

In the preceding chapters, we presented emergency responders' views of the risks they face in the line of duty and their most critical personal protection needs. As Chapter Two illustrated, the emergency response community is extremely diverse in the size and structure of its organizations, the populations it serves, the tasks it undertakes, and the hazards it encounters. Not surprisingly, the subsequent chapters brought to light important similarities and differences in emergency responders' views of risks and personal protection needs.

In this concluding chapter, we gather together these perspectives into a number of findings across broad issue areas, which collectively may be considered an initial step in developing a personal protection agenda for the emergency responder community. First, we offer observations on improving both equipment and practices, which together are defined as *personal protection technologies*. Most of these observations were originally put forth as recommendations, summarized in Table 9.1, from individuals who participated in the RAND discussions. Several observations were extrapolated from participants' comments. Next, we turn to several broader policy issues raised by the community discussions that are salient to the personal protection of emergency responders and that warrant further research, analysis, and discussion.

COMMUNITY PRIORITIES

Reducing Physical Stress and Improving Comfort

Personal protective equipment often is heavy and burdensome to the wearer and can cause physical stress and overexertion. Physical stress and overexertion are the top causes of injuries and deaths among firefighters, accounting for more than one-quarter of all injuries and almost one-half of deaths in the late 1990s (as was shown in Figure 2.4 in Chapter Two). Physical stress and heat dissipation were also major concerns for police officers wearing ballistic vests and hazmat personnel wearing chemical-protective clothing.

Table 9.1**Personal Protection Priorities and Recommendations Raised by the Emergency Responder Community**

Personal Protection Priorities	Specific Recommendations
Reduce physical stress and improve comfort	<ul style="list-style-type: none"> • Improve garment breathability • Reduce equipment weight • Ensure consistent and appropriate sizing of components • Enhance ergonomic characteristics
Improve communications	<ul style="list-style-type: none"> • Make radio systems interoperable • Improve communications capabilities with SCBA • Improve radio design to allow hands-free use and use with gloves
Upgrade communicable disease protection	<ul style="list-style-type: none"> • Increase protective equipment options for EMS personnel and police
Develop practical respiratory and chemical protection equipment and guidelines for first responders	<ul style="list-style-type: none"> • Improve the chemical and biological protection of garments and respirators • Design protective equipment such that it minimizes interference with responder activities • Require more chemical/biological hazard training
Improve PPT standby performance	<ul style="list-style-type: none"> • Develop integrity monitoring and service-life monitoring technologies • Enhance compactness and portability of protective equipment • Address logistical complications • Reduce protective equipment maintenance complexity and cost
Expand training and education	<ul style="list-style-type: none"> • Require more training on sophisticated protective equipment • Reduce complexity of new equipment
Benchmark best safety practices	<ul style="list-style-type: none"> • Study and benchmark safety practices, particularly for EMS and police • Study and benchmark PPT enforcement practices

Reducing physical exertion and stress is becoming an increasingly critical concern of the responder community. Several discussion participants noted that while the frequency of structural fires is decreasing, the intensity of fire events is increasing, and the hazards found across the range of emergencies that responders are expected to face are becoming more complex. The recent terrorist attacks in the United States support this view: Responder activity stretched into days and weeks after the attacks on the Pentagon and World Trade Center. With the anthrax attacks, emergency responders all over the country were called out to a large number of “white powder events,” which had their own associated demands and personal protection requirements. Overheating, foot blisters,

“mask face,” and neck strains from heavy helmets were among the many chronic ailments that diminished productivity and led many responders at the scenes to forego any protection at all (Jackson et al., 2002).

Keeping emergency responders physically fresh and unencumbered while providing adequate protection clearly is a challenge from a technology standpoint. With current personal protective technologies, increased thermal protection and barriers to toxic chemicals and biological agents (i.e., increased encapsulation) generally result in increased heat and moisture retention and discomfort. At the same time, emergency responders appear to be pleased with the primary protective functionality of much of their equipment. If anything, emergency responders raised concerns about *excessive* protection.

Rather than maximizing protection, the feeling of the emergency response community was that reducing physical stress on responders and increasing their comfort should now be made a top priority. Recommendations made by study participants to address the problem of excess physical stress included developing lighter-weight, more-flexible structural firefighting garments and ballistic vests and improving the heat dissipation and vapor transmission capability of those garments through better materials and construction. Other options included reducing and redistributing the weight of SCBA bottles and other components.

Beyond the personal protection gear itself, important procedural measures that were noted include keeping firefighters well hydrated and rested, and carefully monitoring their work cycles and physiological condition. To this end, responders suggested developing ways to monitor real-time health status—such as body temperature, heart rate, and respiration—during a response. Such information could powerfully inform decisionmakers at the command level about when to rest or rotate responders to avoid serious injury or death. Improved accountability systems that make use of advanced sensors, GPS, and communication technologies were seen as being critical to remotely tracking individual responders’ location, activities, and condition. Other participants recommended a low-tech approach: better training and adherence to conventional rest-and-rehabilitation protocols.

Indeed, some participants argued that thermal protection afforded by the firefighter ensemble was too great (especially since the introduction of improved hoods) and had reached such a level that firefighters could no longer sense their environment through their equipment. One suggested solution was the use of “smart” coats with built-in temperature sensors and alarms. While these coats are currently available, they have not been well accepted because of reliability concerns. Several practice solutions also were put forth: more-realistic training

opportunities involving real fires, a more cautious or defensive approach to structural firefighting, and closer adherence to already existing safety protocols.

Improving Communications

Communications problems were among the most consistently noted shortcomings by emergency responders, firefighters in particular. The communications issue is significant in regard to protecting emergency responders because communications help the community to gather and disseminate information and manage their response activities. Moreover, reliable communications will become more important in the future as more information and data become available and need to be shared. Two issues were cited on this point, one related to radio hardware and one related to communication system functionality and interoperability.

First, emergency responders mentioned several problems with handheld radios: They are difficult to use when wearing respiratory protection; they are difficult to operate while wearing gloves; they require the use of at least one hand, making them difficult to operate when the user's hands are engaged in other tasks (and making it difficult for the user to do anything else with his or her hands while operating the radios); and their controls are often inadvertently activated in the rugged environments in which they are used. Radio components and voice amplifiers integrated with the SCBA face piece were seen as offering only limited improvements in voice clarity and ease of use. These problems become more acute under the total-encapsulation environments required for hazmat and WMD response. Therefore, further development of integrated respirator-radio technologies with "hands-free" features and wireless connections was seen as being highly desirable.

Second, when acquiring communications systems, emergency response organizations must make trade-offs among selecting the most appropriate system in terms of price, performance, ease of integration, and other factors for their own jurisdictions. Being able to communicate with other agencies in mutual-aid scenarios is a lower priority. A common refrain heard in the discussions was that departments could not communicate with each other easily. Communication gaps exist among departments in the same city, among departments in neighboring jurisdictions, and among municipalities and state and federal agencies. There have been efforts, supported by the federal government, to make all emergency responders convert to 800-MHz trunked digital radio systems. These efforts have met with limited success because these systems

- are often seen as being prohibitively expensive (e.g., given the necessary up-front conversion costs)

- suffer performance problems (e.g., non-sight-line signal penetration)
- do not provide an “all-in-one” communications solution (e.g., agencies must still maintain parallel and backup systems).

Talk of a new 600-MHz communications option does not address the cost or integration concerns.

The general feeling of the emergency response community was that no solution to these problems is in sight. Communications systems are large, complex, and expensive, and the number of technology suppliers to the emergency response community is small. Moreover, the market for emergency response communications technologies is fragmented, and agencies’ purchasing power is limited compared with industrial users. This limited purchasing power minimizes the community’s ability to influence R&D and design decisions or influence pricing. To overcome performance and integration obstacles in the short term, municipalities that are still relying on analog systems must be motivated to convert to the 800-MHz technology *and* coordinate their efforts with other agencies. However, motivating municipalities to take these steps will require substantial financial incentives. To overcome these obstacles over the longer term, resources will have to be applied to a comprehensive emergency response communications R&D agenda that addresses interoperability, scalability, cost-effectiveness, reliability, and ease-of-use concerns.

Upgrading Communicable Disease Protection

According to the RAND discussion participants, the threat of communicable disease in routine emergency response is the top concern for emergency medical service responders and a primary concern among police as well. Of the range of hazards that was discussed in this study, the threat of communicable disease emerged as the one for which protection needs are greatest, in part because of the lack of viable protection options, particularly for the hands and face. For all the concern expressed by emergency responders, very little was mentioned in the way of recent innovations or recommendations. This lack of options for protection against communicable diseases may indicate that more fundamental research and development into fluid-borne pathogen protection is needed. It may also suggest that equipment is not the entire solution, and that a comprehensive approach including enhanced training and operational protocols is needed.

Developing Practical Respiratory and Chemical Protection Equipment and Guidelines for First Responders

Currently, a number of efforts are being made to improve WMD protection for emergency response. Most of these efforts center on high-tech solutions for emergency response specialty operations. A top priority for emergency responder departments is providing respiratory and other chemical and biological protection for first-responding police officers, firefighters, and emergency medical service personnel.

Historically, only specialized teams, such as those for hazmat response, have had training and access to advanced chemical and biological protection. These units are typically deployed only when circumstances indicate that special equipment and training are required. However, the majority of calls for assistance are handled by patrol officers, firefighters, and EMS personnel who have little or no chemical/biological protection or training. This situation has given rise to concern in agencies across the country that these first responders also need enhanced protection to deal with an increasing threat of terrorism and industrial accidents.

Despite the demand for better protection for first responders, participants pointed out that there is a critical lack of appropriate equipment, training, guidelines, and know-how to provide the level of protection required. Air-purifying respirators are items of principal interest in this area. While APRs are commonplace in industry—where their use is guided by rigorous environmental characterization and usage guidelines—little attention has been paid to the use of APRs in first-response scenarios. Yet, an emergency response environment is very different from the workplace environment in industry. In an emergency response scenario, chemical substances are likely to be unidentified, the users' physical surroundings are unpredictable, and there is likely very little time to don equipment or protective clothing. Moreover, the emergency response community repeatedly called for performance standards and certification procedures for chemical/biological protection that is appropriate for first-responder applications. Departments that had evaluated respiratory and chemical protection routinely expressed frustration over the fact that the available guidance is overly industry oriented. In response to these concerns, respiratory- and chemical-protective clothing standards for emergency responders are beginning to be developed.

Hazard detectors are a related technology of interest that first responders can readily use. Drawing on the experiences of industry and the medical profession, responders recommended the development and diffusion of passive "badge-type" detectors or sensors, which indicate when the user is exposed to chemical

or radioactive contamination, and other rapid and easy-to-use environmental monitoring and risk-assessment technologies.

The conclusion reached from the discussions is that governmental guidance for respirators and chemical-protective clothing should be expanded to address the needs of first responders. This guidance should take into account not only the physical characteristics of chemical-protective clothing and equipment, such as fit, air filtration cartridge options, and ease of communications when wearing the equipment, but also operational considerations, such as how users are to be fitted and trained to use the equipment, when such equipment should be used, how to conduct operations when using the equipment, and when to evacuate a scene even when wearing such equipment.

Improving Personal Protective Technology Standby Performance

One need that emerged indirectly from the discussions is the need to improve the “standby performance” of protective gear. Improving emergency responder protection traditionally has emphasized the development of technologies and capabilities for use in emergency response activities. However, participants indicated that they desired greater PPT availability and readiness. These needs can be met by improving total service performance—that is, performance when equipment is being used and when it is not being used. Key priorities identified in this area include the following:

- Low cost
- Ruggedness and durability
- Compactness, light weight, and portability
- Ease of maintenance.

As mentioned earlier in this chapter, many participants said that the thermal protection currently provided by structural firefighting gear is adequate for most tasks for which it is designed. On the other hand, many participants pointed to the accelerated degradation of thermal protective garments when the garments are exposed to ultraviolet light. Police officers mentioned that PPT stored in the trunk of a squad car becomes damaged when evidence is placed in the trunk. They also noted that PPT becomes damaged when it is exposed to heat and moisture, and PPT is frequently lost. Thermal imagers and environmental monitors get dirty, banged up, and dropped.

As equipment becomes more complex, it also tends to become more susceptible to perturbations, and it tends to become more expensive to repair, creating undesirable trade-offs for emergency response organizations, especially smaller

ones. Thus, one area for focused improvement is “ruggedizing” PPT to reduce the likelihood of damage, slow equipment degradation, and minimize maintenance requirements.

The emergence of new hazards and the introduction of new PPT raise concerns about PPT logistics—i.e., storage, transportability, and maintenance. The increasing amount of gear that is being deployed in emergency response is leading to storage and transportation problems in stations, on vehicles, and on individuals. Storage space is at a premium, and storerooms, vehicle trunks, and tool belts are running out of room. As we have shown in this report, if personal protective equipment is not readily available when it is needed, emergency responders are unlikely to use it. This situation suggests a priority need, at this point, to reduce the size and weight of PPT components, rather than increase protective equipment performance.

Concerns about escalating costs of PPT maintenance, which lead to trade-offs in the level of protection that is available to responders, point to the need for improvements in the areas of PPT maintenance and reliability. Many emergency responders expressed uncertainty about the status of their protective gear. They have limited real-time opportunities to test how the protective performance of PPE degrades over time due to normal wear, environmental assaults such as heat and moisture, and nonuse and storage. The PPE performance tests that are available often require destruction of the equipment, such as for inspection of bunker gear interior layers and respirator cartridges.

Respondents also lack independent validation of their judgment on whether or not to use certain equipment. Accordingly, they expressed interest in having ways to facilitate inspection and confirm integrity of equipment. For example, color-change indicators and other technologies that warn of impending failure or expired service life were viewed as worth pursuing by all members of the community. End-of-service-life indicator systems could simplify maintenance of a number of components, including turnouts, chemical-protective clothing, and respirator cartridges, by helping to assure that gear is not discarded too soon or held in service too long. Such systems would be valuable for equipment that is not used frequently, such as equipment for WMD events. Before such technologies will be used, however, they must be regarded as being highly reliable.

Expanding Training and Education

The subject of PPT and emergency response training and education came up repeatedly in many of the discussions. In sum, community representatives stressed that a greater amount of training and education must be made a part of any policy to improve the protection of emergency responders in the line of

duty. Providing emergency responders with personal protection equipment without also providing proper training, it was argued, vitiates the equipment's effectiveness, and, at worst, is unethical.

Several challenges the community faces in this area were noted by participants:

First, skills maintenance is critical. PPT training, when provided, is often done at the front end when the equipment is first introduced and the responder receives his or her initial training, and refresher training is not done frequently enough. Community members pointed out that maintaining certain levels of training and expertise for a range of protective technologies and safe practices is difficult for most responder organizations, particularly those that are volunteer based. These issues are particularly troublesome with highly knowledgeable but infrequently used technologies (e.g., complex environmental monitoring devices) and in some decisionmaking circumstances (e.g., in industrial or WMD-type events).

Second, for the training to be most effective, it must include realistic "operational" or "situational" scenarios and simulations. For firefighters, actual fire scenarios are becoming increasingly important as the frequency of major fires decreases. For WMD and other special operations scenarios, exercises using a live agent, such as tear gas, were seen as being essential for testing decisionmaking and operations in high-stress environments. However, the inherent costs of such testing and the regulations governing it were said to be constraining opportunities for situational simulations. "To do rescue training the way you're supposed to is expensive," said an EMS representative.

Third, many participants spoke highly of the federal WMD terrorism training efforts provided since the late 1990s under the Nunn-Lugar-Domenici Act. Not only do such efforts facilitate PPT preparedness, and in many cases use live scenarios, they also offer valuable opportunities for community members to get to know each other. This indirect benefit facilitates potential future cooperation in mutual-aid situations and encourages cross-fertilization of ideas and know-how among local agencies. However, funding for such training activities, as was said earlier, is not large enough to maintain a sufficiently skilled cadre of personnel across the United States, given force turnover and staff rotation policies.

Fourth, for all types of training, local law enforcement agencies are at a particular disadvantage given their staffing policies. Adequate funds must be made available not only for the actual training activities, but also to cover the cost of trainees' time and the time of replacement personnel filling in for the trainees. As a result, agencies find it very difficult to train large groups of personnel and sustain competency across an entire force over time.

Finally, an issue raised by many participants throughout the emergency response community was the need for training and education to develop greater analytical capabilities in all quarters of the community. Protecting the health and safety of emergency responders traditionally has been approached through the development of protective equipment and standard operating procedures. Emergency responders have been trained to follow these procedures. Today, the threats responders face are more uncertain; the “human element,” such as heavily armed assailants and terrorists aiming for maximum impact, is more aggressive than in the past; the potential risks to responders and communities are greater; and personal protection technologies are more complex. “We are starting to apply basic hazmat procedures to all calls,” said one police department leader. As a result, emergency responders must rely on their own knowledge acquisition and problem-solving capabilities to a greater extent. As such, personal protection is becoming more dependent on enhanced threat awareness, detection, and identification; information sharing and analysis; and operational discretion and flexibility. All of these challenges call for fundamental changes in the intensity, frequency, and substance of personal protection training and education.

Benchmarking Best Safety Practices

Among all the emergency response services in the United States, the fire service is noted for having the most comprehensive personal protection equipment and practice standards. Nonetheless, in a number of areas, uniform practices have not been widely adopted in the fire service (even where standards are in place), and performance appears to vary greatly among fire departments. Police and emergency medical service representatives reported even greater variance in the employment of both personal protection equipment and practices. Those practices include:

- Workplace safety practices (in the station or precinct house)
- Line-of-duty safety practices (such as safe driving, hazard awareness, and personnel accountability)
- Enforcement of PPT use
- Physical fitness and wellness promotion and testing.

Many participants candidly acknowledged that they were struggling with deficiencies in these areas and were seeking reliable solutions. Participants spoke about programs and measures, often ad hoc, that they had pursued to remedy those deficiencies, often with limited success. At the same time, many participants pointed to models of good practice in other agencies and services.

Participants typically learn about examples of good practices at professional meetings and or by reading professional publications.

However, information on best practices is largely based on anecdotal evidence and does not provide a reliable guide for safety management. For example, there was little uniformity in participants' descriptions of the key attributes of a successful or unsuccessful PPE enforcement or physical fitness program, other than mentioning broad categories such as "leadership" and "funding." This response is not surprising: To assess and compare the performance of personal protective equipment in a laboratory setting is easier than attempting to assess and compare the performance of organizations in a community setting. The need for further study and benchmarking of organizations' behavior and practices is not trivial: As we have seen, personal protection practices are as critical to responder health and safety as personal protection equipment.

Government enforcement of federal and state occupational health and safety regulations in industry has resulted in efforts to better understand variations in safety program performance among companies. As firms have sought to manage financial and legal risks and boost employee morale and retention, various benchmarking efforts have been conducted to identify critical organizational variables—such as leadership, communications, teamwork, and morale—and more rigorously measure and compare those variables among peer firms. The absence of federal OSHA regulation of state and municipal agencies has created a disincentive for such efforts in the emergency response community. However, developing the ability to rigorously document and compare practices among emergency response organizations could tease out critical variables that are essential for improving responder health and safety and establish reliable benchmarks against which organizations can be compared.

POLICY ISSUES FOR THE FUTURE

In addition to uncovering differences in how organizations and individuals view occupational hazards and personal protection needs, the discussions with participants also elicited fundamental differences of opinion on important health and safety policy issues for the emergency response community. In this section, we touch on some of those policy debates.

Many policy issues are complex and pose challenging questions. However, one broad question permeates most of these issues: What is the proper balance between distributed and centralized decisionmaking? In the United States, emergency response is handled in a highly decentralized, grassroots manner. Solutions to problems, such as problems concerning personal protection, largely have been left to the local departments, or even the individual responder, and are heavily driven by the free market. In the post–September 11 envi-

ronment, the perceived threats to responders' health and safety have become more varied and complex and are on a scale previously unimagined. As a result, some community members raised fundamental questions about the adequacy of current decisionmaking strategies and put forth ideas (summarized in Table 9.2) that suggested the need for a more top-down, directed, or hierarchical approach to addressing fundamental policy issues.

Personal Protective Technology Research and Development

RAND's discussions with the emergency responder community revealed that there are a number of impediments to, and resulting gaps in, PPT research and development that limit progress in reducing injuries to, and improving the capabilities of, the emergency responder workforce.

Table 9.2

Key Policy Areas and Issues Raised by the Emergency Responder Community

Policy Areas	Specific Issues
PPT research and development	<ul style="list-style-type: none"> • Research should be more strategic and multidimensional, including more fundamental, long-term research • Greater emphasis on ensembles is needed • R&D should address response activity rather than services • Decentralized market limiting innovation and purchasing power should be addressed
Discretion in personal protection decisionmaking	<ul style="list-style-type: none"> • Expanding role of emergency responders and improved hazard assessment warrant increased attention to activity-specific tailoring of protection
PPT standards for emergency medical services and law enforcement	<ul style="list-style-type: none"> • EMS and police communities need dedicated personal protection, safety, and standardization efforts
PPT performance assessment	<ul style="list-style-type: none"> • Reliable and objective equipment performance assessments need to be developed
PPT standardization and interoperability	<ul style="list-style-type: none"> • Mutual-aid agreements and extended operations should be facilitated by enhanced standardization and interoperability
The role of risk in emergency response	<ul style="list-style-type: none"> • Examine emergency responders' perceptions of and their responses to risks inherent in emergency response • Promote efforts to decrease risk through improved information management, clarified protocols, and improved equipment

A common complaint we heard was that the emergency responder community, while large in numbers of professionals and volunteers, has limited purchasing power compared with industrial users of similar technologies. This limited buying power is the result of the decentralized market for PPT that the emergency responder community constitutes and tight municipal budgets. The PPT market is so decentralized because municipalities, acting independently, are the principal purchasers of PPT. Many participants noted that municipal personal protection equipment and training budgets were very tight because of widespread weakness in the U.S. economy and unprecedented budget shortfalls experienced by many city and state governments. In addition, resources that were promised by the federal government had yet to be appropriated.

Limited purchasing power may also limit the influence of the emergency responder community on research and development directions. Many participants felt that, as a result, R&D is driven largely by the priorities of industry. Widespread dissatisfaction with radios issued for firefighting was cited as one problem resulting from PPT not being developed specifically for emergency responders' needs. Similarly, the historic lack of a substantial mainline law enforcement market for PPT was blamed for the absence of equipment designed specifically for law enforcement.

To add to the decentralized PPT market, much of the PPT research and development has been conducted by equipment and services suppliers. These entities are also decentralized and often focus on a narrow segment of the development chain, further fragmenting the PPT development and diffusion process. For example, respirator manufacturers develop respiratory protection, garment makers produce protective clothing, and various other businesses produce helmets, boots, radios, and sensors, generally with little coordination among these groups. Even for a single component, development may be spread among several entities. Protective garments, for example, often evolve from development at three levels, with innovations at each level occurring in a separate field: chemical companies develop new materials, textile mills combine these materials into fabrics, and garment manufacturers focus on equipment design and performance. One important result of this fragmented supplier base is that development of protective technologies and the standardization and certification process have been focused primarily on discrete components rather than on the entire ensemble.

Another challenge in PPT R&D is that emergency responders have very diverse protection needs. The hazards they face can vary according to a number of factors, including the branch of service, the size of the community, or even the time of day. Emergency personnel must work in a wide variety of incident environments that have a unique mix of hazards and that are often dynamic and unpredictable. The hazards associated with illegal drug laboratory re-

sponses, for example, are of particular concern to law enforcement agencies. As a result, multiple-use components (i.e., those offering protection against a wide spectrum of risks) are highly valued by emergency responders. A desire for integrated, multiple-risk protection designs is further driven by cost and logistic factors. Smaller organizations with limited equipment and training budgets, especially volunteer organizations, cannot handle complex equipment logistics (e.g., storage, transportation and maintenance). Again, the fragmented nature of personal protection development and demand tends to reduce market incentives to develop universal solutions.

RAND's discussions with the emergency response community brought to light several broader impediments to PPT research and development:

- **Cost.** Research and development efforts aimed at total ensemble solutions are complex. For example, participants mentioned the difficulty of conducting applied research, creating standards, and establishing certification procedures for an entire firefighter ensemble and its various wearing positions, such as standing, crouching, and lifting. Financial resources may need to be directed at research that takes a total-ensemble approach.
- **Short time horizons.** In responding to demand driven by a fragmented municipal-level market, most R&D efforts are focused on short-term incremental advances. Research aimed at innovations desired by the entire emergency response community that would have far-reaching effects (e.g., ultra-lightweight and breathable protective materials) is very limited and not sustained.
- **Service orientation.** Most PPT R&D is focused on serving the needs of a specific service. However, community representatives suggested that their personal protection concerns often cross service boundaries. For example, members of every service expressed the desire for better chemical and biological detection capabilities and better biological- and chemical-protective capabilities of garments and respirators. A service-specific orientation to PPT R&D thus contributes to the fragmentation of R&D and may also leave critical R&D gaps: Little R&D is directed toward the needs of emergency medical personnel, and far less is being directed toward the needs of other personnel at major incident sites, such as sanitation workers, public works personnel, and construction trades workers.

Addressing these shortcomings may require a new approach to PPT research and development, namely the initiation of more strategic, top-down priority setting. The personal protection research agenda that would result from this approach would have diverse goals. The research would be balanced between short-term efforts addressing the performance shortcomings of discrete com-

ponents, such as boots and helmets, and longer-term basic research aimed at less-specific, but not less-important, goals. One example is addressing ways to improve protection against toxic chemicals and communicable diseases. Similarly, such research needs to address component integration: Participants repeatedly stated that it is critically important that equipment components be compatible—i.e., interface properly—and that they do not detract from the overall performance of other equipment or the ensemble. Finally, personal protection research would be driven by hazard-, incident-, and service-oriented perspectives.

Discretion in Personal Protection Decisionmaking

One of the major concerns to emerge from the discussions is the increasing variety of response scenarios and specialized tasks that emergency responders must undertake. This trend has raised important policy questions about the extent to which emergency responders should have more-specialized or risk-specific PPT alternatives rather than all-purpose personal protection options.

A related issue concerns determining the appropriate decisionmaking level for assessing the risks that emergency responders face and choosing the personal protection options to address those risks. For structural firefighting, for example, much of the risk assessment is essentially conducted at the national level. Decisions governing the selection of protective equipment and protocols for the use of that equipment are made by national-level institutions and are implemented through communitywide standards (e.g., NFPA 1971). These standards have favored a universal approach to personal protection—for example, use of an SCBA for all respiratory-protection needs. These standards have become so widely accepted that they have been implemented by most fire departments in the country and are referenced in the legislation of many states.

As a consequence of having a nationally imposed standard that calls for a single protective ensemble for all responses, firefighters across the nation use similar protective equipment in similar ways. The result is a decisionmaking model in which risk assessment, at least in terms of the thermal-protective ensemble, has been pushed “upstream” of departments or individuals. Such a model has important trade-offs, many participants observed.

An advantage to using this model is that standards reduce the need for individuals and departments to assess risks at an incident scene, and they provide clear guidance for firefighter protection. The process of assessing risk and evaluating protection needs is a difficult and complex one, and the majority of fire departments do not have the qualifications and resources to carry it out.

A disadvantage of this model is that it reduces risks and protection needs to a common conservative (i.e., maximum protection) baseline. As one participant noted, “A fire in Boston is about the same as a fire in Seattle,” but variations in climate, building construction, city layout, and industrial-residential mix, as well as the capabilities and resources of individual departments, can mean different risks and protection needs from one location to another. Similarly, standards exist for only a single type of protective ensemble, and those standards are designed to protect against the most serious hazard—fire. Not given consideration are other types of incidents to which firefighters often respond, such as vehicle collisions, medical emergencies, structural collapses, and brush fires, which result in exposures and risks that are frequently different from those in a structural fire.

In some cases, risk-specific protection can be partially achieved through customer-specified design of the protective gear. However, in many incidents, responders may disregard standards and informally assemble “risk-specific” ensembles through “mixing and matching” or layering of components. Some departments and firefighters already are using alternative gear, such as ranger boots, battle dress uniforms (BDUs), and lightweight gloves, on an informal basis. Informal adaptations of protective gear typically involve individual decisionmaking and may be inconsistent with the gear’s intended design. As a result, this practice may leave firefighters underprotected.

Instituting a single standard has been very effective for raising firefighting organizations nationwide to a common baseline that offers a very high level of protection. However, hazard- and risk-assessment capabilities are improving with better training and diagnostics, potentially enabling departments and individuals to select more-appropriate levels of protection based on the known risks rather than a level of protection prescribed by existing national standards. This suggests that the national risk-assessment and standard-setting model used in the fire service could be improved by allowing for more location-specific and incident-specific information to be used in determining protection needs and by giving firefighters a range of protective options.

Formal movement toward sanctioning the use of incident-specific gear has occurred with the introduction of NFPA garment standards for EMS use (National Fire Protection Association, 1997) and for USAR use (National Fire Protection Association, 2001c). These standards specify design, performance, and testing criteria for protective clothing to be used for particular activities. While the introduction of such standards is an important first step, an issue that has yet to be addressed is the need for criteria for deciding when different types of protective ensembles should be used.

Personal Protective Technology Standards for the Emergency Medical and Law Enforcement Services

A key component of any personal protection strategy is finding ways to maximize PPT use and compliance. Findings from the discussions indicate that PPT use and compliance have been high-priority concerns, and that compliance in certain areas has improved considerably in recent years, particularly in firefighting. Use of SCBAs during fire attacks, for example, is nearly ubiquitous among the departments with whom we met. Similarly, nearly all firefighters wear NFPA-compliant turnouts. Increased PPE compliance has been a hard-won struggle, and several departments echoed the sentiment of one fire chief, who noted that, “If you had asked five years ago, the answer would have been different.”

Increased PPE compliance in the fire service was attributed to a number of factors, including promulgation and updating of equipment and practice standards; availability of more comfortable and ergonomically correct equipment; improved compliance training; increased awareness of studies demonstrating the effectiveness of protection use in reducing injuries; more stringent certification requirements that have driven noncompliant gear out of the market; and more strict enforcement at the department, state, and federal levels.

The extent of PPT use varies significantly across the emergency response community. Specifically, PPT use in emergency medical service response and law enforcement was repeatedly cited as being far behind PPT use in firefighting. One reason for the lower levels of PPT use in emergency medical services and law enforcement was the lack of clearly defined and well-accepted standards for PPT design, performance, and use in emergency response. For example, the majority of emergency medical service responders noted that they prefer disposable protection (e.g., sleeves, gowns, masks, gloves), for which few standards exist outside of the standards for clinical (e.g., hospital) and industrial settings. As one participant put it, “We want EMS to be like firefighting, where all the junk is off the market.” Some law enforcement and EMS organizations have sought to circumvent this shortcoming by adopting protective equipment and practices certified by outside agencies, such as NFPA, NATO, ISO, and OSHA, whenever possible.

Efforts to enhance responder safety in law enforcement and the emergency medical services have been undertaken by federal agencies, professional associations, and labor unions. However, neither law enforcement nor EMS receives the level of guidance and support that the fire service receives from the federal government (through the U.S. Fire Administration) and a dedicated professional body (NFPA). Law enforcement benefits from the support of NIJ, but it has no NFPA analog. EMS organizations, on the other hand, benefit from the

guidance of the National Association of Emergency Medical Technicians, but they have no support from a dedicated government agency. The shortcomings in the level of formal guidance and support that the emergency medical and law enforcement services receive present formidable hurdles to improving responder safety in areas such as equipment design, testing, certification, and procurement; occupational health and safety research; compliance and enforcement; and safety education, training, and communications.

Personal Protective Technology Performance Assessment

Numerous participants mentioned identifying, evaluating, and selecting protective technologies as areas of the acquisition process that needed improvement. While NFPA, NIJ, and other design and performance standards ensure a basic level of functionality and protection, distinguishing among the wide variety of certified gear within each equipment class is not straightforward. Most responder organizations resort to informal, ad hoc personal protection technology evaluation and information-gathering and analysis efforts because they lack access to reliable information sources on PPT performance to inform their procurement decisions.

Given this situation, the creation of an objective, third-party assessment capability would greatly facilitate PPT evaluation and acquisition decisions. A few departments have formal in-house evaluation capabilities, and some departments hire outside consultants to perform this function, but these options are available only to larger, more-wealthy organizations. As discussed in Chapter Eight, the National Institute of Justice took an important step toward performance evaluation by producing a resource guide to assist with the selection of chemical and biological agent protection for emergency responders (National Institute of Justice, 2002), one of a series of NIJ guides on technologies for emergency responders. The NIJ guides provide performance evaluations for commercially available equipment based on a suite of selection criteria and vendor-supplied performance data. The guides represent an important contribution, given that many RAND participants indicated that they lacked detailed knowledge about PPT, particularly for chemical and biological response.

The emergency response community would benefit from similar third-party information and performance assessment of PPT for firefighting, community policing, medical response, and other conventional responder activities. Reliable third-party PPT performance assessment would in particular facilitate the PPT decisionmaking process regarding new technologies for the nation's smaller emergency response organizations.

Personal Protective Technology Standardization and Interoperability

Although emergency response often requires mutual aid among responder organizations, acquisition of PPT is rarely coordinated between services and jurisdictions to ensure interoperability (interchangeability) and sharing of equipment (for instance, sharing of respirator components). PPT interoperability has been a subject of discussion in the emergency responder community for many years. Problems with a lack of interoperability of PPT and a lack of uniform PPT training, maintenance, and use protocols for responders at the scene of the World Trade Center attacks and other terrorist incidents have raised the importance of this subject as a policy matter (Jackson et al., 2002).

Interoperability and standardization may be addressed from the bottom up through greater interagency coordination of acquisitions and training. Among the local agencies that participated in the RAND discussions, this coordination was not a high priority. Moreover, the costs of transitioning to a new technology combined with agencies' historical allegiances to specific equipment and suppliers are substantial impediments to change.

An alternative is to pursue interoperability from the top down through, among other strategies, the promulgation of federal uniform design standards or purchasing arrangements. In the communications arena, the federal government has for many years encouraged and supported the development and diffusion of 800-MHz trunked radio systems to facilitate interagency communications, response coordination, and mutual assistance. In 1998, the Department of Defense and the Department of Justice founded the InterAgency Board for Equipment Standardization and InterOperability which, as a first step, has developed a national Standardized Equipment List for use by responder agencies and organizations in preparing for and responding to weapons of mass destruction terrorism (InterAgency Board for Equipment Standardization and InterOperability, 2001).¹

The nation's goal of improving homeland defense capabilities further suggests that efforts to promote PPT standardization and interoperability should be a community priority. In addition to facilitating mutual aid and equipment sharing at large-scale events, standardization may help to

- facilitate potential technology transfer and equipment sharing between civilian and military organizations
- promote economies of scale and lower costs for equipment acquisitions and logistics

¹The Standardized Equipment List recommends equipment types; in most cases, it does not prescribe specific proprietary brands or designs.

- simplify PPT evaluation and acquisitions decisionmaking
- focus PPT education and training efforts.

However, the low priority for PPT interoperability at the local level and problems with its implementation (as illustrated by the lagging adoption of 800-MHz trunked communications systems) suggest that substantial financial and other incentives will have to be provided to local authorities to facilitate the transition to standardized PPT and to realize the benefits noted earlier.

The Role Risk Plays in Emergency Response

The inherent risks in emergency response are heightened by responders' personal and professional commitments to render assistance, characterized by the credo "Risk a life to save a life." Many participants noted that the high-stakes nature of the profession was part of what makes it attractive to potential recruits. The specter of weapons of mass destruction has raised the stakes even higher. Several participants also observed that emergency response doctrine has become more proactive in recent years, given the greater need, for example, to aggressively confront terrorists. More-aggressive postures have been supported by better protective technologies. At the same time, improvements in PPT, many senior personnel argued, have encouraged greater risk-taking by emergency responders.

Difficulties in formulating policy regarding risk-taking in emergency response partly stem from the lack of specific information about the effect of responder behavior on health and safety. While a significant volume and variety of injury data have been collected, an area in which occupational health and safety surveillance is particularly incomplete is in the role of emergency responder behavior. Participants raised questions in a number of areas about the impact of responder behavior on safety, including the following:

- What are the merits of wearing turnout gear during nonfire responses?
- How great is the need for responder rehabilitation at extended responses?
- What is the impact of responder fitness on managing physical stress?
- What are the costs versus the benefits of emergency vehicles traveling at high speed in "lights and sirens" scenarios?
- What constitutes improper or overextended PPT use?

More-extensive data collection and dissemination, especially as they relate to police and emergency medical service responders, would help guide personal protection R&D, education, and training activities. It could also be used to

modify responder behavior, said many participants, by heightening responders' awareness of the risks associated with particular decisions.

At the command and department level, questions about risk arose in the context of the extent to which emergency response should be "offensive" (e.g., acting to stabilize a situation as quickly as possible) or "defensive" (e.g., retreating from a hazardous scene). One fire service representative described how his department approached protection through a combination of procedures, engineering, and, in some cases, simply staying away, noting that "every hazard will self-mitigate eventually." Many participants noted that fire services elsewhere in the world tend to assume a more defensive stance from the start of an event, and law enforcement representatives spoke of strict policies that their agencies were implementing governing high-speed pursuits.

Since the loss of more than 400 responders in the collapse of the World Trade Center towers, the issue of risk has been uppermost in the minds of both commanders and rank-and-file personnel. The anthrax attacks also introduced heightened cautiousness across the emergency response community. Police commanders, for example, openly questioned the merit of sending their personnel into zones with unknown hazards given that most personnel lack critical personal protection equipment and training.

The questions raised in this report about the current and potential hazards that emergency responders face and the changing nature of the emergency responder profession point to fundamental policy issues that must be addressed. These issues merit focused discussion across the entire emergency responder community as the United States enters a new era in which emergency responders must be fully prepared to meet not only the challenges that routine emergencies present but also new challenges emerging from an increasingly unpredictable environment.