marathon-bombings-research-lessons.

Brown, Bernice B with RAND. Delphi Process: "A Methodology Used for the Elicitation of Opinions of Experts." *ASTME Vectors*, Feb. 1968. https://www.rand.org/content/dam/rand/pubs/papers/2006/P3925.pdf.

Brown, Thomas. "An Experiment in Probabilistic Forecasting." Report Prepared for the Defense Advanced Research Project Agency. 1972. http://www.rand.org/content/dam/rand/pubs/reports/2006/R944.pdf.

Bucci, Steven, David Inserra, Jonathan Lesser, Ph.D., Matt A. Mayer, Brian Slattery, Jack Spencer and Katie Tubb. "After Hurricane Sandy: Time to Learn and Implement the Lessons in Preparedness, Response, and Resilience." *Heritage*, Oct. 24, 2013. http://www.heritage.org/research/reports/2013/10/after-hurricane-sandy-time-to-learn-and-implement-the-lessons.

Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain, Brussels, Belgium. International Disaster Database (EM-DAT). Advanced search conducted on Oct. 11 2016. http://www.emdat.be/advanced_search/index.html.

Charleston Resilience Network. *Understanding the October 2015 Charleston Floods: A Symposium Report.* February 2016. http://www.charlestonresilience.net/wp-content/uploads/2016/06/CRN_Flood_Symposium_Report-_FINAL.pdf.

City of Summit, Office of Emergency Management. *Hurricane Sandy October 2012 After Action Report.* http://www.naseo.org/Data/Sites/1/documents/committees/energysecurity/documents/nj-summit-hurricane-sandy-after-action-report.pdf.

CNN. "Colorado Theater Shooting Fast Facts." Last updated July 4, 2016. http://www.cnn.com/2013/07/19/us/colorado-theater-shooting-fast-facts/.

CNN. "Dallas Sniper Attack: 5 Officers Killed, Suspect Identified." Posted July 9, 2016. http://www.cnn.com/2016/07/08/us/philando-castile-alton-sterling-protests/.

CNN. "How big was the Moore, Oklahoma, tornado?" Last updated May 27, 2013. http://www.cnn.com/2013/05/27/us/infographic-moore-tornado/.

CNN. "Charleston Church Shooting: Who is Dylann Roof?" Posted June 23, 2015. http://www.cnn.com/2015/06/19/us/charleston-church-shooting-suspect/.

CNN. "Mass Shooting at Inland Regional Center: What We Know." Posted Dec. 5, 2015 http://www.cnn.com/2015/12/03/us/what-we-know-san-bernardino-mass-shooting/index.html.

CNN. "Orlando shooter texted wife during attack, source says." Posted June 17, 2016. http://www.cnn.com/2016/06/16/us/orlando-shooter-omar-mateen/.

CNN. "Orlando Shooting: 49 Killed, Shooter Pledged ISIS allegiance." Posted 13 June 2016. http://www.cnn.com/2016/06/12/us/orlando-nightclub-shooting/.

CNN. "Timeline of Orlando Nightclub Shooting." Posted June 17, 2016. http://www.cnn.com/2016/06/12/us/orlando-shooting-timeline/index.html.

Colomer, Joseph M. *Handbook of Electoral System Choice*. London and New York: Palgrave Macmillan, 2004.

Cranor, Lorrie Faith. "Declared-Strategy Voting: An Instrument for Group Decision-Making." Dissertation presented to the Sever Institute of Washing University, Saint Louis, Missouri, December 1996.

Cubic. "Cubic's Intific Selected to Develop Infantry-Level Virtual Test Bed Technology for DARPA." Published July 6, 2015. https://www.cubic.com/News/Press-Releases/ID/1512/Cubics-Intific-Selected-to-Develop-Infantry-Level-Virtual-Test-Bed-Technology-for-DARPA.

Dalkey, Norman and Olaf Helmer. "An Experimental Application of the Delphi Method to the use of experts." *Management Science*, 1963.

Delbecq, A.L., and A.H. VandeVen. "A Group Process Model for Problem Identification and Program Planning." *Journal Of Applied Behavioral Science*, 1971.

Delbecq, A.L., and A.H. VandeVen. *Group techniques for program planning: A guide to nominal group and Delphi processes*. Glenview, Illinois: Scott Foresman and Company, 1975.

Defense Advanced Research Projects Agency. "Adaptable Navigation Systems." Accessed Oct. 21, 2016. http://www.darpa.mil/program/adaptable-navigation-systems.

Defense Advanced Research Projects Agency. "Beyond GPS: 5 Next Generation Technologies for Positioning, Navigation, and Timing." Posted July 24, 2014. http://www.darpa.mil/news-events/2014-07-24.

Defense Advanced Research Projects Agency. "Distributed Battle Management." Accessed Oct. 21, 2016. http://www.darpa.mil/program/distributed-battle-management.

Defense Advanced Research Projects Agency. "ENGAGE." Accessed Oct. 20, 2016. http://www.darpa.mil/program/engage.

Defense Advanced Research Projects Agency. "Insight." Accessed Oct. 17, 2016. http://www.darpa.mil/program/insight.

Defense Advanced Research Projects Agency. "In Vivo Nanoplatforms (IVN)." Accessed Oct. 18, 2016. http://www.darpa.mil/program/in-vivo-nanoplatforms.

Defense Advanced Research Projects Agency. "Resilient Synchronized Planning and Assessment for the Contested Environment (RSPACE)." Accessed Oct. 21, 2016. http://www.darpa.mil/program/resilient-synchronized-planning-and-assessment-for-the-contested-environment.

Defense One. "Military Funded Study Predicts When You'll Protest on Twitter." Feb. 23, 2016. http://www.defenseone.com/technology/2016/02/military-funded-study-predicts-when-youll-protest-twitter/126156/.

Defense One. "The Military Is Pouring Money into Smart Fabrics, But There's a Holdup." Apr. 18, 2016. http://www.defenseone.com/technology/2016/04/military-wants-smart-fabrics-theres-holdup/127589/.

Department of Emergency Services and Public Protection. *Sandy Hook Elementary School Shooting Reports.* Accessed on Oct. 18, 2016. http://cspsandyhookreport.ct.gov.

Ellis, Ralph, Ashley Fantz, Faith Karimi, and Eliott C. McLaughlin. "Orlando Shooting: 49 Killed, Shooter Pledged ISIS allegiance." CNN, June 13, 2016. http://www.cnn.com/2016/06/12/us/orlando-nightclub-shooting/.

Ellis, Ralph, Ashley Fantz, Elliott C. McLaughlin, and Tim Hume. "Orlando Shooting: What Motivated a Killer?" CNN, June 14, 2016. http://www.cnn.com/2016/06/13/us/orlando-nightclub-shooting/index.html.

Emergency Management. "Wealth of Video Intelligence is an Exceptional Resource for EOC's." Posted June 30, 2015. http://www.emergencymgmt.com/safety/-Wealth-of-Video-Intelligence-Is-an-Exceptional-Resource-for-EOCs.html.

Emergency Management. "Establishing an Analytics Culture in Public Safety." Modified Sept. 3, 2013. http://www.emergencymgmt.com/safety/Analytics-Culture-Public-Safety.html.

Engadget. "DARPA's 'Virtual Eye' lets soldiers see around obstacles." Posted June 24, 2016. https://www.engadget.com/2016/06/24/darpas-virtual-eye-lets-soldiers-see-around-obstacles/.

Farrell, David M. *Electoral Systems: A Comparative Introduction*. New York: St. Martin's Press, 2001.

Federal Aviation Administration. Fact Sheet. "Fact Sheet – Small Unmanned Aircraft Regulations (Part 107)." June 21, 2016. https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20516.

Federal Aviation Administration, *Small Unmanned Aircraft Rule (Part 107)*, June 2016.

Federal Bureau of Investigation. *A Study of Active Shooter Incidents in the United States between 2000 and 2013*. Washington: Federal Bureau of Investigation, September 16, 2013.

Federal Bureau of Investigation. "Next Generation Identification." Accessed Oct. 14, 2016. https://www.fbi.gov/services/cjis/fingerprints-and-other-biometrics/ngi.

Federal Bureau of Investigation. Situational Information Report. "(U//FOUO) Violence Against Law Enforcement Officers and Riots Planned for 8-10 July 2016." July 7, 2016.

Federal Emergency Management Agency. *Authorized Equipment List.* Washington: Federal Emergency Management Agency, May 8, 2015.

Federal Emergency Management Agency. "Hazus." Accessed Oct. 18, 2016. https://www.fema.gov/hazus.

Federal Emergency Management Agency. *Hurricane Sandy FEMA After-Action Report*. July 1, 2013. https://www.fema.gov/media-library-data/20130726-1923-25045-7442/sandy_fema_aar.pdf.

Federal Emergency Management Agency, Center for Domestic Preparedness. "Patient Identification Technology Introduced At CDP." Accessed Oct. 14, 2016. https://cdp.dhs.gov/news-media/article/patient-identification-technology-introduced-at-cdp.

Federal Emergency Management Agency. *The Response to the 2011 Joplin, Missouri, Tornado Lessons Learned Study.* Dec. 20, 2011.

Federal Emergency Management Agency. "Threat and Hazard Identification and Risk Assessment." Last updated Mar. 19, 2015. https://www.fema.gov/threat-and-hazard-identification-and-risk-assessment.

Federal Information Processing Standards, *Advanced Encryption Standard (AES), Publication 197*, 2001.

Fenton, Justin and Kevin Rector. "Police Union blasts commanders in 'after action review' of riot." *Baltimore Sun*, July 8, 2015. http://www.baltimoresun.com/news/maryland/freddie-gray/bs-md-ci-fop-report-20150708-story.html.

Fernandez, Manny, Richard Perez-Pena, and Jonah Engel Bromwich. "Five Dallas Officers Were Killed as Payback, Police Chief Says." *New York Times*, July 8, 2016. http://www.nytimes.com/2016/07/09/us/dallas-police-shooting.html?_r=0.

Firehouse. "Disaster Response – Commanding from the Storm: Lessons Learned from Oklahoma Tornadoes – Part 3." Apr. 1, 2014. http://www.firehouse.com/article/11290259/disaster-response-oklahoma-tornado.

Fox News. "Social media analysis suggests links between Baltimore and Ferguson violence." Apr. 28, 2015. http://www.foxnews.com/tech/2015/04/28/social-media-analysis-suggests-links-between-baltimore-and-ferguson-violence.html.

Fritz, Angela. "Record-breaking May rainfall in Texas and Oklahoma, by the numbers." *Washington Post*, June 1, 2015. https://www.washingtonpost.com/news/capital-weather-gang/wp/2015/06/01/record-breaking-may-rainfall-in-texas-and-oklahoma-by-the-numbers/.

General Dynamics Mission Systems. "Command Post of the Future (CPOF)." Accessed Oct. 21, 2016. https://gdmissionsystems.com/c4isr/cpof/.

Gladstone, Rick, and Karen Zraick. "Charleston, SC, Church Shooting: Live Updates." *New York Times*, Accessed Oct. 18, 2016. http://www.nytimes.com/live/updates-on-charleston-church-shooting/.

Gibbs, Deputy Mayor Linda I., and Deputy Mayor Caswell F.Holloway, *Hurricane Sandy After Action*, May 2013. http://www.nyc.gov/html/recovery/downloads/pdf/sandy_aar_5.2.13.pdf.

Goodman, Leah McGrath. "The EMBERS Project Can Predict the Future with Twitter." *Newsweek*, Mar. 7, 2015. http://www.newsweek.com/2015/03/20/embers-project-can-predict-future-twitter-312063.html.

Google. "About the Connected Citizens Program." Accessed Oct. 14, 2016. https://support.google.com/waze/partners/answer/6372611?hl=en.

Google. "Crisis Map." Accessed Oct. 24, 2016. https://sites.google.com/site/geomedialab/crisis-response.

Gupta, Sanjay. “San Bernardino Doctor Was First Responder to Massacre.” CNN, Dec. 5, 2015. http://www.cnn.com/2015/12/03/health/san-bernardino-swat-doctor-profile/index.html.

Hays County/San Marcos Joint EOC Operations. *Hays County 2015 Flooding Events After Action Reports.* 2015. http://www.co.hays.tx.us/data/sites/1/pdf/press-releases/2016/hays-county-may-october-2015-flooding-aar.pdf

Holdeman, Eric. “Lessons from the Oso Mudslide.” *Emergency Management*, May 31, 2014. http://www.emergencymgmt.com/emergency-blogs/disaster-zone/lessonsfromtheosomudslide.html.

In Public Safety. “After-Action Report: Learning From Baltimore’s Response to Riots.” Posted July 1, 2015. http://inpublicsafety.com/2015/07/after-action-report-learning-from-baltimores-response-to-riots/.

International Organization for Standardization, *Real-time locating systems-- Test and evaluation of localization and tracking systems, ISO/IEC DIS 18305*, 2016.

Jenkins, Kevin. “2 Now Missing After Deadly Utah Floods Kill 18.” *USA Today*, Sept. 16, 2015. http://www.usatoday.com/story/news/nation/2015/09/16/flash-flood-utah/32489017/.

Johns Hopkins University. *Recommendations for Enhancing Baltimore City’s Preparedness and Response to Mass Demonstration Events*. Dec. 2015. http://mayor.baltimorecity.gov/sites/default/files/Baltimore%20City%20Recommendations%20v120415_0.pdf.

Johnston Archive. “Terrorist acts and related incidents in the United States.” Last updated Sept. 19, 2016. http://www.johnstonsarchive.net/terrorism/wrjp255a.html.

Karimi, Faith, Catherine E. Shoichet, and Ralph Ellis. “Dallas Sniper Attack: 5 Officers Killed, Suspect Identified.” CNN, July 9, 2016. http://www.cnn.com/2016/07/08/us/philando-castile-alton-sterling-protests/

King, Pat. “Disaster Response: Commanding the Storm Part 1.” *Firehouse*, Dec. 1, 2013. http://www.firehouse.com/article/11230811/lessons-learned-from-oklahoma-tornados.

Know Before You Fly. “Know Before You Fly.” Accessed Oct. 24, 2016. http://knowbeforeyoufly.org/for-public-entities/.

Lawrence Livermore National Laboratory. “‘Second skin’ uniform protects soldiers from biological and chemical agents in the field.” Aug. 3, 2016. https://www.llnl.gov/news/%E2%80%98second-skin%E2%80%99-uniform-protects-soldiers-biological-and-chemical-agents-field.

Links, Jonathan PhD., Katie O’Connor, and Laruen Sauer, MS. *Recommendations for Enhancing Baltimore City’s Preparedness and Response to Mass Demonstration Events*. Dec. 4, 2015.

http://mayor.baltimorecity.gov/sites/default/files/Baltimore%20City%20Recommendations%20v120415_0.pdf.

Linstone, Harold A., and Murray Turoff. *The Delphi Method: Techniques and Applications*. Reading, Mass.: Addison-Wesley, 1975.*Los Angeles Times*. "Police worry about their own safety after killings: "It's a different world." Posted Aug. 31, 2015. http://www.latimes.com/nation/la-na-blue-lives-matter-20150831-story.html.

Mangeri, Anothony S. "After-Action Report: Learning From Baltimore's Response to Riots." *In Public Safety*, July 1, 2015. http://inpublicsafety.com/2015/07/after-action-report-learning-from-baltimores-response-to-riots/.

McKay, Jim. "Lessons Learned from the Response to the Oso, Wash., Mudslide." *Emergency Management*, July 3, 2014. http://www.emergencymgmt.com/disaster/Lessons-Learned-Response-Oso-Wash-Mudslide.html.

Medscape. "World Class Emergency Response in Boston Marathon Bombing." September 2016. http://www.medscape.com/viewarticle/853394.

Melvin, Craig, "Seven injured in Missouri as trains collide, trigger highway bridge collapse." *MSNBC*, May 25, 2013. http://usnews.nbcnews.com/_news/2013/05/25/18490608-seven-injured-in-missouri-as-trains-collide-trigger-highway-bridge-collapse?lite.

McFareen, Susan RN, PHN. *2014 Ohio Measles Outbreak Unified Command response: After-Action Report/Improvement Plan*. Sept. 24, 2014. http://www.richlandhealth.org/upload/documents/2014ohiomeaslesresponseaar-ip.pdf.

Merchant, Nomaan. "Report Released on Texas Fertilizer Plant Explosion." *Journal of Emergency Medical Services*, Apr. 30, 2014. http://www.jems.com/articles/2014/04/report-released-texas-fertilizer-plant-e.html.

Mosendz, Polly. "Nine Dead in Shooting at South Carolina Church, Suspect Dylann Roof Caught in Shelby, North Carolina." *Newsweek*, June 17, 2015. http://www.newsweek.com/report-nine-shot-charleston-south-carolina-church-shooting-344235.

Motorola. "Case Study: Revolutionizing Emergency Care: Setting A New Standard in Patient Triage, Tracking and Treatment." 2010. https://www.zebra.com/content/dam/msi-new/assets/web/Business/_Documents/Case%20studies/_Static%20files/Electronic%20Patient%20Triage%20Case%20Study.pdf.

National Aeronautics and Space Administration. "Climate change: how do we know," Last modified Oct. 5, 2016. http://climate.nasa.gov/evidence/.

National Aeronautics and Space Administration. “LifeGuard: Wireless Physiological Monitor.” Accessed Oct. 18, 2016. http://www.nasa.gov/centers/ames/research/technology-onepagers/life-guard.html.

National Center for Atmospheric Research. “NCAR to Develop Wildland Fire Prediction System for Colorado.“ Dec. 9, 2015. http://www2.ucar.edu/atmosnews/news/18317/ncar-develop-wildland-fire-prediction-system-for-colorado.

National Fire Protection Association. “Firefighter deaths by nature and cause of injury.” Last updated June 2016. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/fatalities-and-injuries/firefighter-deaths-by-cause-and-nature-of-injury.

National Fire Protection Association. “U.S. fire department profile.” January 2016. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/the-fire-service/administration/us-fire-department-profile.

National Fire Protection Association, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, NFPA 1851*, 2014.

National Fire Protection Association, *Standard on Protective Ensembles for Technical Rescue Incidents, NFPA 1951*, 2013.

National Fire Protection Association, *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, NFPA 1971*, 2013.

National Fire Protection Association, *Standard on Emergency Services Work Clothing Elements, NFPA 1975*, 2014.

National Fire Protection Association, *Standard on Personal Alert Safety Systems (PASS), NFPA 1982*, 2013.

National Fire Protection Association, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies, NFPA 1992*, 2012.

National Fire Protection Association, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents, NFPA 1994*, 2012.

National Fire Protection Association, *Standard on Protective Clothing and Ensembles for Emergency Medical Operations, NFPA 1999*, 2013.

National Institute of Justice, *Ballistic Resistant Protective Materials, NIJ Standard 0108.01*, 1985.

National Hurricane Center. *Tropical Cyclone Report: Hurricane Sandy*, AL182012. Feb. 12, 2013. http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.

National Institute for Occupational Safety and Health. *9 Volunteer Fire Fighters and 1 Off-Duty Career Fire Captain Killed by an Ammonium Nitrate Explosion at a Fertilizer Plant Fire- Texas*. Nov. 12, 2014. http://1dwuce14590f1spkp61tjfrp.wpengine.netdna-cdn.com/wp-content/uploads/sites/4/2014/11/TX-West-Niosh-report.pdf.

National Law Enforcement Officers Memorial Fund. *2016 Mid-Year Law Enforcement Fatalities Report.* Washington: National Law Enforcement Officers Memorial Fund, July 2016. http://www.nleomf.org/facts/research-bulletins/.

National Aeronautics and Space Administration. "Climate change: how do we know," Last modified Oct. 5, 2016. http://climate.nasa.gov/evidence/

National Oceanic and Atmospheric Association. *National Coastal Population Report: Population Trends from 1970 to 2020.* Washington: National Oceanic and Atmospheric Association, Mar. 2013.

National Transportation Safety Board. *Collision of Union Pacific Railroad Freight Train with BNSF Railway Freight Train Near Chaffee, Missouri*. May 25, 2013. http://www.ntsb.gov/investigations/accidentreports/reports/rar1402.pdf.

National Weather Service. *Service Assessment: May 2013 Oklahoma Tornadoes and Flash Flooding*. March 2014. http://www.nws.noaa.gov/os/assessments/pdfs/13oklahoma_tornadoes.pdf.

National Weather Service. *Service Assessment: The Historic South Carolina Floods of October 1–5, 2015.* July 2016. http://www.nws.noaa.gov/os/assessments/pdfs/SCFlooding_072216_Signed_Final.pdf.

NBC Staff. "Sniper Ambush Kills 5 Officers, Injures 7 in Dallas Following Peaceful Protest." NBC, Dallas Fort Worth, July 8, 2016. http://www.nbcdfw.com/news/local/Protests-in-Dallas-Over-Alton-Sterling-Death-385784431.html.

New York City Mayor's Office. *Hurricane Sandy After Action, Report and Recommendations to Mayor Michael R. Bloomberg*. May 2013.

Newsweek. "9/11's second wave: cancer and other diseases linked to the 2001 attacks are surging." Sept. 7, 2016. http://www.newsweek.com/2016/09/16/9-11-death-toll-rising-496214.html.

Newsweek. "Nine Dead in Shooting at South Carolina Church, Suspect Dylann Roof Caught in Shelby, North Carolina." Posted June 17, 2015. http://www.newsweek.com/report-nine-shot-charleston-south-carolina-church-shooting-344235.

NVIDIA. "DARPA Virtual Eye Lets Responders 'See' What They Can't See." Posted June 23, 2016. https://blogs.nvidia.com/blog/2016/06/23/darpa-virtual-eye/.

Office of the Director of National Intelligence, Intelligence Advanced Research Project Activity. “Open Source Indicators.” Accessed on Oct. 10, 2016. https://www.iarpa.gov/index.php/research-programs/osi.

Office of the Director of National Intelligence. “About IARPA.” Accessed Oct. 10, 2016. https://www.iarpa.gov/index.php/about-iarpa.

Office of the Director of National Intelligence. “Open Source Indicators.” Accessed Oct. 10, 2016. https://www.iarpa.gov/index.php/research-programs/osi.

Office of Inspector General, Department of Homeland Security. *FEMA’s Initial Response to the Oklahoma Severe Storms and Tornadoes*. Mar. 2014. https://www.oig.dhs.gov/assets/GrantReports/2014/OIG_14-50-D_Mar14.pdf.

Office of the State’s Attorney Judicial District of Danbury. *State’s Attorney, Report of the State’s Attorney for the Judicial District of Danbury on the Shootings at Sandy Hook Elementary School and 36 Yogandanda Street on December 14, 2012*. Nov. 25, 2013. http://www.ct.gov/csao/lib/csao/Sandy_Hook_Final_Report.pdf.

Organization for the Advancement of Structured Information Standards, *Common Alerting Protocol (CAP), Version 1.2*, 2010.

Organization for the Advancement of Structured Information Standards, *Emergency Data Exchange Language (EDXL) Distribution Element, v. 2.0, EDXL-DE-V2.0*, 2013.

Owens, Margorie. “How the Dallas Downtown Shooting Developed.” ABC, WFAA8, July 11, 2016. http://www.wfaa.com/news/crime/how-the-downtown-dallas-shooting-developed/267167395.

Parks, Casey. “10 Dead, 7 hurt in school shooting in Roseburg.” Oregon Live, Oct. 4, 2015. http://www.oregonlive.com/pacific-northwest-news/index.ssf/2015/10/active_shooting_reported_at_um.html.

Premise Alert Program. “Premise Alert Request Form.” Accessed Oct. 24, 2016. http://papremisealert.com/us/wp-content/uploads/Microsoft-Word-Premise-Alert-Form-8-13.doc.pdf.

Public Safety Communications Research Program. “Public Safety Audio Quality.” 2016. http://www.pscr.gov/projects/testing_evaluation/audio_quality/pscr_audio_quality_research.pdf.

Project 25 (P25) Technology Interest Group, *Project 25 (P25) Technology Interest Group Standards*, 2016, http://www.project25.org/.

Pub. L. 104–191, 110 Stat. 1936, *Health Insurance Portability and Accountability Act of 1996*, 1996.

Rescher, N. *Predicting the Future*. Albany, NY: State University of New York Press, 1998.

Sackman, H. 1974. “Delphi Assessment: Expert Opinion, Forecasting and Group Process.” Rand Corporation, 1974.

Sanchez, Ray, Michael Martinez, and Doug Criss. “Pray for us”: Calls, Texts Relay Horror of California Mass Shooting.” CNN, Dec. 3, 2015. http://www.cnn.com/2015/12/02/us/california-shooting-scene/index.html.

Sandy Hook Advisory Commission. *Final Report of the Sandy Hook Advisory Commission*. Mar. 6, 2015. http://www.shac.ct.gov/SHAC_Final_Report_3-6-2015.pdf.

Sanquist, TF, MP Baucum, and BR Brisbois. “Attention and Situational Awareness in First Responder Operations, Guidance for the Design and Use of Wearable and Mobile Technologies.” U.S. Department of Energy by Pacific Northwest National Laboratory. http://nwrtc.pnnl.gov/PDFs/RTAs/RTA_Situational_Awareness.pdf.

Schmidt, Michael, and Richard Perez-Pena. “FBI Treating San Bernardino Attack as Terrorism Case.” *New York Times*, Dec. 4, 2015. http://www.nytimes.com/2015/12/05/us/tashfeen-malik-islamic-state.html?_r=1.

Shapiro, Emily. “A Gun Shop and an Uber Ride: The Alleged Whereabouts of Accused Uber Driver Hours Before Shootings.” ABC News, Feb. 23, 2016. http://abcnews.go.com/US/gun-shop-uber-ride-alleged-wherabouts-accused-uber/story?id=37133080.

Shoichet, Catherine, Anne Claire Stapleton, and Greg Botelho, “Colorado Planned Parenthood Shooting: 3 dead, suspect captured.” CNN, Nov. 27, 2015. http://www.cnn.com/2015/11/27/us/colorado-shooting-probe/.

Smith, Kharley Bagley EMC, and Kenneth E. Bell, EMC. *Hays County 2015 Flooding Events After Action Report*. Accessed Oct. 19, 2016. http://www.co.hays.tx.us/data/sites/1/pdf/press-releases/2016/hays-county-may-october-2015-flooding-aar.pdf.

Smith, Rob. “After Action Review: Fertilizer Plant Explosion.” *EMS World*, Aug. 1, 2013. http://www.emsworld.com/article/11065067/west-tx-fertilizer-plant-explosion.

Smith, Steven. “Oregon Community College Shooting: Focus Points.” Guardian Defense, Oct. 12, 2015. http://guardiandefenseplan.com/oregon-community-college-shooting-focus-points/.

SR 530 Landslide Commission. *SR 530 Landslide Commission Final Report.* Dec. 15, 2014.

Stapleton, AnnClaire, and Ralph Ellis. “Timeline of Orlando Nightclub Shooting.” CNN, June 17, 2016. http://www.cnn.com/2016/06/12/us/orlando-shooting-timeline/index.html.

State of Connecticut, Division of Criminal Justice. *Report of the State’s Attorney for the Judicial District of Danbury n the Shootings at Sandy Hook Elementary School*

and 36 Yogananda Street, Newtown, Connecticut on December 14, 2012. Nov. 25, 2013. http://www.seattle.gov/Documents/Departments/Emergency/ScientificArticles/187053363-Sandy-Hook-Final-Report.pdf.

System Planning Corporation. *Aurora Century 16 Theater Shooting After Action Report for the City of Aurora, Colorado.* Arlington: System Planning Corporation, TriData Division, April 2014. https://www.courts.state.co.us/Media/Opinion_Docs/14CV31595%20After%20Action%20Review%20Report%20Redacted.pdf

Tague, Nancy R. *The Quality Toolbox.* ASQ Quality Press, 2nd ed. 2004.

Texas State Fire Marshal's Office. *Firefighter Fatality Investigation, Investigation FFF FY 13-06.* April 2013. https://www.tdi.texas.gov/reports/fire/documents/fmloddwest.pdf.

Thermopylae Sciences & Technology for the U.S. Department of Homeland Security. "Supporting Geospatial Efforts for DHS." November 2014. http://www.t-sciences.com/news/supporting-geospatial-efforts-dhs.

Texas Department of Public Safety. "State of Texas Emergency Assistance Registry (STEAR) – Public." Accessed Oct. 24, 2016. https://www.txdps.state.tx.us/dem/stear/public.htm

Texas State Fire Marshal's Office. *Firefighter Fatality Investigation*. West, Texas: Apr. 17, 2013. http://www.tdi.texas.gov/reports/fire/documents/fmloddwest.pdf.

The Center for Health Affairs. News Release. "Patient Tracking System Now Available to Ohio Hospitals and Emergency Agencies." May 27, 2016. http://www.chanet.org/TheCenterForHealthAffairs/MediaCenter/NewsReleases/2016/May/Patient-Tracking.aspx.

The SR 530 Landslide Commission. *The SR 530 Landslide Commission Final Report*. Dec. 15, 2014. http://www.governor.wa.gov/sites/default/files/documents/SR530LC_Final_Report.pdf.

Tibbetts, John, and Christian Davenport. "In South Carolina, 'potentially historic' flooding after days of rainfall." *Washington Post*, Oct. 4, 2015. https://www.washingtonpost.com/national/in-south-carolina-potentially-historic-flooding-after-days-of-rainfall/2015/10/04/2fd1d8a2-6aa5-11e5-9bfe-e59f5e244f92_story.html?tid=ptv_rellink.

Trenberth, Kevin, John Fasullo, and Theodore Shepard. "Attribution of climate extreme events." *Nature*, June 22, 2015. http://www.nature.com/nclimate/journal/v5/n8/full/nclimate2657.html

Tribune News Service. "Report: Kalamazoo Shooting Suspect Asked Victim to Give Dollar 'To Make America Great Again." *Chicago Tribune*, Apr. 1, 2016.

http://www.chicagotribune.com/news/nationworld/midwest/ct-kalamazoo-shootings-suspect-20160401-story.html.

Twitter. Nic Hornstein. Posted June 12, 2016 at 4:40am.

Twitter. Orlando Pulse. Posted June 12, 2016.

Twitter. "#snowedoutatlanta." https://twitter.com/hashtag/snowedoutatlanta.

U.S. Army. "Permethrin-treated uniforms protect against lethal diseases." July 1, 2014. https://www.army.mil/article/129210/Permethrin_treated_uniforms_protect_against_lethal_diseases.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, *NWS Central Region Service Assessment Joplin, Missouri, Tornado – May 22, 2011*. Kansas City, MO: National Weather Service, Central Region Headquarters, July 2011. http://www.nws.noaa.gov/om/assessments/pdfs/Joplin_tornado.pdf.

U.S. Department of Homeland Security. "Bomb Threat Call Procedures." Accessed Oct. 24, 2016. https://emilms.fema.gov/is906/assets/ocso-bomb_threat_samepage-brochure.pdf.

U.S. Department of Homeland Security. *U.S. Coast Guard Incident Management Handbook*, COMDTPUB P3120.17B. Washington: Department of Homeland Security, May 2014. https://www.uscg.mil/d9/D9Response/docs/USCG%20IMH%202014%20COMDTPUB%20P3120.17B.pdf

U.S. Department of Homeland Security *FEMA's Initial Response to the Oklahoma Severe Storms and Tornadoes*, OIG-14-50-D. Mar. 2014.

U.S. Department of Homeland Security, Science and Technology Directorate. "Finding Individuals Disaster Emergency Response FINDER: Update." Modified May 31, 2016. https://www.dhs.gov/sites/default/files/publications/Finding-Individuals-Disaster-Emergency-Response-FINDER-Updated-160531-508.pdf.

U.S. Department of Homeland Security. News Release. "DHS S&T Announces Next Accelerator Topic." Aug. 8, 2016. https://www.dhs.gov/science-and-technology/news/2016/08/08/news-release-dhs-st-announces-next-accelerator-topic.

U.S. Department of Homeland Security. "Homeland Security Information Network." Accessed Oct. 21, 2016. https://www.dhs.gov/homeland-security-information-network-hsin.

U.S. Department of Homeland Security. "Interagency Modeling and Atmospheric Assessment Center (IMAAC)." Published May 16, 2016. https://www.dhs.gov/imaac.

U.S. Department of Homeland Security, Science and Technology. News Release. "NICS, A Communication Platform For First Responders, Now Available Worldwide."

Aug. 8, 2016. https://www.dhs.gov/science-and-technology/news/2016/08/08/news-release-nics-communication-platform-first-responders-now.

U.S. Department of Homeland Security, Science and Technology. "Next Generation Incident Command System-NICS." Accessed Oct. 10, 2016. https://www.dhs.gov/sites/default/files/publications/Next%20Generation%20Incident%20Command%20System-NICS_0.pdf.

U.S. Department of Homeland Security, Science and Technology. Press release. "DHS S&T Announces New Partnership to Improve Communications for the Nation's First Responders." Oct. 5, 2016. https://www.dhs.gov/science-and-technology/news/2016/10/05/dhs-st-announces-new-partnership-improve-responder.

U.S. Department of Homeland Security, Science and Technology. "Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders." 2016. https://www.dhs.gov/sites/default/files/publications/Precision-Outdoor-and-Indoor-Navigation-and-Tracking-for-Emergency-Responders-Fact-Sheet-508.pdf.

U.S. Department of Homeland Security, Science and Technology. *Project Responder 4: 2014 National Technology Plan for Emergency Response to Catastrophic Incidents.* Washington: Department of Homeland Security, July 2014. https://www.dhs.gov/sites/default/files/publications/Project%20Responder%204_1.pdf

U.S. Department of Homeland Security, Science and Technology. "Radio Internet-Protocol Communications Module." Modified May, 26, 2016. https://www.dhs.gov/sites/default/files/publications/Radio-Internet-Protocol-Communications-Module_SLUpdate-160526v2-508.pdf.

U.S. Department of Homeland Security. "S&T's Interoperable Solution Makes It Easier and Cheaper for First Responders to Communicate." Jan. 6, 2015. https://www.dhs.gov/science-and-technology/can-you-hear-me-now.

U.S. Department of Homeland Security, Science and Technology. "Virtual Training: Simulation Tool for First Responders." Modified Sept. 20, 2014. https://www.dhs.gov/sites/default/files/publications/Virtual%20Training-Simulation%20Tool%20for%20First%20Responders_0.pdf.

U.S. Department of Justice. Press Release. "Justice Department Announces Enhanced Policy for Use of Cell-Site Simulators." Sept. 3, 2015. https://www.justice.gov/opa/pr/justice-department-announces-enhanced-policy-use-cell-site-simulators.

U.S. Department of Justice, Office of Community Oriented Policing Services. *After-Action Assessment of the Police Response to the August 2014 Demonstrations in Ferguson, Missouri*. 2015. https://ric-zai-inc.com/Publications/cops-p317-pub.pdf.

U.S. Department of Justice, *Global Justice XML Data Model*.

U.S. Department of Justice, *National Information Exchange Model*, 2014.

U.S. Department of Justice, Office of Justice Programs. "Amber Alert, *America's Missing: Broadcast Emergency Response*." Accessed Oct. 18, 2016. http://www.amberalert.gov.

U.S. Department of Transportation, Federal Highway Administration. "Analysis, Modeling, and Simulation for Traffic Incident Management Applications." Last modified Oct. 20, 2015. http://www.ops.fhwa.dot.gov/publications/fhwahop12045/2_synth.htm.

U.S. Environmental Protection Agency. "ALOHA Software." Last modified Sept. 15, 2016. https://www.epa.gov/cameo/aloha-software.

U.S. Geological Survey. *Effects of Urban Development on Floods*, Fact Sheet 076-03. Washington: U.S. Geological Survey, November 2003). http://pubs.usgs.gov/fs/fs07603/pdf/fs07603.pdf.

U.S. Geological Survey. "Emerging Technologies." Last modified Feb. 10, 2016 http://water.usgs.gov/osw/flood_inundation/science/emerging-tech.html.

U.S. Geological Survey. "How can climate change affect natural disasters." Last modified June 15, 2016. https://www2.usgs.gov/faq/node/5611.

Washington Post. "Stunning serendipity saves man and his dog from N.C. floodwaters." Posted Oct. 11, 2016. https://www.washingtonpost.com/news/morning-mix/wp/2016/10/11/insane-drone-photo-on-twitter-help-rescue-flood-victim-and-dog-halfway-across-country/.

Waze. "Connected Citizens by Waze." Accessed Oct. 24, 2016. https://docs.google.com/gview?url=https%3A%2F%2Fs3-eu-west-1.amazonaws.com%2Fwaze-partner-assets%2FCCPFactSheet.pdf.

Weather.com. "Flooding in North Carolina From Hurricane Matthew Incurs $1.5 Billion In Damage, Authorities Say." Oct. 16, 2016. https://weather.com/news/news/hurricane-matthew-north-carolina-update.

Weather.com, "South Carolina's Catastrophic Floods Caused by One of the Most Prolific Rainfall Events in Modern U.S. History." Posted Oct. 11, 2015. https://weather.com/news/news/south-carolina-historic-flood-rainfall-record-extreme.

Winton, Richard. "Hollywood hospital pays $17,000 bitcoin to hackers; FBI investigating." *Los Angeles Times*, Feb. 18, 2016. http://www.latimes.com/business/technology/la-me-ln-hollywood-hospital-bitcoin-20160217-story.html.

"Worldwide Integrated Crisis Early Warning System." Lockheed Martin. Accessed Oct. 10, 2016. http://www.lockheedmartin.com/us/products/W-ICEWS/W-ICEWS_overview.html.

WFAA. "How the Dallas Downtown Shooting Developed." Posted July 11, 2016. http://www.wfaa.com/news/crime/how-the-downtown-dallas-shooting-developed/267167395

WTVD. "Drone and Social Media Help Rescuers Save Veteran in Hurricane Matthew Flooding." Posted Oct. 11, 2016. http://abc11.com/weather/drone-and-social-media-help-rescuers-save-veteran-in-hurricane-matthew-flooding/1550476/.

Yan, Holly, and Michael Person. "Michigan shooting rampage: What we know and don't know." CNN, February 22, 2016. http://www.cnn.com/2016/02/22/us/kalamazoo-michigan-what-we-know-and-dont-know/.

Zengerie, Patricia, and Megan Cassella. "Millions more Americans hit by government personnel data hack." Reuters, July 9, 2015. http://www.reuters.com/article/us-cybersecurity-usa-idUSKCN0PJ2M420150709?feedType=RSS&feedName=topNews&utm_source=twitter.

Zipprich, Jennifer PhD, Kathleen Winter, MPH, Jill Hakcer, PhD, Dongxiang Xia, PhD, James Watt, M.D. and Kathleen Harriman, PhD.. "Measles Outbreak – California, December 2014- February 2015. Centers For Disease Control and Prevention: Feb. 13, 2015." http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6406a5.htm

"3 Dead In Springs Planned Parenthood Shooting; Gunman In Custody." KKTV, Dec. 1, 2015. http://www.kktv.com/home/headlines/Active-Shooter-Situation-At-Planned-Parenthood-356013081.html.