Chapter Seven

SYSTEMS-LEVEL PROTECTION ISSUES

The previous four chapters focused principally on individual-level protection for personnel in different emergency response organizations who face a range of diverse hazards. In this chapter, we broaden our scope and examine protection issues at the systems level. *Systems-level protection* refers to protective technologies that operate at the command or unit level and include communications, hazard monitoring and assessment, personnel management, and various “human factors.” The difference between the two levels of analysis may be difficult to define precisely, but the distinction carries some important conceptual implications. In particular, addressing systems-level issues is likely to be more complex and involve more stakeholders than addressing individual-level issues, but systems-level technologies also have the potential to have a greater effect in terms of meeting protection needs.

**COMMUNICATIONS**

The need for better communications was a universal theme heard in the RAND discussions. This need is driven by the desire to improve the management and safety of personnel as emergency response incidents become more complex. Moreover, information and knowledge—gathered and shared via communications networks—are becoming more critical to decisionmaking and safety.

**Tactical Communications**

Firefighter representatives were particularly concerned about shortcomings in existing tactical communications technologies given the conditions that exist in the environments in which they work, such as high ambient noise levels and intense heat, and the difficulties in communicating through a respirator. (These issues are discussed in Chapter Three.) However, these concerns are increasingly salient to emergency medical service personnel, law enforcement personnel, and other responders because, as we have seen, many departments are acquiring SCBAs and other technologies to protect their personnel against
Strategic Communications

Both police and fire departments emphasized strongly that there are fundamental problems with radio communication systems that extend beyond the tactical problems just mentioned. These problems have to do with networks and protocols governing communication among individual responders, departments, and services. As such, they transcend the boundaries between these organizational elements and therefore are strategic concerns for the entire emergency responder community.

One problem with radio communications systems that was cited in the RAND discussions is that police, fire, and emergency medical services in many jurisdictions use incompatible radio systems and therefore cannot communicate easily with each other at incidents. A lack of interagency communications has been cited as contributing to the lack of coordination between the New York City police and fire departments at the time of the imminent collapse of the World Trade Center towers on September 11, 2001 (McKinsey & Company, 2002). Interagency communications are a critical enabler of the Incident Command System (ICS): “We collocate on a regular basis, but we don’t have the ability to communicate,” said one big-city law enforcement representative.

A related concern is the problem with interjurisdictional communications: Departments in the same service from different jurisdictions often are unable to communicate, leading to coordination problems in mutual-aid situations. One participant related that after a massive tornado struck his city in the late 1990s, the incompatibility of communications systems among the region’s jurisdictions prevented authorities from coordinating their activities. The result was a “nightmare”: Too many units arrived at the scene, many of which were self-dispatched, hampering response efforts.

Similarly, participants spoke of incompatible communications systems among local, state, and federal agencies, a growing concern in a period of heightened awareness about terrorism threats. In one example, a representative from a fire department whose jurisdiction neighbors state wildlands and hence routinely engages in joint operations with state forest firefighters, noted that the two

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1 The *Incident Command System* is a standardized approach for organizing and managing emergency responses at incident scenes. The ICS management structure consists of five major components: the incident command (including a command staff), operations, planning, logistics, and finance/administration. The ICS includes a common terminology to allow interagency communication, standardized organizational processes, and a scalable incident management structure.
groups could not communicate with each other because they used separate radio frequencies.

In response to these problems, there has been a strong push in recent years in many communities to modernize communications systems. In an effort to ensure reliable interservice and interjurisdiction communications, communities are transitioning from conventional analog radio-to-radio technologies to higher-frequency (800 megahertz [MHz]) “backbone” or “trunked” networks that rely on a system of base stations and repeaters permanently installed in a service area that manage and relay radio signals. These efforts have been supported by grants from the federal government and state and regional emergency management authorities. The primary drivers of implementing trunked systems are that the systems allow all users to intercommunicate and they can be scaled up to accommodate additional services and users over time. The systems also provide enhanced transmission clarity in most environments, employ automated frequency control to help manage radio traffic, and monitor radio users’ identifications to facilitate personnel accountability.

We found in our discussions, however, that many departments that had acquired these systems were not fully satisfied with their performance. Participants cited both technological and organizational problems. One complaint about the trunked systems involved constraints on communication behaviors. Some participants disliked the 1.5-second pause the repeater generates when a user activates the transmission switch, which often clips off messages. Others complained that the system does not allow users to talk over one another. If a responder overmodulates or forgets to release the transmission switch in a stressful or panic situation, others cannot interrupt or speak over that responder. Some participants noted that working with these limitations could be addressed through training and experience with the systems, and that problems would diminish as users became more familiar with the technology.

This [800 MHz trunked] system doesn’t work. It needs too many repeaters, which costs too much money. The idea is good, but it’s too expensive to implement.

—Fire service representative

One of the main technological problems cited in the discussions was unreliable signal transmission. Signal loss and resulting “dead spots” were said to be most problematic in areas with tall buildings or hills, and particularly in areas below grade, such as basements and parking garages. The limited signal penetration into and within high-rise buildings and other difficult environments was seen as being comparable to, if not worse than, the signal penetration with analog
systems. Non-line-of-sight and intrabuilding transmission problems can be improved by increasing the number of repeaters supporting the system. Buildings can also be outfitted with “leaky feeder” systems: cables routed throughout a structure that act as an antenna. However, participants stressed that these solutions added significantly to system cost and, as one fire service representative noted, “most municipalities can’t afford this.” The situation is complicated by questions about who is responsible for installing and maintaining such networks: Are these tasks the responsibility of emergency response agencies, the municipality, or building operators?

Beyond technical considerations, cost and coordination issues are also serious impediments to widespread implementation. Even with financial support from the federal government, the need to coordinate policy and acquisitions across many agencies slows implementation. After seven years of discussions, 14 agencies across one mid-size metropolitan region were still two years away from system implementation. “There does not seem to be a lot of enthusiasm to participate,” said one representative. Other participants pointed out that even when a system is adopted, the system is underfunded, or not all agencies opt to participate, thereby reducing potential system effectiveness. “They bought a $10 million system and put $2 million into it,” said one representative from a mid-size city. Of particular concern was a lack of participation by state and federal agencies, such as the National Guard, Coast Guard, Federal Bureau of Investigation, and U.S. Drug Enforcement Agency.

Yet another challenge with high-frequency trunked radio systems that participants noted is the unresolved problems with frequency allocation and resulting interference among public safety, private wireless services, and commercial, industrial, transportation, and specialized mobile radio users. These problems must be sorted out, participants claimed, before communitywide investment in and implementation and acceptance of a single interoperable communication system are possible.

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2With analog radio-to-radio systems, signal loss can be overcome in some situations by "talking around" the problem, i.e., having personnel nearby relay messages along a chain of individuals. Because transmissions in trunked systems are relayed by repeaters, a user out of range of a repeater has no capability of contact with others. Such concerns led the New York City Fire Department to abandon use of a trunked system after testing it on a pilot basis (Dwyer, Flynn, and Fessenden, 2002).
Given the shortcomings of existing communication systems and the slow pace at which trunked systems are being implemented, few options for interoperable communications exist. Many departments resort to using several different systems to handle all of their communications needs. Unit commanders often use conventional analog radio-to-radio systems to reach responders inside buildings and digital trunked systems to communicate with other services, jurisdictions, and agencies. One agency in a small county reported that their emergency operations truck incorporated seven distinct communications systems: two analog radios, an 800-MHz radio, a cell phone, a pager, a marine band radio, and a satellite phone. Another alternative mentioned in the discussions is that responders sometimes resort to commercial mobile phones and pagers. Again, responders noted shortcomings with this backup option: In large-scale incidents such as natural disasters, industrial accidents, or terrorist attacks, mobile networks can be overwhelmed by heavy civilian use. To solve this problem, several participants called for requiring commercial mobile service providers to give precedence to designated agencies for airtime in certain emergency situations.

HAZARD ASSESSMENT

An important aspect of protecting the health and safety of emergency responders is the ability to detect, monitor, and assess an environment for thermal, chemical, structural, explosive, and other hazards. These tasks help responders decide how to approach a situation and what types of personal protection they should use. Hazard detection, monitoring, and assessment take place in some form at every incident. The tool most commonly used by emergency responders is personal experience. “We go on our knowledge,” said one firefighter. This knowledge may include a firefighter’s experience with how a fire progresses or a police officer’s experience with a particular individual or location. Emergency responders also frequently resort to simple indicators and rules of thumb, such as those concerning the characteristics of a smoke plume or human behavior.

While such approaches are often indispensable, participants in the RAND discussions noted that these approaches also are often inaccurate and insufficient given the increasingly complex and uncertain environments in which emergency responders must operate. For example, building construction and building materials are evolving rapidly, and firefighters’ experience with actual
fire situations is decreasing as a result of the long-term decline in the number of structure fires.

To improve the accuracy and usefulness of hazard assessment approaches, RAND participants suggested improvements in information availability, monitoring technologies, and assessment tools that would help them better understand the hazards they face in the line of duty. Dealing with emerging hazards associated with terrorist events, highlighted by the anthrax attacks of 2001, were cited as a particularly important concern.

Hazard Information

Information available on site is increasingly being used to assess hazards. Many firefighters commented on the value of placards on buildings and vehicles indicating the presence of flammable, reactive, toxic, caustic, explosive, or otherwise hazardous materials. While useful when it is available, participants noted that such information often is not posted or regularly updated, even when required by code. Given the proliferation of building materials and construction types, several firefighters expressed a desire for a similar type of placard system to identify building design. Fire service representatives repeatedly mentioned the increased building collapse hazard in buildings with lightweight truss roof and floor construction, which is now used widely in commercial structures but is often not readily apparent to responders.

Another informational tool used in emergency response is a “pre-plan,” which includes information compiled in advance on, for example, hydrant and standpipe locations, utilities, building design and layout, hazardous material inventories, and service histories from previous calls. Pre-plans may be developed by municipal services or by industries to guide their emergency response personnel. “It will change the way you will attack the fire,” said one participant. Industry representatives expressed satisfaction with their plans. The usefulness of municipal pre-plans, however, was questioned. Some municipal representatives noted that pre-plan information often is stored in a format and location that are difficult to access (e.g., paper copies stored in the fire chief’s vehicle). As one firefighter noted, even when pre-plans exist, “In reality we don’t usually have that information [on hand].”

In addition to on-site information and pre-plans, a third type of hazard information is provided by dispatchers, who gather information from callers or other personnel on the scene. Pre-plan and dispatch information could be made much more usable, participants claimed, by exploiting information technology. Examples of emerging capabilities that are beginning to improve information utility include computer-aided dispatch involving the transmission of dispatch information to mobile data terminals in emergency response vehicles and
integrated Geographical Information System and Global Positioning System (GPS) technologies that generate maps and floor plans, guide vehicles, and locate critical items such as hydrants, stand pipes, and hazardous materials.

**Environmental Monitoring Equipment**

> We all need better detection equipment so we know what we are dealing with.
> 
> —Fire service representative

Portable environmental sensors and analytic devices are coming into more widespread use in the emergency response community to assist the community in its approach strategies and PPT decisionmaking. While most of these devices are used primarily by specialized hazmat teams, participants noted that as technologies improve and become easier to use and prices drop, detectors are increasingly making their way into initial response efforts.

Representatives from one fire department ticked off their priorities for improving infrared imagers. Based on community input, these requests can be extended to many other sophisticated personal protective technologies.

> —For it to be acceptable, it has to be lightweight. Affordability is second.
> —It’s got to be fast [to set up].
> —It has to be easily maintainable.

One tool becoming increasingly commonplace in the fire service is the infrared thermal-imaging camera, with one-fourth of fire departments currently using this technology (U.S. Fire Administration and National Fire Protection Association, 2002). According to study participants, thermal imagery is used mostly for identifying hot spots and determining building integrity during overhaul. It is also used in wildlands fires to identify hot spots in vegetation and root systems. “We are making a lot of decisions based on thermal images,” said a fire department representative from a mid-size city. In principal, thermal imagery can also be used to locate fallen personnel, and one representative relayed a case of using thermal imaging at the scene of an automobile accident to locate and recover a severed limb, which was later successfully reattached.

Infrared imaging technology has improved significantly since it was first introduced in the 1980s. Reductions in equipment size and price have occurred, but the lightest palm-size versions were still seen as an expensive option by many departments. One department in a mid-size city had acquired eight older-model imagers and was seeking more to outfit every apparatus in the service.
The State of California is planning to provide all services in the state with thermal imagers. Emerging video uplink capabilities that can transmit thermal images to commanders were seen as a promising tool for monitoring personnel and operations. Integrated “heads-up” thermal-image displays built into respirator face masks, similar to those developed for military applications, were also seen as a promising development.

First-responding firefighters typically are equipped with a basic four-gas monitor, which is used primarily to determine carbon monoxide levels during the overhaul phase (to ascertain when personnel need to wear SCBAs) and to investigate “strange odor” calls, such as those for natural gas leaks. One big-city fire department reported having placed four-gas monitors on all of its ladder trucks by the mid-1990s. A small-city department reported that all three of its fire squadrons as well as its hazmat team had them.

Right now a [chemical] hazard assessment is not done at “regular” fires. It should be.

—Fire service representative

Many agencies participating in the RAND study reported that they have been acquiring an array of portable devices designed to sample and analyze a variety of gases, liquids, and solids. Many of the firefighters felt that chemical hazard monitoring should be routine at all fires, given the increasingly exotic and often unknown materials encountered in industrial operations and in building construction and interiors. Police and fire departments alike expressed a strong desire for improved sensing capabilities for first responders, in particular to warn responders of an unrecognized terrorist or other hazmat exposure risk. For example, one department reported that it is now seeking to place radiation dosimeters on every fire apparatus. “It’s a key item for use, absolutely,” said a department representative.

More advanced devices, such as portable gas chromatographs or infrared spectrometers, however, are confined to the specialized hazmat teams in most communities and are used only at incidents in which hazardous materials are known or suspected to be present. This restricted use is driven by the fact that the gear is bulky, takes time to set up, and requires special training to use. Equipment cost also was cited as a significant constraint on its wider distribution and use. As an EMS representative noted, “I can’t buy enough. I can’t

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3Such devices typically measure the amount of oxygen, carbon monoxide, hydrogen sulfide, and combustible gases.
afford it.” First-responding police officers typically have no sensors at all at their disposal.

To help prevent first responders from walking into a hazardous zone unknowingly, several participants recommended the development and diffusion of passive “badge-type” chemical and biological detectors worn on garments, similar to radiation badges. Many also wanted long-range, high-sensitivity “prior to lethal” detectors that could provide information about environments that are dangerous to life and health before responders enter those environments. The large number of anthrax scares in autumn 2001 has given rise to the desire for quick, easy-to-use test kits and monitoring devices to detect and identify chemical and biological substances, similar to those used for identifying illegal drugs. Not only can such technologies guide PPT use, but better on-site information can also reduce unnecessary equipment use and decontamination needs. A clear understanding of the risks at hand also can “mitigate the fear factor” among responders and the public, commented one participant. Because of the increasing diversity of potential hazards, stated many respondents, ideal monitoring and identification technologies must provide comprehensive solutions—i.e., those technologies must have broad-spectrum detection capabilities so that multiple instruments are not required.

In the context of large-scale structural fires as well as emerging threats of terrorism, several departments suggested that chemical sensors would be particularly valuable when installed as permanent fixtures in buildings. Broadly analogous to the benefits of smoke-detection and fire-sprinkler systems, participants envisioned chemical sensors that could trigger warning alarms and automatically implement mitigative actions. For instance, air-handling systems could be manipulated to move smoke or chemical hazards away from building occupants and responders. Chemical and radiation detection systems are in widespread use today in industrial facilities; therefore, it was argued, they could easily be developed for public buildings. Such sensor information would be yet more valuable, according to many participants, if it were available to emergency responders at the station or en route to the scene. Commercial systems that can transmit fire panel information, such as temperature sensor readings and the location of activated alarms and sprinklers, directly to responder vehicles are becoming available. This existing technology could be readily adapted, participants suggested, to also convey additional chemical, biological, and radiological sensor data.
Chemical sensors are not that useful, especially in the initial response, because you need to be in the hazard to make the measurement, so you already need the protection.

—Hazardous materials specialist

Some participants questioned the merit of substantial investments in hazard indicators and monitoring. One department argued that much of the discussion about improving responder protection through better environmental hazard monitoring may be misguided because an emergency responder in principle should be wearing adequate protection when initially sampling an environment with suspected hazards. Similarly, participants argued that basing protection decisions on a reading for a restricted range of potential hazards may be dangerous. For example, it was argued that carbon monoxide monitoring alone during overhaul was insufficient: SCBAs should always be worn during overhaul because carcinogens released from building materials and building contents may be present but not readily measurable.

Some fire service representatives also noted that the incremental value of improved environmental hazard monitoring was limited given existing policies in the fire service that allow for only a single PPT option (full bunker gear and SCBA). As a result, most fire service representatives stated, hazard information is more often used to guide operational decisions than to influence personal protection selection because responders must default to maximum protection regardless of the level of environmental exposure. In the case of law enforcement personnel, they typically have so little in the way of personal protection equipment and training that the issue of complex monitoring is largely moot.

An additional issue surrounding the use of environmental monitoring technologies is the level of confidence in their reliability. Several fire service representatives commented on the unreliability of warning indicators, such as personal-alert safety system alarms that signal when a firefighter may have stopped moving. Frequent false alarms, it was argued, motivated many firefighters to not activate those devices. “Smart-ticket” and other technologies used to detect and identify agents such as anthrax and Ricin must also be more accurate than they are now. A false positive, it was noted by two participants, can lead to unnecessary panic among the public as well as among emergency responders, and “is doing the terrorist’s job.” False negatives are even more deleterious because they may motivate responders to operate in unsafe environments. Such concerns typify the challenges involved in introducing new technologies in general, and are amplified in this arena given that the safety and health of emergency responders is at stake.
LOCATION TRACKING

Police and fire department representatives also expressed a strong desire to acquire technologies to monitor the location of individual responders. Participants stated that the primary application of such a capability would be to quickly locate a trapped or injured responder. Additional applications include managing operations at large incidents, such as natural disasters, and guiding personnel through buildings for the purposes of escape, pursuit, or locating spots of concern. Eventually, participants envisioned, simple robots equipped with location monitors and cameras could be dispatched to generate maps of incident scenes that could be used to guide responders. Location tracking of vehicles can facilitate more efficient dispatching and help to manage or investigate driving behavior.

Location monitoring would be great for rescue

—Fire service representative

Participants noted that personal location technologies based on the Global Positioning System are becoming available. In one major city, all fire apparatuses are outfitted with GPS that can be monitored by dispatch. “Now we want to take this to the people [level],” said one participant. “I am interested in a GPS locator so I can tell where the [fallen] guy is,” stated one leader of a big-city fire department. Participants frequently cited the use of personal location technologies in the military, but they are seen as being prohibitively expensive for municipal use. GPS also suffers from poor vertical resolution and signal penetration problems in large or underground structures, limiting its applicability in multistory buildings.

Other location technologies are in discussion and development, it was noted, such as technologies that employ radio triangulation (exploiting differences in travel times of radio signals between a source and multiple receivers), radar (exploiting the travel time of reflected radio signals), and inertial tracking systems (using accelerometers to compute cumulative movement, also known as “dead-reckoning” systems). Radio-based systems may require either fixed antennas to be installed in buildings or temporary beacons to be placed around the site—raising cost issues not unlike those with trunked radio systems. Inertial systems suffer from cumulative drift errors that limit their usefulness. Hybrid systems are also being researched: One novel concept employs GPS-equipped vehicles parked around an incident scene to act as position beacons for radio location systems.

Should the cost and technology hurdles be overcome, two participants envisioned that individual-level location tracking technologies could be linked with
communications systems and monitoring technologies to transmit emergency responder vital statistics (obtained automatically by physiological sensors located in garments), ambient temperature and environmental hazard data, remaining air supply, and other data to a central dispatch center where those data could be monitored. One participant added that while such solutions may be seen as being costly, the benefits from reduced responder injuries and deaths were likely to outweigh the costs.

HUMAN FACTORS

Another interesting issue that emerged from the community discussions as having important implications for personal protection of emergency responders is how personal discretion and decisionmaking can be critical determinants of PPT effectiveness. This section discusses some of these important human factors, including knowledge management (effectively utilizing available information), safety practices and enforcement, and the influence of service traditions and organizational culture.

Knowledge Management

As discussed in the previous sections, more advanced technologies for hazard information gathering are becoming available in the emergency response community. Yet, RAND’s discussions with members of the community suggested that very few services have yet to take full advantage of this trend. Several reasons for this were identified.

As noted earlier, one impediment to acquiring such technologies is the initial cost, especially for large departments. Another limitation to utilizing more-advanced technologies is the ongoing cost and complexity of maintaining such systems. Several participants noted that an information management system is only as good as the information in it, but updating databases is an expensive task. Several fire departments with which we met had mobile computer terminals, but some departments rarely used them because little useful information was available on the system.

Personal views on the value of the information that dispatchers relay varied considerably. Inadequate training of medical dispatchers, said one participant, resulted in insufficient information on site conditions and risks being obtained from callers and subsequently relayed to responders. Another noted that the value of the information depended in part on whether the dispatch center was
operated by the responding service. Similarly, the challenge for pre-planning efforts was assuring that the information in the plans was regularly updated and maintained. One recommended solution was that the maintenance of hazard and building information systems needs to extend beyond the emergency response departments so that the information can be input by a variety of municipal services, such as building code enforcement, water, power, and transportation services.

Forty rads, is that bad? I need to know if it’s good or bad. If we were nuclear physicists, we wouldn’t be cops.

—Law enforcement representative

The discussion of information systems also focused on training of personnel to use them. A small-city fire service evaluated the performance of a computerized personnel accountability system that also maintained data on the health condition of responders. The system was seen as performing more functions than responders could realistically use in the field. The fire service opted to adhere to the “keep it simple” strategy and continued using accountability tags mounted on the back of firefighters’ helmets. A fire service in a mid-size city reported having approximately 100 hazard detection devices in service ranging from more-basic technologies to sophisticated equipment. “We can deal with just about anything out there,” said a representative, but he added that some of the equipment is not used because there are not enough line personnel trained to use it. One big-city fire department had acquired a number of $75,000 chemical analyzers to be used in the field. However, a representative of that department observed, “The complexity of the equipment is really overloading the normal firefighter. We are at the point where we really need to be able to hire lab technicians.” However, the city’s hiring and pay practices made it difficult for the department to acquire, train, and retain such skilled personnel.

To me, simple is better. Firefighters have a tendency to shy away from things that are complicated.

—Fire service leader

Many participants argued that environmental monitoring technologies should be simple to operate and understand: “No interpretation, no choices, just on or off,” said one participant in referring to how a device should operate. “Ease of

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4 Dispatch services are often consolidated in such a way that a single department or third-party service may dispatch for the police, fire, and EMS departments in a city or even in multiple cities.
use is a big deal,” said another participant. A law enforcement representative said he wanted hazard monitoring equipment to supply real-world answers, not numbers, that provide guidance on what to do. Other participants (including those with hazmat expertise) expressed doubts that such simplified (“firefighter friendly”) approaches were realistic. For example, it was noted that knowledge of the concentration of a hazardous agent is by itself of limited use, and translating the reading into actionable information, such as “don SCBA” or “high explosion hazard,” is a complex process that is fraught with uncertainties and requires specialized training.

Safety Practices and Enforcement

You have to have discipline. There must be procedures established beforehand. Those procedures must be analyzed. The procedures must be implemented by everyone. We don’t have that. We don’t have the education. We don’t have the training. We don’t have command system. We don’t investigate [injury] incidents. We have a lot of gaps.

—Fire service leader

The RAND discussions tended to focus on high-visibility health and safety risks (such as thermal and chemical hazards) responders face at the scene of an event and advanced technologies to address those risks. Of particular concern was reducing the likelihood of acute injuries and death. However, discussions with several agencies pointed to chronic and day-to-day risks and occurrences that, although typically less acute than high-visibility risks, are often more prevalent. Such day-to-day risks also typically require more basic technology and practice solutions. A number of diverse issues were raised in this area, including the following:

- A person responsible for safety reported that shoulder injuries, followed by knee injuries, were a significant problem in his fire department: “If I could teach them to pull hose properly, I could dramatically reduce shoulder injuries.”

- Another individual reported that a significant proportion of injuries in his fire department were incurred while firefighters were getting on and off apparatuses.

- Back and knee injuries are the largest sources of workers’ compensation claims for small-city fire/emergency medical services, and those injuries were mostly attributable to moving and lifting patients.
Such injuries can take a toll on a responder’s career. Injuries also were seen as imposing significant costs on an organization in terms of compensated sickness time, workers’ compensation insurance and payouts, overtime costs associated with filling open shifts, and additional costs of training replacement personnel.

Several departments noted that they are actively trying to reduce workplace injuries for three reasons: (1) in an effort to cut lost work time, liability claims, and litigation; (2) as part of city and state safety programs; or (3) as a result of regulatory sanctions. Efforts being made to reduce slips, trips, and falls include improving station lighting, keeping station floors clean and dry, installing grab bars and nonskid surfaces on apparatuses, ensuring optimal fit of bunker pants, and selecting footwear with enhanced ankle support and wide heels.

Despite the growing desire to improve workplace safety and health, several agencies reported that they lacked the funds to properly monitor and analyze injury data and workplace practices or to implement programs to address the issue. One fire department leader acknowledged, “If we did a better job analyzing injuries, we would have a better understanding of what caused them.”

We put them in a competitive environment and they often end up driving over their ability. It is probably the one aspect of police service that we want to regulate the most.

—Law enforcement representative

Motor vehicle accidents are a major cause of death and injury for all emergency responders. As noted in Chapter Two, 40 percent of police officer deaths, 18 percent of firefighter deaths, and approximately 50 percent of emergency medical service responder deaths involve motor vehicles. Motor vehicle accidents caused by emergency responders were of concern to several participants in the RAND discussions. Several participants noted that young police officers are tempted to drive too aggressively in a “lights and siren” situation, resulting in a significant share of officer injuries occurring in traffic accidents. Injuries (sometimes also to innocent bystanders) and issues concerning judgments and liabilities had motivated one department to pay more attention to driving behavior and implement a “very restrictive” driving policy. Other police departments also mentioned their driving and pursuit policies.

Traffic accidents were also cited as an issue for firefighters and EMS personnel, especially volunteers. In EMS, one participant asserted, the challenge in data analysis is in discerning the benefits versus the costs of driving at excessive speed. Driving practices used by emergency responders in “lights and sirens” conditions, such as driving at high speed, driving against oncoming traffic, and running red lights makes a positive difference in medical outcomes for only a
small fraction of transported patients, he argued, but adds significantly to risks to emergency responders and bystanders. In all cases, better driver training and enforcement were seen as part of the solution.

"Accidents occur not because we don’t have the equipment, but because we don’t use the equipment." —Fire service leader

Enforcement of safe practices was cited by many participants as an area for improvement to prevent injuries of all types. One small-city fire department representative indicated that many injuries occur because firefighters on his force do not wear personal protective equipment (PPE) properly. Photographs of fire scenes, he added, were reviewed to identify problems in this area. A police representative noted that mobile computer terminals create a distraction inside the patrol car and their improper use may cause accidents. “Our policy says [officers] must pull over before they look at the screen or type. Do they? No.” At major incidents, one participant said, not all firefighters in his department adhere to rules governing rest and rehabilitation: “If we follow our policy, then it works okay.”

Rather than acquiring more or better protective gear, enforcement of safety rules and regulations was viewed by some participants as the top priority for improving responder health and safety. “Training and compliance are the biggest needs. We carry the necessary equipment,” said one battalion chief. “You can carry all the stuff in the world, but you’ve got to wear it,” argued another law enforcement representative. “They aren’t very conscientious about wearing PPE,” said a small-city fire service safety officer, during a discussion of exposures to pathogens. “It’s a battle to get [firefighters] to wear seat belts,” said another fire service representative. One fire department representative in a small suburb noted that his service responds to less than one major structural fire per year. This has resulted in laxness in using structural PPE.

**Responder Fitness and Wellness**

The need to improve protective gear was a principal concern of rank-and-file firefighters, patrol officers, and emergency medical service responders. However, improving protective gear and practices to reduce responder injuries and death will address only part of the risk equation. As discussed in Chapter Two, physical stress, overexertion, and cardiovascular incidents are the leading causes of firefighter death and injury and are significant causes of injuries and death among police and EMS responders as well. Many discussion participants
remarked that strengthening the person and increasing his or her resilience and resistance to stress, fatigue, and injury are key to responder health and safety.

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<th>We are much more fit than we used to be 15 or 20 years ago. It’s a whole new generation of people.</th>
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Many community representatives in leadership positions talked about the impact of fitness, diet, psychological stress, and other personal factors (described broadly as “wellness”) on responder performance, resilience, and risk of injury or death in the line of duty. Those representatives also acknowledged that responder fitness and wellness, like safety and enforcement of safe practices, are major organizational challenges. Many participants pointed to their investment in physical fitness facilities and programs as one means to reduce injuries. At the same time, many participants noted that they had mixed results in trying to achieve fitness and wellness objectives.

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<th>A chief would rather tell the widow that the firefighter died battling a fire, than tell the firefighter that he can’t do it anymore [because he is not fit].</th>
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<td>—Fire service representative</td>
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In many jurisdictions, fitness is a very sensitive subject. Commanders are hesitant to exclude members of their team from their line jobs, especially because alternative nonoperational support positions are relatively scarce and are often considered to be less prestigious than line positions. Requiring personnel to take and pass a medical exam is also a sensitive issue. Unions are concerned about maintaining fairness and protecting their members’ employment status. “I’ve never seen an officer kicked off the department [because he or she] couldn’t pass the physical fitness standard,” observed one police department leader. Some participants attributed success in promoting wellness programs, or a lack thereof, to the culture or leadership of an organization, or to groups of individuals within it. Some pointed to regional and generational factors. For example, fire departments in the Northeast have a reputation of being more tradition-bound and resistant to introducing physical fitness programs than departments in other parts of the country.

In recognizing the need to address physical fitness in the fire service, and the sensitivity of the issue, the International Association of Fire Fighters and the

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5Interestingly, one large fire department reported a concern with injuries sustained during fitness workouts, and it banned basketball playing during work hours.
International Association of Fire Chiefs have implemented some nonpunitive, voluntary fitness initiatives (Runnels, 2003). These initiatives include an overall wellness program addressing physical and mental fitness, a candidate physical ability test to help evaluate the fitness of potential firefighters, and a peer fitness trainer certification program to establish a basis for effectively training firefighters in physical fitness. Despite these efforts, most firefighters do not participate in a fitness program: A recent survey indicates that 792,000 firefighters (approximately 75 percent) serve in departments with no program to maintain basic firefighter fitness and health (U.S. Fire Administration and National Fire Protection Association, 2002). Importantly, the wellness program and candidate test initiatives will soon include data-tracking components that will help evaluate the effectiveness of the programs.

**Tradition and Organizational Culture**

During their discussions with RAND, participants frequently referred to the importance of tradition and culture in the emergency response community, which impacts the selection and use of personal protective technologies. Accordingly, improving the health and safety of emergency responders should not be seen as solely a technology issue but one that must also address tradition and culture.

You know what they say about the fire service: “200 years of tradition unimpeded by progress.”

For some reason firefighters like clean apparatuses and dirty gear. It’s a source of pride.

—Fire service representatives

A prime example of tradition is the wearing of leather helmets with large brims, which are preferred by many firefighters because they hearken back to the early days of professional firefighting, and because wearers are readily identified as firefighters. Many fire departments reported an increased interest in such helmets in the aftermath of the September 11 attacks, despite the view of many responders that those helmets are heavier than more-modern designs. In addition, the larger brims and higher profiles of the traditional helmet design can restrict movement in some situations, prompting users to remove their helmets in order to do their jobs.6

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6One firefighter observed, “What is the first thing you do when you need to enter a vehicle at a collision scene? Take off your helmet.”
Dirty, worn, and burned gear was regarded by many respondents as a sign of experience and a “badge of courage.” Said one EMS manager, “I’ve got a helmet that’s pretty beat up, but I like it.” However, a fire department official responsible for PPT acquisition noted that such preferences often result in personnel accepting the fact that they have a heightened exposure to hazards.

People still use turnouts for everything. [A new type of certified protective clothing] is ideal for nonfire use, but firefighters don’t use it. They cling to bunker gear like a security blanket.

—PPT supplier

Several fire service participants argued that tradition can impact the diffusion of new technologies and practices. Many services have long-term attachments to specific equipment and relationships with equipment suppliers that they are very reluctant to abandon. “I like yellow. I’ve always had yellow,” said a fire department leader about his bunker gear. When conceiving new technologies and procedures, developers need to keep in mind how they will be received by the rank and file. “It’s tradition. That’s what impedes the progress of PPE,” said one participant from the fire service. “If it doesn’t look the same, it won’t be accepted.”

Tradition and culture extend to safety practices and the perception and assumption of risk. “Safety is pretty subjective,” said one fire service representative. Several participants drew a comparison between first responders’ urge to render assistance and the need to take precautionary measures. “It’s very hard to arrive on the scene where somebody needs assistance and contain yourself,” said a police commander. “[If] you see victims, you don’t think PPE,” said another law enforcement representative.

Similarly, enforcing compliance with PPT use in emergency response was seen as being governed by organizational culture, given the fraternal and often voluntary nature of the profession. In a volunteer department, there are no financial penalties for violating the rules. Said one participant, “What are you going to do in a volunteer association? Take away their birthday?” Others raised the concern that the high-stakes culture made emergency response more risky than it needs to be. Speaking of firefighters and EMS responders in his agency, one participant stated, “They aren’t very conscientious about wearing PPE. Firefighting is still regarded as a sport.”

Some participants raised questions about the offensive “rush in” approach to structural firefighting and law enforcement that is dominant in the United States. In contrast, hazmat and bomb squad representatives emphasized their more defensive and cautious approach to situations, their recognition of the
importance of hazard assessment in advance of taking action, and their rigorous adherence to safety protocols.

Interestingly, many participants raised the specter of moral hazard—that is, improvements in personal protective technologies and their use provide a form of insurance that may increase risk-taking. Participants worried that the excellent thermal protection afforded by their protective ensemble has enabled firefighters to overextend themselves in high-risk environments. “A real concern of mine is a false [sense of] security, that [firefighters] feel like they are bullet-proof,” stated a leader of a small fire department. Despite the fact that escape hoods are designed to be used only for very short durations during an escape, law enforcement representatives suspected that the hoods would be used by police officers for operational purposes rather than for immediately exiting a hazard zone.

Organizational culture and tradition, and therefore organizational practices, vary widely by service and region, it was noted throughout the discussions. One factor affecting the willingness to accept new PPT is the age of the responder: Younger personnel, it was frequently argued, tend to be more receptive to new equipment and workplace practices, such as wearing seat belts or ballistic vests. One participant noted that his department was paying more attention to cleaning bunker gear because the public expected firefighters to have a tidy appearance, driven in part by their involvement in various “public service” functions in addition to emergency response. In general, discussion participants broadly attributed variations in PPT practices to organizational culture, leadership, procedures, training, or local experience, such as notable responder injuries or deaths. Given such uncertainty concerning proper practices to follow, one participant recommended that research be funded to identify and document (i.e., benchmark) best safety practices across the emergency response community—a practice that is common in industry.