Document Title: Urban Search and Rescue Technology Needs: Identification of Needs

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Identification of Needs

Sponsored by:
The Department of Homeland Security/Federal Emergency Management Agency

and the
National Institute of Justice

June 2004

Prepared by:
Savannah River National Laboratory
Under Inter-Agency Agreement N

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Department of Homeland Security/Federal Emergency Management Agency
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in collaboration with:
International Association of Fire Chiefs
International Association of Fire Fighters
National Fire Protection Association
National Institute of Urban Search and Rescue
Texas Engineering Extension Service of Texas A&M University

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Opinions expressed in this document are those of the authors and do not necessarily reflect the official position of the US Department of Justice or the Department of Homeland Security.

Contents

Executive Summary

The Department of Homeland Security/Federal Emergency Management Agency and the National Institute of Justice (NIJ) co-sponsored an effort to identify and define functional requirements for new and/or improved technologies that meet the needs of both Urban Search and Rescue (US&R) teams as well as law enforcement agencies. This work was performed in collaboration with state and local agencies and the following internationally recognized organizations: the International Association of Fire Chiefs, the International Association of Fire Fighters, the National Fire Protection Association, the National Institute of Urban Search and Rescue, and the Texas Engineering Extension Service of Texas A&M University. The concept for this effort resulted from the experience of NIJ staff while they were supporting the search and rescue operation at the World Trade Center (WTC) in September 2001. That experience suggested the need for new and improved US&R tools and technologies.

The Savannah River National Laboratory (SRNL), which supported NIJ in its mission at the WTC, led this effort for NIJ. SRNL began work on this task in November 2002 by performing background research, making relevant agency contacts, and organizing a steering panel of recognized US&R experts. This and other groundwork culminated in a workshop held in June 2003 at which select US&R practitioners were brought together from around the country and Canada to identify technology needs.

Several disaster scenarios were discussed in detail at the workshop to facilitate discussion and the generation of functional requirements and corresponding technology needs. These discussions were led by trained facilitators, each having many years of experience in leading US&R training sessions and exercises. The findings from this workshop are summarized in this document.

Findings

As the workshop participants discussed each of six different scenarios, there were recurring requirements/needs that surfaced as high priority needs. These are summarized below (not in prioritized order):

- Improved real-time data access (data pertaining to site conditions, personnel accountability, medical information, etc.)
- The ability to accurately and non-invasively locate survivors following structural collapse – the ability to “see” through walls, smoke, debris, and obstacles
- The ability to communicate (transmit signals) through/around obstacles
- Lighter, more efficient power sources (batteries, fuel cells, or other technologies able to power multiple systems for longer periods of time)
- Improved monitoring systems (i.e., atmospheric, biomedical, personnel accountability, etc.) - real-time, portable, multi-function devices that expand on existing detection capabilities

- Improved Personal Protective Equipment – lightweight, comfortable, and rugged equipment that provides enhanced worker protection against multiple hazards
- Integration/consolidation of functions found in multiple pieces of equipment into a single piece of equipment
- Improved breaching, shoring, and debris removal systems - portable, lightweight, longer life, stronger materials and equipment
- Reliable non-human, non-canine search and rescue systems - robust systems that combine enhanced canine/human search and rescue capabilities without existing weaknesses (i.e., robots)
- Standardization of equipment (communication, search, rescue) - equipment that utilizes common platforms, connectors, power supplies, etc.

Chapter IV provides a detailed description of the findings and appropriate information on current methods and technologies used.

Observations

The following observations were made during the performance of the workshop:

- There is a universally recognized need within the US&R community for new/improved technologies to perform search and rescue functions more safely and effectively.
- Similar efforts to identify technology shortfalls have taken place in the past with minimal resulting technology development. Many of the workshop practitioners were supportive of this effort, yet remain skeptical about the long-term benefit.
- Many of the functional requirements and technology needs identified would indeed benefit both the US&R and law enforcement communities.
- There needs to be a technology "pull" rather than a technology "push". Technologies must be developed in response to specifically identified problems. Developing technologies, and then looking for problems to solve with those technologies will not be successful.
- Technologies/equipment must be thoroughly tested and robust prior to field use. Otherwise, they become an impediment.
- Most, if not all, of the needs/functional requirements identified at the workshop were applicable across the various US&R organizations represented.

Future Work

It is intended for this document to be shared with state and federal US&R agencies. NIJ plans to use this document to identify technologies of interest to both the US&R and law enforcement communities. NIJ will look to develop identified technologies applicable to both communities with out-year funding. The following are recommendations for the path forward:

- It is recommended that this document be provided to the DHS/Science and Technology portfolio manager for US&R for implementation.
- It is recommended that there be a concerted, sustained multi-year US&R-focused technology development effort.
- It is recommended that there be a long-term plan with multi-year funding to reach the goals identified in this report.
- It is recommended that there be established a robustly-funded ongoing process to test and validate US&R technologies through laboratory testing and operational evaluation with practitioners.
- It is recommended that there be a continuing review of technology by practitioners.
- This study did not specifically address the needs of the Incident Support Teams (IST), and it is recommended that there be an examination of IST requirements.

Acronyms

3D	–	3 Dimensional
AE	–	Acoustic emission
AHJ	–	Authority Having Jurisdiction
APCO	–	Association of Public Safety Communications Officials
AVL	–	Automatic Vehicle Locator
BNICER	–	Biological, Nuclear, Incendiary, Chemical, Explosive, and Radiological
BoO	–	Base of Operation
CBIRF	–	Chemical Biological Incident Response Force
COW	–	Cellular on Wheels
DHS	–	Department of Homeland Security
DMAT	–	Disaster Medical Assistance Team
DMORT	–	Disaster Mortuary Operational Response Team
EAN	–	Emergency Area Network
EPA	–	Environmental Protection Agency
ESF	–	Emergency Support Function
ESP	–	Expert Steering Panel
FBI	–	Federal Bureau of Investigation
FDA	–	Food and Drug Administration
FEMA	–	Federal Emergency Management Agency
FRP	–	Federal Response Plan
GIS	–	Geographical Information System
GPS	–	Global Positioning System
Hazmat	–	Hazardous Materials
IAFF	–	International Association of Fire Fighters
IAFC	–	International Association of Fire Chiefs
IC	–	Incident Command
ICS	–	Incident Command System
IETRI	–	International Emergency Technical Rescue Institute
IR	–	Infrared
IST	–	Incident Support Team

K9 – Canine
kHz – Kilohertz
LA – Los Angeles
LAN – Local Area Network
LCT – Lethal Concentration Threshold
MSDS – Material Safety Data Sheet
MUSAR – Michigan Urban Search and Rescue
NAAK – Nerve Agent Antidote Kit
NFPA – National Fire Protection Association
NIJ – National Institute of Justice
NIUSR – National Institute for Urban Search and Rescue
PASS – Personal Alert Safety System
PDA – Personal Digital Assistant
PPE – Personal Protective Equipment
RF – Radio Frequency
RFID – Radio Frequency Identification
ROV – Remotely Operated Vehicle
SCBA – Self-Contained Breathing Apparatus
SRS – Savannah River Site
SRNL – Savannah River National Laboratory
TAMU – Texas A&M University
TEEX – Texas Engineering Extension Service
TIS – Technical Information Specialist
US – United States
USG – United States Government
US&R – Urban Search and Rescue
VOX – Voice Activation
WAN – Wide Area Network
WMD – Weapons of Mass Destruction
WTC – World Trade Center

Chapter I. Introduction

This report identifies and describes an inventory of technology needs within the Urban Search and Rescue (US&R) community. These needs are functional requirements that are currently going either unmet or are not being fully met by existing technologies. The activities undertaken by the Savannah River National Laboratory (SRNL) to generate this report have been sponsored and overseen by the National Institute of Justice (NIJ).

NIJ is the research, development, and evaluation agency of the United States (US) Department of Justice. Historically, NIJ has been dedicated to researching crime control and justice issues. This mission has expanded in recent years to include issues of domestic terrorism, since terrorist acts committed on US soil are considered criminal acts. NIJ's role is not only to identify research and technology needs but also to guide the development of affordable and effective tools and technologies to enhance the administration of justice and public safety.

SRNL is the technical laboratory of the US Department of Energy's Savannah River Site (SRS). SRS has been producing special nuclear materials for US nuclear weapons for over 50 years. Technology developed and used at SRS is now being applied to other areas outside of the site, including alternative fuel (hydrogen) sources, law enforcement, and public safety.

SRNL has been providing technology support to NIJ since 1999, primarily assisting local law enforcement agencies with custom remote video systems. SRNL has a large cache of camera, video, and robotic equipment that can be quickly configured to perform surveillance and inspection activities in a wide variety of situations. This partnership led NIJ to request SRNL technical support during the search and rescue efforts at the World Trade Center (WTC) in September 2001, primarily in the area of custom video systems. On the scene, SRNL personnel were able to gather technical requirements from search and rescue workers and quickly design and fabricate video systems. These systems included a pole camera for reaching into the debris field, a drop camera for looking into voids, a doggy-cam to work in conjunction with canines, and overview video systems to assist with victim location and excavation at Ground Zero. As a result of the WTC efforts, NIJ generated an official request for SRNL to lead a more formal technology needs assessment. Work on this new task began in November 2002.

One of the first steps taken by SRNL personnel was to perform a significant amount of preliminary research in the field of US&R. SRNL personnel began this task with a great deal of insight into the field gained by providing technical support during the search and rescue efforts at the WTC, attending a training session for US&R, and supporting law enforcement agencies. However, additional knowledge and information were required prior to establishing the strategy for this effort. Toward that end, contacts were made with leaders of several Federal Emergency Management Agency task forces in an effort to discuss the task. These contacts led to numerous informational discussions and face-to-face meetings and provided access to other key personnel representing domestic and international US&R organizations. These individuals provided US&R-related documents and advice based on experience and acted as a sounding board during the initiation of this effort.

To guide and validate the process used to generate this inventory of needs, and to validate the final results, NIJ requested that SRNL establish an Expert Steering Panel (ESP). The panel that SRNL organized consisted of highly knowledgeable and respected individuals representing six organizations having the greatest influence on US&R. The ESP membership is detailed in Appendix A, while Chapter III describes the task methodology and the role of the ESP.

Much of the early groundwork discussed above was completed prior to the first meeting of the ESP held in February 2003. Information gathered during this investigative process was shared with the ESP in an effort to seek confirmation or to discuss potential alternatives.

To gather the information required for this report, several different information collection methodologies were considered. These included literature searches, personnel interviews, questionnaires/surveys, practitioner workshops, etc. Following consultation with the ESP and other select individuals, it was decided to conduct a workshop with a significant number of US&R practitioners. Practitioners were the targeted individuals since they would be most familiar with potential technology shortfalls. These were the people whose success or failure rested on the tools/technologies at their disposal. Although each of the collection methodologies listed above would have yielded useful information, SRNL, NIJ, and the ESP felt that a workshop, where participants could benefit from the synergy of being together in one room, would be the most efficient and effective way of developing a comprehensive inventory.

Chapter II. US&R Background Information

The Federal Response Plan (FRP) is an agreement between 26 federal agencies and the American Red Cross that outlines the mobilization of federal resources to supplement efforts of state and local governments that are overwhelmed in the event of a disaster or emergency situation. The FRP is organized into twelve Emergency Support Functions (ESF) which reflect the types of federal assistance that will most likely be needed in an emergency situation. ESF #9 covers Urban Search and Rescue (US&R), and the Department of Homeland Security/Federal Emergency Management Agency developed the National US&R Response System to address ESF #9. The National US&R Response System provides for the coordination, development, and maintenance of the federal effort with resources to locate, extricate, and provide medical treatment to victims trapped in collapsed structures and to conduct other life saving operations. The US&R System includes 28 individual US&R task forces and three Incident Support Teams (ISTs), which provide technical assistance for command, control, and logistical support of US&R resources assigned to an incident.

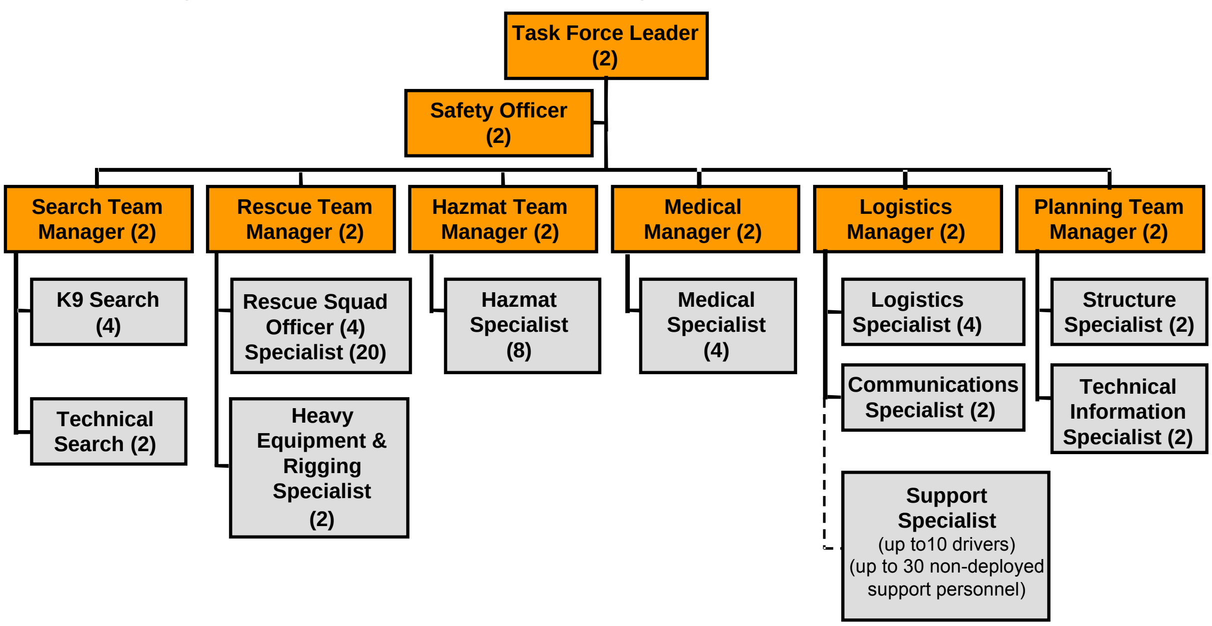
Each US&R task force is a highly-trained, multi-disciplinary organization that can perform physical, electronic, and canine search; extricate victims from collapsed structures; provide emergency medical care to victims and rescuers; assess and control affected utilities; perform hazardous materials monitoring; and evaluate and stabilize damaged structures. US&R task forces are equipped to respond to any type of disaster including man-caused intentional and accidental events (bombings, terrorism) and natural disasters (hurricanes, tornadoes, and earthquakes). The 28 US&R task forces across the country are sponsored and staffed by state and local organizations:

State	Task Force	Local Organization
Arizona	AZ-TF1	Phoenix Fire Department
California	CA-TF1	LA City Fire Department
	CA-TF2	LA County Fire Department
	CA-TF3	Menlo Park Fire Department
	CA-TF4	Oakland Fire Department
	CA-TF5	Orange County Fire Authority
	CA-TF6	Riverside City Fire Department
	CA-TF7	Sacramento Fire Department
	CA-TF8	San Diego Fire-Rescue Department
Colorado	CO-TF1	West Metro Fire Protection District
Florida	FL-TF1	Miami Dade County Fire and Rescue
	FL-TF2	City of Miami Fire and Rescue
Indiana	IN-TF1	Indianapolis Fire Department
Maryland	MD-TF1	Montgomery County Fire & Rescue
Massachusetts	MA-TF1	City of Beverly
Missouri	MO-TF1	Boone County Fire Protection District
Nebraska	NE-TF1	Lincoln Fire and Rescue
Nevada	NV-TF1	Clark County Fire Department
New Mexico	NM-TF1	State of New Mexico

New York	NY-TF1	New York City Emergency Management
Ohio	OH-TF1	Miami Valley Fire and Emergency Medical Services Alliance
Pennsylvania	PA-TF1	Pennsylvania Emergency Management Agency
Tennessee	TN-TF1	Memphis Division of Fire Services
Texas	TX-TF1	Texas A&M University System
Utah	UT-TF1	Salt Lake City Fire Department
Virginia	VA-TF1	Fairfax County Fire and Rescue
	VA-TF2	Virginia Beach Fire Department
Washington	WA-TF1	Pierce County Emergency Management

To ensure a full deployment and allow for rotation of personnel, each task force strives to have over 210 highly trained technical specialists to fill the 70 positions required. The specialists include firefighters, paramedics, law enforcement officers, physicians, structural engineers, hazardous materials technicians, heavy rigging specialists, and canine handlers. Each task force also has an equipment cache worth $2.4 million to support disaster operations. The current cache contains equipment that has been adopted from other industries with a minimal amount of US&R-specific equipment. The cache includes construction-type tools, sophisticated electronic equipment, medical supplies, hazardous materials monitoring equipment, protective gear, communications equipment, computers, video and photographic recording devices, administrative supplies, and materials to feed, shelter, and support the task force. The ability to respond and operate in environments contaminated by weapons of mass destruction (WMD) agents is a recent enhancement to the teams' capabilities. The task force must be able to deploy within six hours of notification and must be self-sustaining for 72 hours.

The following chart outlines the task force organization:



Search Team
The Search Team is responsible for locating victims trapped in rubble, debris, collapsed buildings, or other dangerous situations. The team's capabilities include electronic (visual imaging, acoustic/seismic, and thermal imaging), canine, and physical search. These strategies and techniques may be applied separately or in combination, depending on the situation.

Rescue Team
The Rescue Team is responsible for evaluating incident areas for hazards, stabilizing damaged or collapsed structures, breaching, site reconnaissance, victim extrication, and heavy equipment and rigging. The Rescue Team is experienced in shoring, lifting, breaking, and breaching steel, wood, unreinforced masonry, and reinforced concrete structures.

Hazardous Materials (Hazmat) Team
The Hazmat Team is responsible for conducting site environmental surveys, monitoring for hazardous materials (including WMD), assessing the requirements for hazmat response capabilities, overseeing decontamination efforts, and handling all other issues related to hazardous materials. The Hazmat Team also oversees team member safety when functioning in contaminated environments.

Medical Team
The Medical Team is made up of physicians, nurses, and paramedics who provide physical monitoring and emergency medical treatment to rescuers, victims, and search canines at the incident scene during the entire mission. The Medical Team is also responsible for managing the medical cache and maintaining team member medical records.

Logistics Team
The Logistics Team includes three specialist functions: Logistics, Communications, and Support.

The Logistics Specialist acts as a liaison with other agencies and officials and is responsible for the equipment cache. Responsibilities related to the cache include maintaining the cache; packaging, transporting, distributing, and maintaining the cache during a mission; coordinating transport logistics; procurement of needed items not in the cache; security and accountability; maintaining records and reports, selecting the Base of Operations (BoO) site, and managing operation of the BoO.

The Communications Specialist is responsible for all aspects of task force communications: communications and coordination with the IST, intra-crew communications, acquiring necessary communications frequencies from the IST, assessing the local communication infrastructure, establishing a communication link with the local jurisdiction in the absence of an IST, briefing team personnel on the communications plan, monitoring electrical and battery supply status and reordering as needed, and monitoring team communications for compliance with established procedures.

The Support Specialist is responsible for assisting the Logistics Team Manager in establishing a staging area and/or BoO and providing for its security, on-site preparation of the equipment cache, and all vehicles. Support Specialists include drivers, forklift operators, and similar personnel.

Planning Team

The Planning Team includes three specialist functions: Planning Team Manager, Structures, and Technical Information. This team is responsible for developing the task force tactical plan, assessing the condition and integrity of structures, providing engineering/structural advice, gathering site-specific incident information, managing technical information, and performing documentation, including maintaining an operations log.

Command/Supervisory Positions

The Command/Supervisory positions are responsible for the leadership, management, and coordination of the task force during operations. Their responsibilities also include working with local officials to integrate resources and develop incident action plans, coordinating the task force's efforts in conjunction with local officials, ensuring that established protocols and practices are used, and reporting activities.

General Task Force Operations

Task Force Operations begin with a general update and briefing from the Field Incident Commander. Part of the team establishes the BoO, which is the on-site operational facility where the Task Force Leader, Team Managers, Communications Specialist, Logistics Specialist, and Technical Information Specialist coordinate task force activities. At the same time, a search and reconnaissance team is deployed to perform initial search and rescue operations, monitoring, and intelligence gathering. A search and reconnaissance team is made up of a Search Team Manager, two Canine Specialists, a Technical Search Specialist, a Medical Specialist, a Structures Specialist, a Hazmat Specialist, and two Rescue Specialists.

The search and reconnaissance team begins by collecting and processing information that facilitates marking of areas that require stabilization and areas where victims are detected. Personnel move into the incident area beginning in the safe areas and advancing further as stabilization is accomplished. The team performs hazards assessments, gathers information about the scene, and performs physical search for victims. If any live victims are found, all efforts are focused there to rescue the victim. Medical treatment is provided for live victims as soon as possible, even prior to extrication. Following the initial physical search, more detailed search begins with canines and electronic search equipment. These efforts continue until there is no evidence that live victims remain to be found.

Chapter III. Task Methodology

Expert Steering Panel

To guide this effort, a steering panel of senior-level Urban Search and Rescue (US&R) experts was organized, and members of this panel include representatives from the following organizations:

Organization	Representative
Department of Homeland Security/Federal Emergency Management Agency (DHS/FEMA)	Dave Webb
International Association of Fire Fighters (IAFF)	Rich Duffy
International Association of Fire Chiefs (IAFC)	Chase Sargent
National Fire Protection Administration (NFPA)	Gary Tokle David Hammond Frank Florence (alternate)
National Institute for Urban Search and Rescue (NIUSR)	Lois Clark McCoy John Blitch (alternate)
Texas Engineering Extension Service (TEEX)	Tim Gallagher

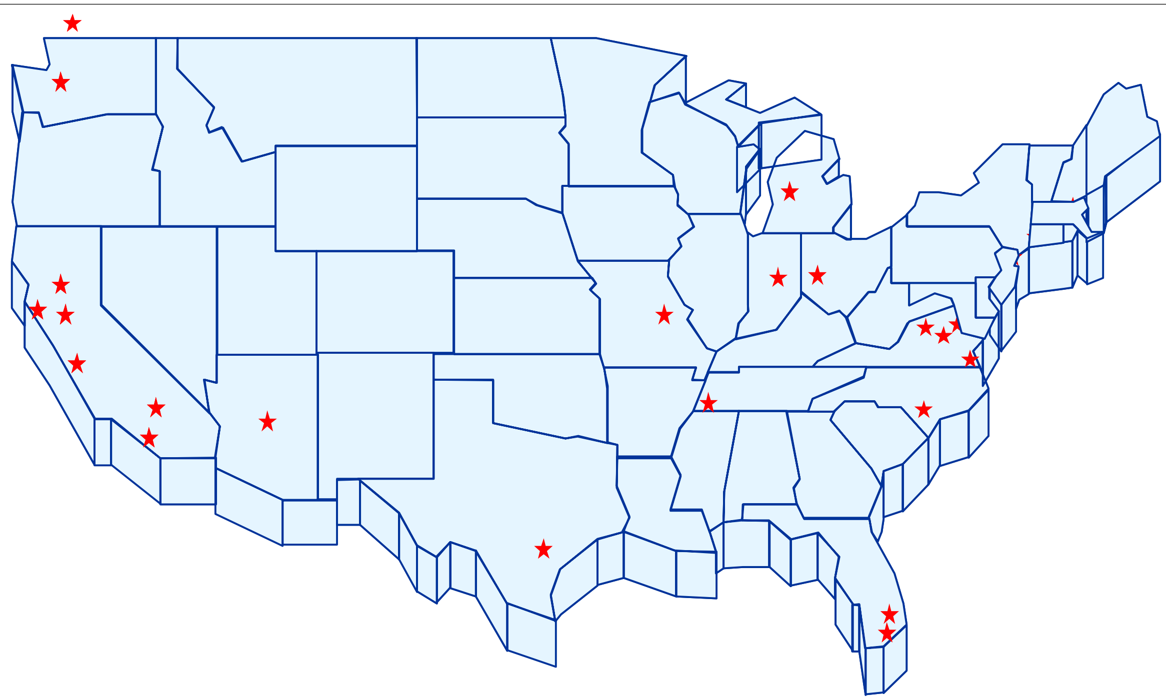
The Expert Steering Panel (ESP) served several important roles in the performance of this task:

- The ESP provided guidance for the task methodology. It was decided that the best way to gather the information necessary would be through a face-to-face workshop involving US&R practitioners from both FEMA and non-FEMA task forces. It was also decided that the structure of the workshop would be to lead the participants through a series of disaster scenarios aimed at bringing out technology needs and functional requirements.
- The ESP identified key people to participate in the workshop as scenario developers, facilitators, and practitioners. Due to the standing in the community of the individuals on this panel, they were able to provide access to personnel throughout the country who would be best suited to participate in the practitioner workshop. Several panel members were also instrumental in the practitioner workshop itself through the development of the scenarios and facilitation of the workshop.
- The ESP provided validation of the scenarios for the workshop by reviewing and modifying them to ensure that the scenario discussions would lead to the desired information being obtained during the workshop.

- The ESP provided validation of the findings of this report. Having spent a tremendous amount of time in various roles within the US&R field, these individuals were able to analyze the results and provide general concurrence in the accuracy and completeness.

Practitioner Workshop

The key component of the data collection process was the practitioner workshop. This workshop was held June 24th-25th, 2003 in Las Vegas, Nevada. Several different dates and venues were considered prior to making this final selection. Opportunities to "piggyback" on other US&R events being held during the same timeframe were investigated, but the decision was made to hold the workshop as a stand-alone event. This ensured that the attendees could be hand-selected and that the potential for distractions would be minimized. Attendees were selected from numerous FEMA and non-FEMA task forces, and a complete listing of workshop attendees and their affiliations is available in Appendix E. A graphical representation of their task force affiliations is shown below. The workshop facilitators (Appendix D) were chosen from FEMA task forces, with the majority of them from the FEMA Operations Working Group. These individuals have significant experience in US&R and have taught numerous courses and facilitated many training exercises.



Workshop Participant Affiliations

The first step in organizing the workshop was to determine the desired outcome and how best to achieve it. It was determined that the goal of the workshop was to generate a listing and prioritization of functional requirements and technology needs in the US&R community that were either going unmet or could be met more effectively. With guidance from the ESP, a scenario-based approach was decided upon as the most appropriate format, with US&R practitioners being led through disaster scenarios in order to generate the desired information.

The decision was made to organize the workshop participants into four US&R teams comprised of individuals representing the more recognized US&R disciplines:

- Technical Search
- Canine Search
- Rescue
- Hazmat/Weapons of Mass Destruction
- Communications
- Logistics
- Command
- Plans
- Medical
- Engineering/Structures
- Technical Information

Each of the four teams was independently led through the scenarios. They were asked to list US&R functions that needed to be performed that either couldn't currently be performed or whose performance could be enhanced through the use of technology. Each team, with a representative from each of the disciplines listed above, was expected to think, interact, and attack the problem as a US&R task force would.

At the workshop, each team was given approximately 2 hours to discuss each scenario that they were given. Each session included two facilitators, one recorder, and the participant team. The facilitators walked the team through the scenario and led the ensuing discussion. Typically, the first few minutes of each session were used to present the details of the scenario. The next 30 minutes were dedicated to looking at the scenario from a first responder's perspective, and the remaining time was spent discussing it from a US&R perspective.

Following these team sessions, the generated data was organized and broken down by US&R discipline. The participants were then regrouped by discipline (i.e., all search people together, all command people together, etc.) to review the data and provide validation and prioritization. A summary of the findings and useful background information is given in Chapter IV.

Disaster Scenarios

In parallel with the overall workshop organization, three US&R experts developed the six disaster scenarios that would be used in the workshop. One of the experts, David Hammond, took the lead in finalizing and formatting the scenarios to meet the criteria set forth by the ESP, and the scenarios were reviewed and validated by the ESP. The listing of scenario developers can be found in Appendix B, and the scenarios can be found in Appendix C.

The scenarios were designed to be realistic and thought provoking and to include a wide array of hazards and technical challenges. They include man-made (transportation, terrorist, explosion, fire, etc.) as well as natural disasters (weather-related, earthquake, etc.) and involve potential secondary effects from chemical, biological, and nuclear agents. Several of the scenarios were based on actual incidents, while others were created for the sole purposes of this workshop.

The following information was provided for each scenario:

- General Description
- Type of Disaster
- Condition of Collapse
- Facility Occupancy
- Specific Detailed Information
- Weather Report
- Information Shared at Briefing
- Type of Assistance Requested

All of the above information for each scenario was given to the workshop participants in advance and at the beginning of the specific scenario discussion. The intent was to provide all pertinent information up front and not change any of the scenario conditions. The participants were instructed to discuss functional requirements and technology needs and refrain from "solving" the scenario. The scenarios were discussed from two perspectives: (1) as a first responder and (2) as a US&R task force member. To facilitate the discussions, the following questions were posed:

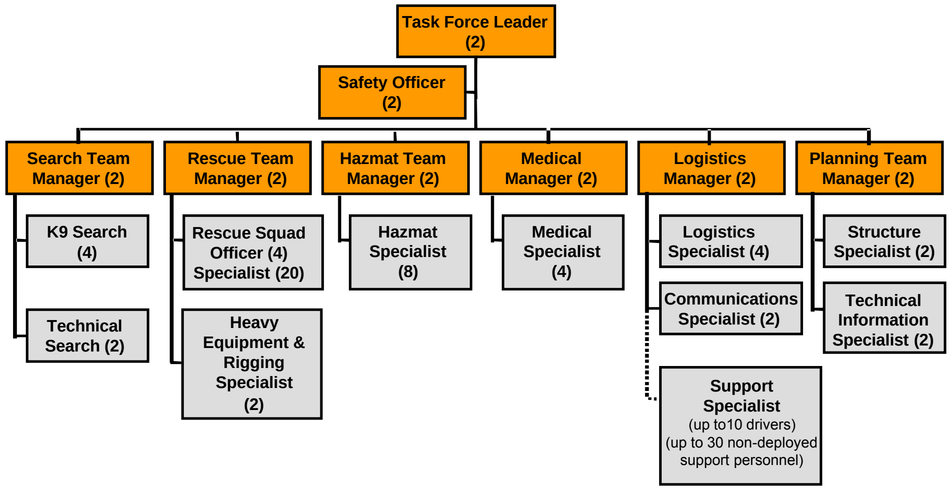
- How would we handle this situation with current methods/equipment?
- How would we like to handle this situation if there were no constraints?
- What don't we currently do well that would really help us in this scenario?

Documentation of Needs

Functional requirements and technology needs discussed during the workshop sessions were captured on flip charts, hand-written notes, and audio tapes by the facilitators and recorders. The data was then recorded in electronic spreadsheets. Following the workshop, the data from all sessions was merged, and the redundancies were removed.

The data was then grouped into the categories listed below, which are representative of the organizational functions of the US&R task force:

- Search
- Rescue
- Hazmat
- Medical
- Logistics
- Planning
- Command/ Supervisory



Document Compilation

Following the workshop, Savannah River National Laboratory (SRNL) personnel, with assistance from workshop participants and facilitators, edited and categorized the raw data, which consisted of lists of thoughts, needs, requirements, and concepts. The purpose of this effort was to attempt to provide initial editing, remove redundancies, provide clarification where needed, and provide an initial structure for the data.

As the compilation effort continued, it became apparent that additional information would be needed to better present the needs generated at the workshop. To enable the reader to put the needs in context, it was felt that knowing the current state-of-the-technology (i.e., how is this function currently performed, if at all) would be beneficial. To accomplish this, SRNL personnel worked with members of the ESP, workshop participants, and other US&R task force members to obtain this baseline information. This information is presented as part of the findings in Chapter IV.

Chapter IV. Findings

Summary

This is a summary of the highest priority needs cited across the Urban Search and Rescue (US&R) functions (not in prioritized order):

- Improved real-time data access (data pertaining to site conditions, personnel accountability, medical information, etc.)
- The ability to accurately and non-invasively locate survivors following structural collapse – the ability to "see" through walls, smoke, debris, and obstacles
- The ability to communicate (transmit signals) through/around obstacles
- Lighter, more efficient power sources (batteries, fuel cells, or other technologies able to power multiple systems for longer periods of time)
- Improved monitoring systems (i.e., atmospheric, biomedical, personnel accountability, etc.) - real-time, portable, multi-function devices that expand on existing detection capabilities
- Improved Personal Protective Equipment (PPE) – lightweight, comfortable, and rugged equipment that provides enhanced worker protection against multiple hazards
- Integration/consolidation of functions found in multiple pieces of equipment into a single piece of equipment
- Improved breaching, shoring, and debris removal systems - portable, lightweight, longer life, stronger materials and equipment
- Reliable non-human, non-canine search and rescue systems - robust systems that combine enhanced canine/human search and rescue capabilities without incorporating existing weaknesses (i.e., robots)
- Standardization of equipment (communication, search, rescue) - equipment that utilizes common platforms, connectors, power supplies, etc.

Discussion of Needs

The following portion of the document discusses in greater detail the US&R technology needs associated with functions. Where practical, a description of current practices and "state-of-the-technology" is given.

Search

Victim Detection Methods (Priority: High)

Current methods of victim detection include physical void search (visual/vocal), audible call-out, electronic viewing, electronic listening, and canine search.

US&R Team with Canines at Ground Zero

Unaided physical void search involves deploying personnel onto the incident site to physically look for victims. Audible call-out involves calling out, requesting victims to make a “knocking” sound, and arranging listeners in a grid pattern to help pinpoint the location.

Electronic viewing devices, including search cameras, infrared devices, and fiberoptics, are used in conjunction with breaching devices for access beyond obstacles into void spaces. Miniature search cameras specifically designed for US&R are small diameter, pole-mounted devices, but they are limited in depth of penetration into void spaces. Infrared (IR) imaging systems are also used to see through smoke and dust and identify hot spots inside of walls and sources of fire in very smoky environments. The disadvantage of IR is that all sources of heat are detected, not just victims, and temperature differences cannot be seen through obstructions. Flexible fiberscopes are another electronic viewing tool that is used to search extremely tight spaces; however, snaking the fiberscope into holes is very difficult. An alternative to the flexible fiberscope is a rigid borescope.

Acoustic Listening Device

Acoustic/seismic devices are used for listening to detect survivors, and their application involves the deployment of an array of pick-up probes around the perimeter of the search area. If sounds are detected, the probes are assessed individually to determine which gives the strongest indication and should be closest to the source of the sound. The array of probes can be redistributed around the original probe giving the strongest indication to more precisely identify the victim's location. Some disadvantages of this method are the presence of interfering signals, limited range, ineffectiveness in concrete, and inability to detect unconscious victims.

Canine search is an effective victim detection method, and canine teams are usually used in combination with electronic search devices. A canine team consists of the canine and its handler. Two canine teams are assigned to search a site in order to provide verification of a find. The dogs use their senses of hearing and smell to detect victims buried under debris and indicate finding the scent of a buried victim by various means. Some disadvantages of using canines are performance variances between canines, effects of environmental conditions (humidity and heat) on abilities, lengthiness of the process, and difficulties in determining the scent source as it rises through rubble.

It is desired to improve the current methods and to develop new methods for detecting victims in addition to those already used.

Desired improvements to existing electronic equipment include the following:

- Visual search devices
  - Extended telescopic capability for reaching further into void spaces
  - Helmet camera to enable transmission of visual images to Command personnel
  - Capability to transmit video signal wirelessly in an environment resistant to Radio Frequency (RF) transmission
  - Improved thermal/infrared imagery
  - Real-time high resolution imagery
  - Ability to see individuals en masse (radar screen) and zoom in on any individual to monitor their situation, possibly via satellite

- Acoustical equipment
  - Capability to pinpoint multiple acoustic sounds at one time
  - Higher power, portable microphone
  - Better sonic monitors
  - Electronic evaluation of sounds using a database/library of common sounds to help distinguish between sounds (i.e., cat vs. human, etc.)

The following desired features apply to existing equipment and any new equipment being developed:

- Lightweight, low volume, and durable
- Wireless transmission capability
- Good visual display that is visible under all conditions
- Easy to operate, learn, and train on

Some new capabilities and their desired features are:

- Penetrating, non-visual detection devices
- Ability to detect items of interest through smoke, walls, steel, debris, and other obstructions
- Ability to identify materials and density - currently, materials are identified based on the Structure Specialist's knowledge and experience
- Identify void spaces – the current method is to drill a pilot hole through the obstacle and insert a camera into the void space
- Ability to detect hazardous materials (hazmat) – as with identifying void spaces, a pilot hole is drilled, and the Hazmat Specialist monitors for hazardous materials through the hole, takes a sample, and checks the sample on the spot

- Visual display of what is detected so that the user does not have to interpret the information - display could be in the form of high-resolution video glasses or a heads-up display; a 3-dimensional (3D) display would be helpful
- Sensor equipment to detect life signs in rubble
- Hand-held artificial "dog nose" (electronic)
- Device that can detect the cell phone signal of a victim

Canine (Priority: High)
Currently, the canines search the site and indicate a find through several means, including barking. Although the canines are well trained and reliable, there is no way to know if a victim is missed. It is desirable to have the following enhancements to canine search:

Shirley Hammond and Sunny from CA-TF3

- Improve canine sampling ability by drawing air through the space toward the dog (not driving the air, where it has a chance to escape prior to reaching the dog)
- Monitoring equipment with mapping capability to indicate a canine's location during its mission
- Capability to communicate better with the dog during its mission and the ability to transmit and receive information
  - Communications with handler: small, voice-activated radio integrated into helmet allowing handler to talk to dog and to peers
  - 2-way audio for communicating with victim: microphone and speaker on dog
- Improved visual and audio capabilities
  - Contact lens-sized device for canine including video and communications that could possibly be implanted on the dog
  - Waterproof video/audio attachment on dog with rip-away harness for safety
- Transport capability and access for dogs to the site: currently, this can be dangerous and very difficult
  - Remotely activated (opened/closed) cages/crates for difficult access areas
  - Access enhancements (improved scaffold, platform)
  - Equipped with high-powered microphone to pick up dog barking
- Means for dog to transport items to victim when extrication is not immediate (radio, water, oxygen tubing, water/food, etc.)
- Means to identify passageways/voids on a computer using canine path of travel
- Capability to obtain good search intelligence (where, how they get out, map)
- Tracking and monitoring of dogs possibly with bark-activated Global Positioning System (GPS)
- Dogs that are stronger and have tougher footpads
- Means to treat injured canines
- Ability to decontaminate canines rapidly and indicate decontamination success

Some of the aforementioned canine issues will be discussed in more appropriate sections. For instance, decontamination is discussed in the Hazmat section.

Remotely Operated Vehicles (ROVs) & Search Robotics (Priority: High)

There is a need to use something other than canines or humans to search for victims. Humans and canines have limitations. They tire, can make mistakes, and most importantly, are not expendable. Devices need to be developed that can perform similar functions, perhaps even more effectively. These devices may include:

- ROVs for going over rubble with a camera or other sensors, such as IR or sonar to perform victim search or structural assessment; including data transmission capability
- Flexible, durable "snake" robot to go through the smallest hole to search for victims
- Unmanned aerial vehicle, such as helicopters and balloons, to view the site
- ROV for use in flooded areas, such as basements (with GPS)

ROV operating at Ground Zero

Search Tracking and Monitoring (Priority: High)

A detailed process of making physical marks with paint is used to identify areas that have been searched. A more sophisticated, electronic method is desired to record, track, and identify areas that have been searched to prevent unnecessary redundant search. Beneficial features include GPS or similar tracking, real-time updating, functionality in a wide range of environments (inside, through steel/concrete/other), and availability of information to all authorized personnel at all times. Also, a better, more highly visible and recognizable marking system would be advantageous. More specifically, markings that last up to 5 days and can be seen in any environment and at a distance would be beneficial.

Search Animals Other Than Dogs (Priority: Low)

Dogs are often too large to access confined spaces where victims may be trapped. Smaller dog breeds are starting to be used for this purpose. However, even smaller animals with similar inherent search capabilities are needed. There has been limited work done with rodents and insects in an effort to meet this need.

Rescue

Improved Breaching Tools (Priority: High)
A need was identified for faster, more aggressive breaching (cutting, coring, and burning) and breaking devices. Breaking and breaching are currently done using standard power tools, such as saws, drills, jackhammers, and similar devices. It is desirable to have tools or methods to perform these functions faster without destabilizing the structure or injuring victims. Some of the desired features include:

Set up for breaching training

- Portable
- Lightweight and durable
- Self-contained, long-life power source
- Able to penetrate many materials
- Able to function in any environment
- Magnitude increases in speed: For example, one rescuer specifically mentioned reducing the time to cut a beam from 4 hours to 20 minutes
- Alternate methods, such as laser cutting with depth control
- Able to perform multiple functions, such as cutting, breaking, and sawing, in one tool *(Priority: Low)*

Tensioned Cable Cutter (Priority: High)
During the workshop, it was mentioned that there is a need for a device or method to isolate, hold in place, and cut tensioned cables. Upon further investigation, it was determined that this can be done now, but it is a slow process and must be done carefully. Cutting is done one strand at a time using a whizzer saw. Tensioned cables can store a great deal of energy and will whip when the tension is relieved by severing the cable. Safety of the rescuer should be the key feature of a new device or method.

High-Angle Rescue System (Priority: High)
Currently, the minimum requirements for the design, performance, testing, and certification of safety rope and related components used during rescue and emergency operations are defined by the National Fire Protection Association (NFPA) 1983 Standard (2001), Fire Service and Life Safety Rope and System Requirements. The components addressed in the standard include: life safety rope, personal escape rope, harnesses, and related equipment, such as carabiners and snap links. Improved high-angle access and removal systems are desired for rescue teams and victims. The improved system should be rapid to operate, readily deployable, portable, and easy to use, and it must meet the NFPA 1983 standard.

Improved Anchor Mounting (Priority: High)
The acrylic adhesive currently used to mount anchors requires approximately one hour to attach and has only a one-year shelf life. Some US&R teams use mechanical anchors as well as adhesive. A method for mounting anchors that takes less time and provides a reliable mount would be beneficial, but it must be covered by NFPA 1983.

Improved Portable Lighting (Priority: High)
Large floodlights with a generator for power are currently used for lighting work areas. It would be beneficial to have the intensity and brightness produced by floodlights in a smaller package with a self-contained power source for use in underground or difficult-to-access areas.

Rescuer Safe Zone (Priority: High)
The ability to more effectively establish safe zones for rescue personnel is needed. Safe zones are those areas within a collapsed structure or debris field that are structurally sound and stable. Technology needs within this area include:

- Movable, portable safe zone containers
- Method to identify safe zones and continually update due to changing situation
- Capability to build safe zone with no interruption to search

Shoring Devices with Warning Systems (Priority: High)
Several shoring methods are currently used. Spot shores are temporary, adjustable aluminum shores that are removed when the work is done. Leave-in place wooden shores are also used, and the properties of the wood serve as a built-in warning system because the wood crushes in a recognizable pattern prior to collapsing. Another type of shore used is a pneumatic shore, which is expanded using air pressure. Pneumatic shores are used as emergency spot shores because they are quick and convenient to install. The pneumatic expansion feature is not used; the shore is simply extended manually and then pinned into position. Advanced methods of shoring are desired with the following features:


Crush pattern of wood shore

- Safe
- Synthetic Materials
  - Injectable, expandable, quick-drying, floatable foam
  - Composite materials, such as plastic, Kevlar, tubular, etc.
  - Strong as timber
- Clean cut
- Portable and lightweight


Typical shoring

- Adjustable/Expandable
- Strong
- Flexible
- Modular components to create different sized shoring
- Quick and easy to make/erect on site
- Low water usage
- Low dust to minimize airborne contaminants
- Smart - able to sense load and position
- Incorporating state-of-the-art warning systems
- Recyclable
- Deployable by ROV

Building Member Repair System (Priority: High)
Repairs to building members, such as columns, are currently done by putting up steel plate forms and filling them with grout. This method is routinely used to repair columns. A better method is desired that would act as a structural bandage, is quick to put in place, and has built-in sensors to indicate the condition of the bandage.

Rapid Sealant (Priority: High)
An improved capability to rapidly seal pipes, tunnels, or large openings is desired. Currently, a fast-setting grout is used. It would be beneficial to have some type of “magic” foam to fill odd-shaped openings.

Liquid and Gas Removal (Priority: High)
Standard pumps are currently used to remove gases, liquids, and slurry during rescue operations. Two examples of equipment used for US&R are submersible pumps and air evacuation systems for removing carbon dioxide. There is a need for improved methods that have the following features: higher capacity, higher speed, higher volume, low weight, compact size, durable, and all-products capable.

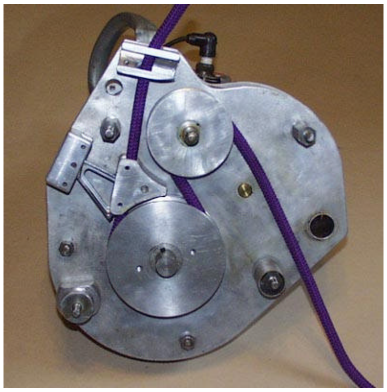
Watercraft (Priority: Low)
The need for a durable, lightweight watercraft to assist in rescue operations was mentioned. This need is similar to an inflatable boat that will carry a large number of people and has the additional features of fuel-efficiency, minimal draft, and the ability to navigate in all conditions.

Electrical Power Interruption System (Priority: Low)
This need is related to rescuer safety. When electrical lines are down or electrical conductors are exposed, the ability to disable electrical power would protect workers from the potential hazards of shock, electrocution, or ignition of flammable materials. An electromagnetic pulse device was mentioned as an example of an electrical power interrupter.

Better Methods for Building Retaining Walls (Priority: Low)
Sandbags are currently used when rescue workers need to build a retaining wall. The bags arrive on pallets and are filled with sand on the scene. This requires time and

energy that could be focused on search and rescue operations. A better, faster method for building a retaining wall is desired.

Super-light Motorized Ascending Device (Priority: Low)
Motorized ascending devices are used for vertical climbing and use motors, cams, and pulleys to pull/raise a rope. They are used in certain applications by rescuers to lift victims. These devices typically weigh more than 25 pounds, and there is a desire to make them lighter.


Motorized Ascending Device

Higher Capacity Lifting Systems (Priority: Low)
Currently, standard capacity chain falls and come-alongs are used. It is desired to have devices like these with capacities much greater than existing 3-ton gear and that incorporate digital load cells.

Lightweight, Strong Cable (Priority: Low)
Currently, wire rope is used, and five levels of wire rope are available in the cache. A smaller, lighter alternative with high tensile strength is desired.

Heavy Equipment/Rigging

Means of Lifting (Priority: High)
A means of lifting heavy items that is stable, quick to set up, and can be placed close to the work site is needed. Currently, cranes are often used at disaster sites, but they are not part of the US&R equipment cache. They are typically obtained from local sources. As a result, a crane, if it is even available, may take a long period of time to locate and obtain. Other lifting equipment currently used includes winches, "come-alongs", and pulleys that are often attached to either tripods or "A-frame" assemblies. These systems can be set up rather quickly but may have some limitations in regard to lifting capacity and stability on uneven surfaces.

Heavy equipment in use at Ground Zero

Multi-function Machine (Priority: High)
There is a need for a remotely controlled, highly flexible, maneuverable, all-terrain, compact, and lightweight piece of equipment to perform a multitude of tasks (including debris removal). An additional feature is a hydraulic arm that can be used to remove debris, lower equipment to a desired location, etc., while the operator stands at a safe

location. Ideally, this machine would have multiple attachments for performing different operations.

Powered Exoskeleton (Priority: Low)
Another technology discussed during the workshop was that of a powered exoskeleton, a garment or apparatus worn by the user that amplifies the power associated with a given movement. An example is the force amplification device used in the movie "Aliens".

Modular Safe Haven for Underground Applications (Priority: Low)
US&R practitioners feel that a modular "safe haven" that could be used in underground entry/rescue would be beneficial. An enclosure, such as a rail car, was described that would be kept at an internal pressure slightly higher than ambient to prevent in-leakage of "bad" air.

Modular Equipment Carrier (Priority: Low)
Currently, many US&R task forces have access to small utility vehicles such as the John Deere "Gator", but they are not part of the equipment cache. Additionally, they have limitations in regard to payloads and the ability to function on any terrain (steep inclines, vertical surfaces, water, etc.). US&R practitioners would like to have an equipment carrier that can serve for both logistical tasks and debris removal, has a long-term power source, and has the ability to travel and transport equipment between structures and between the local Base of Operations (BoO) and the work site.

Hazmat


Hazmat Kit

Improved Hazardous Materials Detectors (Priority: High)
Multifunction detectors are needed that detect Biological, Nuclear, Incendiary, Chemical, Explosive, and Radiological (BNICER) materials. US&R currently uses the following types of hazardous materials detectors:

- Device that detects and identifies hazardous concentrations of chemical warfare agents including blister, nerve, and blood agents
- Handheld device that detects nerve and blister agents, recognizes pepper spray and mace, and identifies hazardous compounds as well as gamma radiation
- Chemical detection set kit, which has two tube sets that are specific to chemical warfare agents: The kit identifies and quantifies a range of chemical substances and includes three simultaneous test set kits for measuring 15 different organic and inorganic chemicals and/or chemical families. Gases measured include: acid gases, basic gases, carbon monoxide, hydrocyanic acid, nitrous gases, carbon dioxide, chlorine, hydrogen sulfide, phosgene, sulfur dioxide, aliphatics, aromatics, petroleum hydrocarbons, ketones, and chlorinated hydrocarbons.
- Portable multi-function monitor with ultraviolet lamp: The system monitors for lower explosive limit, oxygen level, carbon monoxide presence, and hydrogen sulfide. The unit also has a function to sample for volatile organic compounds.
- Portable radiological monitoring kit with 3 probes, capable of monitoring alpha, beta, and gamma radiation

The desire is to have one portable device that can perform the same functions as all of the above equipment, monitor for multiple hazards, and include the features below which the teams do not currently have:

- Wireless transmission of data
- Detect contaminants in liquids
- Monitor for multiple hazards, including toxic industrial chemicals, toxic industrial materials, and chemical, biological, radiological, and nuclear agents
- Highly resistant to false alarms and false positives, in particular, chemical sensors resistant to false alarms from smoke/fire
- Long-term power source
- User-friendly
- Safe, efficient in all environments and not impacted by environmental (heat, cold, humidity) exposure
- Weatherproof
- Immediate indication of hazardous materials
- Accurately identify mixtures of chemicals

- Inexpensive air monitor to detect multiple airborne items
- Passive
- Rugged; durable; survivable
- Cost-effective enough that all emergency responders can afford it *(Priority: Low)*
- Remote monitoring sensors to allow personnel to detect hazardous materials at a distance
- Integrated into gear: Self-Contained Breathing Apparatus (SCBA), heads-up display, PPE

Atmospheric Monitoring (Priority: High)
Atmospheric monitoring is currently performed by Hazmat Specialists, and limited monitoring is performed by Rescue Specialists. There is a need to detect, monitor, and predict chemical hazard plumes, possibly via improved thermal imaging cameras or chemical imaging cameras or a combination of both. It would also be beneficial to have aircraft monitoring or a remotely controlled/robotic atmospheric monitoring system.

Personal Monitoring Equipment (Priority: High)
The desire is to have a personal monitoring device, preferably wearable, that monitors continuously for exposure to radiation, chemicals, biological agents, and other harmful substances. US&R teams currently use radiation pagers, electronic radiation dosimeters, and pencil-type radiation dosimeters that display the radiation dose received by the wearer. Also, consideration is being given to adding dosimetry badges to the cache. No capabilities for monitoring personal exposure to other hazards are available in the equipment cache.

Typical personal monitoring devices

Personal Alert Safety System (PASS) Improvements (Priority: High)
Only US&R team members wearing a SCBA carry a PASS device. These devices were originally developed for the fire service to alarm if a firefighter became incapacitated, and their requirements are detailed in the NFPA Standard for PASS devices, NFPA1982. The current standard requires only a motion detector, but many additional features are desired in a PASS device. These features include the addition of a BNICER detector, sensitivity less than or equal to Lethal Concentration Threshold (LCT) 50 (lethal concentration at which 50% of exposed would die), and networking to a central accounting system.

Capability to Indicate the Location and Extent of Radiation Hazards (Priority: High)
There is a need to have a means of indicating increasing levels of radiation, such as a spray that changes color as it encounters increasing levels of radiation.

Improved PPE (Priority: High)
The PPE currently in the equipment cache includes:

- Disposable boot covers
- Chemical resistant boots
- SCBA with 60-minute cylinders
- Level B 1-piece coveralls with hood and bootie sock sealed-seam construction
- Plain coveralls
- Limited use Level A encapsulating suit, disposable with built-in flash protection, NFPA compliant
- Escape bottle systems (10 minute)
- Assortment of gloves:
  - Disposable gloves
  - Disposable gloves, silver shields (outer glove)
  - Disposable gloves, latex (inner glove)
  - Gloves, neoprene or nitrile middle glove layer

These items provide a degree of protection from hazards but fall short of the desired features for PPE. Boots, gloves, and rain gear that are lightweight, form-fitting, and breathable would improve the mobility of the workers. The need is to have PPE that protects against a full range of hazards (chemicals, biological agents, etc.) for personnel. Rescue workers suggested a smart suit that protects the worker from the full range of hazards, is liquid-resistant, monitors vital signs, monitors and alarms for hazards and exposure, is comfortable and lightweight, and cools or heats the body. The suit would ideally incorporate a tracking device and communications gear and be durable, abrasion-resistant, and reusable. Respiratory protection with a better air-purifying respirator for US&R was suggested. PPE compatible with search and rescue activities sums up this need.

Canine PPE (Priority: High)
The only PPE available for canines is booties for paw protection. These are rarely used because they reduce the flexibility and feeling of the dog's paws. For example, booties are not used in rubble because they cause the dogs to lose traction. Also, booties reduce the feeling to the point that dogs have stepped on hot spots that they normally would have avoided, and the booties have caught on fire. The dog handlers each carry a water bottle to hydrate the dog and rinse its nose. Dogs are decontaminated after each mission using soap (usually dishwashing liquid) and water.

There is a need to develop PPE for canines that will not impair their senses (especially smell and hearing) or their abilities to work. Search and rescue canines are medium in size weighing an average of 50 pounds and can carry up to ten pounds with no problems. One suggestion mentioned by a dog handler is temporary protective material that is easy to put in place and remove and prevents absorption of harmful materials. Another suggestion is a means to efficiently cool/hydrate the dogs while working in extremely hot conditions (thin gel packs, patches dispensing electrolytes, vests, spray, etc.). A third suggestion is a protective coating for dogs' paws to eliminate "booties". The coating must allow paws to breathe, must last a limited time or wash off during decontamination, and could be sprayable or dippable. A fourth suggestion is a high-tech canine life vest to meet some PPE needs and include GPS tracking capability, but this is a low priority.

Decontamination Solution (Priority: High)
US&R currently uses a contamination reduction kit containing surgical wipes, utility brushes, distilled water, water/bleach solution, mildly basic detergent, liquid soap, vinegar, teaspoon, containment device, disposable towels, and 3-gallon hand sprayer. It is desirable to have better methods for decontamination that improve the effectiveness. There is a need for waterless decontamination solutions that quickly evaporate, are non-toxic and non-irritating to victims, act rapidly, and are approved by the Food and Drug Administration and the Environmental Protection Agency. Currently, there is debate about how long it takes for bleach solutions to work. The time cited is approximately 15-20 minutes. That is too long to be practical as it creates a logistical bottleneck. Decontamination methods are desired that are suitable to all hazardous materials, bind contaminants, and work immediately and rapidly (process 300 vs. 30 people). The need for a floating decontamination station was also mentioned.

More effective way to determine decontamination results (Priority: High)
The effectiveness of decontamination is currently checked using the handheld monitors. The desire is to have electronic real-time data from all monitors, a meter to identify when to shift to PPE levels, and a system that identifies that patients and rescuers are contaminant-free after decontamination.

Control Agents and Containment Devices/Methods for Contamination or Other Materials (Priority: High)
The US&R teams do not currently carry any traditional hazmat control gear. It is desired to have methods for controlling and containing contamination, neutralizing/inhibiting hydrocarbons, rapidly and easily applying a human-friendly neutralizing agent (possibly a vapor mist or spray), and binding, fixing, or collecting radioactive material. Also, there is a need for containment devices, such as bags, for victims and other items. It is unknown how effective current body bags are for containing chemical or radiological contamination. A “flocculating” substance deployable by aircraft was suggested for large-scale containment and control. A sprayable concrete or similar material was suggested to control radioactive contamination or loose debris at the incident scene. There is a low-priority desire to have a method or device to reduce the concentration of radiation in an area. For example, if a plane loaded with Cesium crashes and rescuers have to work in those areas, a means (spray, liquid, barrier foam, etc.) to either "wash away" or reduce the concentration of radioactive material in a given location to allow rescuers to safely work in that area is desired.

Unit to Collect Environmental Samples (Priority: Low)
US&R teams desire the capability to collect environmental samples of air, soil, etc. to determine the hazards to which rescuers and victims are exposed.

Medical

Sealed Body Bags (Priority: High)

Body bags presently used for human remains are constructed of thick vinyl sheeting with a zipper for sealing purposes. The need exists to more effectively isolate human remains from the outside environment and vice versa. The remains may be contaminated (radioactive, chemical, biological, etc.), and there is a need to ensure that personnel are not unnecessarily exposed to these contaminants. Additionally, for evidentiary purposes, it is important that the remains not be disturbed or contaminated with any foreign agents present in the environment.

Method to Provide Environmental Control Around Trapped Victim (Priority: High)

Presently, several methods are used to keep victims warm/cool. First, blankets or tarpaulins can be used to cover accessible portions of the victim. Next, warm/cool clean air can be blown into the area occupied by the victim. The victim can also be warmed through the use of warm oxygen (inhalation) or through the use of warm intravenous solutions. It would be beneficial to be able to surround the victim with an enclosure that would allow a more precise control of conditions, such as humidity, temperature, etc, and ensure an oxygen concentration of 21%.

Extended "Snake-Eye" with Victim Monitoring (Priority: High)

When a victim is not fully accessible (i.e., limited access to head, arm(s), or leg(s) only) information regarding the medical condition of the individual is commonly gathered through visual means. This may be accomplished through direct visual access or through use of a search camera inserted into a small opening in a debris field. Having a device that could navigate through small openings and around obstacles would greatly aid this process. Although small articulated video systems do exist, their capabilities (reach, ruggedness, flexibility, etc.) are limited. Additionally, this device would be further enhanced by having an end-effector (similar to a hand) with sensors and a degree of dexterity to allow "hands-on" monitoring of the victim for temperature, pulse, respirations, etc.

Remote device applying medical sensors

Provide Medical Link from Field to Medical Center (Priority: High)

Currently, when responding to a disaster, emergency medical personnel must first locate and contact medical facilities within the vicinity of the disaster site to arrange for treatment of victims should the need arise. This is done prior to arriving at the disaster site. It is common for US&R team medical personnel to try to locate these facilities on the Internet prior to departing and then to attempt to contact them via phone while en route. Once at the scene, if consultation with these medical facilities is required, land lines or satellite phones are most often used. When a patient must be transported from the disaster site to a medical facility, a paper copy of pertinent medical information (known medical history, medical condition, etc.) is typically sent along with the victim.

It is desired to be able to perform these various functions electronically. This would entail locating and contacting medical facilities via electronic means without having to "search" for them, transferring and exchanging information in real-time [i.e., utilizing a wireless handheld device, like a personal digital assistant (PDA)], and being able to consult with medical specialists via interactive video. The ability to do this would save valuable time and would help to minimize human errors during transcription of information, etc.

Real-time, Remote Victim Tracking, Monitoring, Evaluation, and Treatment Equipment (Priority: High)
Portable monitoring and treatment equipment exists (i.e., blood analyzers, pulse/oxygen analyzers, etc.), but their use requires medical personnel to be in direct contact with the patient. Monitoring and treating a patient often requires direct access to the bloodstream, which is difficult to maintain because blood tends to clot unless there is a flow in (intravenous drip) or a flow out. Another potential difficulty arises in that some additions to the bloodstream (i.e., medication, etc.) must be made "venously" (from the vein verses the artery) while some analyses require access to arterial blood. Thus, more than one access port may be required. As well, there are functions for which portable equipment does not currently exist or is impractical, such as ultrasound for detecting internal bleeding, x-ray, etc. One of the major constraints with portable equipment is that space where it must be deployed (i.e., in the hole) is often very limited. So, although equipment systems may be small, they may not be small enough. In addition, it is desired to have a "smart" tag for each victim that contains individual identification and important medical information, including blood type, medical history, allergies, etc.

Method of Detecting Carbon Dioxide to Locate Live Victims (Priority: High)
There currently exists a means for inserting a tube/probe into a confined space to detect the presence of carbon dioxide. This allows the US&R team to possibly detect live, unconscious victims. There is a desire to enhance this capability and to actually use exhaled carbon dioxide to assess a patient's respiratory status and general wellbeing. The shortfalls of existing technology include equipment fragility as well as the fact that the probe must be placed directly into the airflow. This is usually accomplished by integrating it with a mask that is placed over the patient's nose/mouth or through intubation, which is placing a tube directly into the trachea.

Victim Clothing (Priority: High)
There is a need for victim clothing that is environmentally regulated, one-size-fits-all, and is easily stored.

Medical Prioritization Software (using Artificial Intelligence) (Priority: Low)
Prioritization/triage is currently performed in a manual fashion. There is a need to automate this process with "smart" software. This software would essentially apply the same "rules" currently used by medical personnel in determining priority based on the severity of injuries and probability of survival.

Task Force Medical Monitoring (Priority: Low)
Currently, medical personnel utilize portable monitoring devices and monitor rescuers in a manual fashion, but there is a need for the devices to be more compact, more portable, and less expensive. A small-scale medical scanning device would be very beneficial in the monitoring of rescuers as well as victims. Most, if not all of the required components (hardware) already exist; however, they have not been integrated into a working system.

Portable Monitoring Capability in PASS Units (Priority: Low)
PASS units currently utilize light and/or audio alarms to alert personnel of an unconscious (non-moving) rescuer. This need focuses on the integration of multiple functions within a single piece of equipment. The ability to monitor vital signs, etc. with a PASS unit would be very beneficial. Although not currently available, PASS units could potentially utilize radio signals to transmit information.

Body Mechanics/Ergonomics Assist Devices (Priority: Low)
There is a need to have back and knee support devices incorporated into uniforms and safety gear.

Self-Cleaning Dressing (Priority: Low)
There is a need for dressings that clean as they are applied. An example which clarifies this need is when a needle is pushed through the dressing, it is sanitized/sterilized to reduce infection.

Extraction Devices that Break Apart or Hinge at Strategic Locations (Priority: Low)
When moving personnel via stretcher/extraction device, maneuverability is complicated by the unstructured environment of a disaster site. It is often difficult to navigate around bends or obstacles. Modular stretchers have been designed for this purpose, and the technology already exists but is not suitable for all rescue situations. One of the primary functions of a stretcher is spinal cord immobilization. A jointed stretcher that flexes or pivots does not provide this strict immobilization. An alternative is a partial stretcher, which immobilizes half of the body, allowing for easier maneuvering in confined spaces.

Logistics

Long-term Power Source (Priority: High)
Currently, most portable response equipment is battery powered and limited in duration of use by battery life and limitations of battery technology. There is a need for an improved power source, and the features of an ideal power source include:

- Extended life, possibly for years
- Cross-spectrum compatibility and interchangeability
- Standardization for all equipment to replace a multitude of different power sources now in use: instead of numerous batteries of different sizes, shapes, and charging requirements, only one would be necessary to power radios, laptop computers, electrocardiogram machines, etc.
- Wireless, self-contained
- Integrated into a power vest to supply all devices
- Implementing alternative power source, such as fuel cells, atmospheric energy, etc.

Power Vest

Global Monitoring and Tracking of Resources (Priority: High)
The equipment cache contains most items that a team needs to function for 72 hours. Resource tracking of items in the cache is done on paper using color-coded cards, called “T-cards” because of their shape. When an item is removed from inventory, a T-card is filled out and placed into a bin in a rack. When the item is returned, this is noted on the T-card. This method fails when people fail to implement the system and don’t fill out the cards. T-cards are also used for tracking people and assignments. A more reliable and efficient method for tracking resources would be a real-time, electronic method. The desired features include:

- Self-updating electronic inventory system that tracks and records contents of cache boxes as individual items are removed or returned
- Implementation of technology such as bar code readers or radio frequency identification (RFID): use of RFID would eliminate human error or failure to use the system
- Ability to check status of all resources using desktop, laptop, or hand-held computers that have access to the inventory system
- Integration of different existing resources to allow analysis and trending

On-site Water Treatment Facilities (Priority: Low)
There is a need for on-site water treatment facilities to allow showers, to recycle water, etc. This need could possibly be met with the existing technology of reverse osmosis. Portable systems are available that could be transported and used at any disaster incident location.

Communications

Improved Communications Equipment (Priority: High)

Currently, the main communication device is the radio. However, wireless communications are impeded by obstructions, such as concrete, steel, water, and rubble, without the use of additional equipment to compensate. Repeaters are one type of equipment used to enhance radio communications. They are used for above-ground radio communications, but repeaters for radio communications from above-ground to below-ground are not a standard item in the Federal Emergency Management Agency (FEMA) US&R cache.

Rechargeable two-way radios

This need is the ability to establish and maintain reliable communications with other rescue personnel and track their movements regardless of obstructions between personnel and in environments that are resistant to RF transmission. The ability to communicate one-to-one and one-to-many would be beneficial, and some other desirable features include portability, hands-free operation, and possibly being disposable. A suggestion to connect to the building structure to use as an antenna was mentioned.

Universal Radios (Priority: High)

There is a need to have universal radios that work for all users, are hand-held, change frequency based on situation, have multiple channels, and serve multiple functions (PDA, radio, camera, data device, etc.). All teams are in the process of switching to the Association of Public Safety Communications Officials (APCO) 25 standard. APCO 25 is designed for public safety personnel to improve performance, efficiency, capabilities, and quality in two-way radio communications. Many aspects of this technology need appear to have been addressed by the APCO 25 standard.

Intra-crew (including canine), Inter-crew, and Interagency Communications Capability Linked to Systems Communication (Priority: High)

Currently, the teams use radios, and each team is on a different channel. There are 210 available channels. For two teams to communicate, one of them must switch to the other's channel. Some of the desired features for an improved communications device include the following:

- Small and portable
- Radios of each team recognized by chip
- Transparent to user (hands-free)
- Voice, data, and video integrated (Data transmission is not currently possible; Video transmission is not currently possible, although Kenwood has a technology that clips to a radio and transmits single-frame video.)
- Operational 24/7

- Remotely reconfigurable: it would be beneficial to digitally change all radios simultaneously from a remote location based on who's at the site and the situation; currently, radios must be changed one at a time.
- Ability to function in environments resistant to wireless transmission
- Linked to the PASS; i.e., link the communications to the PASS device so that if rescuer stops moving or is hurt, the device sends a signal via RF to the command center.
- Secure and not public
- Disposable *(Priority: Low)*
- Integrated into gear or into PPE*(Priority: Low)*
- Voice activation (VOX) ability to change channel (VOX is available but is triggered by all sounds other than voice and ties up the channel with useless information) *(Priority: Low)*

Method to Communicate into Rubble and Void Spaces and Transmit/Receive to Victims (Priority: High)
Currently, two-way communication is available on search cameras, but the device must be placed near the victim. It is desirable to be able to communicate with a victim without having physical access.

Portable Satellite Communication Equipment with Voice, Video, and Data Transmission (Priority: High)
US&R currently uses two satellite communication systems: one allows for worldwide communications and the other allows for communication only in specific areas. US&R is moving to a system which operates in North America and is relatively inexpensive. The new system has a push-to-talk feature, allows any number of agencies to be on and communicating all at once, and can also be used for low-speed data transmission. Satellite radios are currently used for voice only because the existing technology is too slow for video and data.

Site Cell Phone Quick Restoration Capability (Priority: High)
In a disaster, the cell phone systems usually fail. It would be beneficial to the responders if a portable cell system infrastructure was available and could be set up at any incident site. An option for meeting this need is access by public safety and rescue personnel to "Cell on Wheels" (COW), a self-contained, fully functional, portable telecommunications site. COW is a mobile cellular tower that provides high-quality cell phone service when the permanent system has failed or is inoperable.

Secure Global Internet/intranet (Priority: High)
A secure global Internet/intranet is not currently available to US&R, and they have no satellite Internet. They have a wired Local Area Network (LAN) that connects a small number of computers and a printer.

A high-speed network would be useful for transmitting Incident Action Plans and basic information to the teams. It is desirable to have a secure on-site network that can be linked into a LAN or Wide Area Network (WAN) allowing encrypted, real-time information transfer to appropriate personnel (for example, Command and Plans) and communications between PCs area-wide (with speed greater than 19.5). It is further desirable to have secure high-speed Internet access that can be wired or wireless.

Real-time 3D Satellite Imaging and Aerial Overview (Priority: High)
This need includes the following aspects:
- Showing conditions pre-incident, during operations, and post-incident
- Real-time updating
- Incorporating GIS (Geographical Information System) mapping
- Portable, durable system
- Showing location of utilities and cutoff systems
- Line-of-sight and long distance transmission
- Usable in environments resistant to wireless transmission
- Part of cache
- User-friendly
- Linked to working teams in real-time
- Use of satellite imagery to perform infrared analysis: determine fire locations using heat signature of a collapsed mass, detect hazardous materials, or locate a body at 98.6 degrees
- Quick to deploy
- Incorporating AVL (Automatic Vehicle Locator) information *(Priority: Low)*
- Showing safe areas *(Priority: Low)*
- Showing resources as they arrive *(Priority: Low)*

Data and Information Handling (Priority: High)
There is a need to improve methods for data and information handling, and the method should include the following features:
- Storage of data in a time log
- Creation of a 3D model over time
- Gathering information/intelligence from field personnel (GIS, real-time video & monitoring data, building footprints, utility access, layers)
- Interoperability between various technology analysis and monitoring assets to communicate and consolidate information
- Standardized method to gather information *(Priority: Low)*
- Data transmission device *(Priority: Low)*
- Method to integrate intelligence in real-time*(Priority: Low)*
- Link redundant capabilities that do not currently talk to each other (satellite, IR, etc.) *(Priority: Low)*

Data Burst Capable Radio to Hook to GPS (Priority: Low)
Currently, GPS only works in open spaces and does not work in buildings, structures, or in rubble.

Capability to Detect and Identify Radio Frequencies and Users (Priority: Low)
It would be beneficial to interface with local agencies and companies. This capability would allow US&R teams to detect the radio frequency of others and talk with them.

Balloon-mounted Repeaters (Priority: Low)
Repeaters are used now with radio communications, but a need to get the repeaters above obstacles and obstructions exists. Balloon-mounted repeaters were suggested but may not be feasible because the repeater would not be stationary and would be moved by the wind. Tethered balloon-mounted repeaters are an option.

Automatic Notification System that Relays to All Workers (Priority: Low)
Currently, emergency communications have a dedicated channel on the radios, and all receiving radios scan that channel continuously to pick up those messages. An automatic system to simultaneously notify all US&R personnel of emergency situations, changing conditions, or other vital information is desired.

Video & Communications Link to the Main Players (Priority: Low)
There is a need for a technology to enable key personnel to stay abreast of the situation and pass along guidance. An important feature is the ability to transmit video images and data over longer range, through wreckage, and to multiple locations. In most disaster situations, the cell phone systems are knocked out. To maintain a video link, possibly via picture phones, would require that the US&R teams bring a portable system to the site.

Hub Detector for WAN (Priority: Low)
US&R teams currently don't have WAN available. The features of a WAN that are important include:

- Ability to work with multiple devices
- Transmission to data site
- Database, library of items or data
- Real-time data transmission (interoperability)

Increased Speed, Flow, and Accuracy of Information (Priority: Low)
It was mentioned that this might not be a technology need but rather a people issue. However, a secure PDA-accessible chat room on the Internet could be a potential solution for disseminating information quickly and accurately.

Planning

Structures

Ground/Structure Movement Sensors (Priority: High)

Electronic Theodolite

There is a need for improved remote warning systems that sense ground/structure movement. Currently, to sense ground/structure movement, US&R personnel utilize transits, theodolites, high precision laser levels, crack gauges, and plumb bobs. Upon arriving at a disaster site, baseline measurements are taken, and horizontal/vertical surfaces are monitored for movement, thus indicating a change in the ground or structure. Three issues are important in evaluating a building: the condition of parts of the building, the condition of the whole building, and the potential for things to fall off of a damaged building. For safety, it is desirable to have a stand-off method for evaluating the structure, such as a device that could be pointed at the building and provide a digital readout of building stresses.

Aftershock Prediction System (Priority: High)

There is not currently a method to sense impending aftershocks. However, warning systems do exist that are activated upon sensing the primary shock wave of an earthquake. A predictive system to warn of impending aftershocks is desired.

Sensing Devices for Loads, Structures, and Shoring (Priority: High)

This is a developing area. Many of the components (i.e., accelerometers, strain gauges, etc.) required to make buildings "smart" already exist. They are currently being integrated into readily deployable systems. Sensing devices are already being integrated into some shoring materials. For a price, shoring materials with embedded load cells are available for use. Although it was suggested by the workshop participants, the use of acoustic emission (AE) to remotely monitor for structural failures is not necessarily a desired option because AE has not proven itself to be a reliable indicator of pending failure.

Structural and Engineering Information Databases Access (Priority: High)

The current practice of the Structures Specialist is to attempt to access paper drawings for structural information, which requires a great deal of legwork. As well, the specialist marks up a standard hazard assessment form to document structural problems with buildings at the incident site. However, structural drawings are not always readily available: they may not exist, may be proprietary in nature, or may just be very inaccessible. One of the major obstacles faced by the Structures Specialist is knowing whom to contact to even locate structural drawings of a given facility. It would save a great deal of time and energy if the Structures Specialist had access to information databases. Technology currently exists to allow real-time access to information databases; however, databases containing the desired information (structural drawings, etc.) do not currently exist. As mentioned above, structural information pertaining to many facilities is not readily available for any number of reasons.

Onsite Computer-aided Engineering Capability (Priority: High)

There is a need to be able to scan blue prints, create 3D models, and perform quantitative hazard analysis rapidly on the scene. The technology exists, through PDA's, digital tablets, and similar devices, to put electronic information in the rescuers' hands, and steps are being taken to adapt software analysis programs for use with these handheld electronic devices. The US&R community is preparing to use a pocket PC with software installed that will allow downloading, creating, editing, and viewing of drawings. In addition to this on-site computer-aided engineering capability, it would be beneficial to have a structural hazard analysis system. The next step following adoption of the method is to transition it to a PDA with appropriate software. A third aspect of computer-aided engineering is computer analysis and modeling of damaged/collapsed buildings, including 3D modeling. Computer analysis and modeling are currently not available to US&R and are low priorities.

Pocket PC

Ability to "See" into Collapsed Areas (x-ray vision) (Priority: High)

There are several technologies currently available that allow the user to "see" aspects of a 3D structure beyond what is seen on the outer surface. These include technologies such as radiography, ultrasound, magnetic resonance imaging, and thermal imaging. Each has its unique capabilities and limitations (resolution, distinction between different materials, ability to "penetrate" dense materials, close coupling requirements, etc.). There is no single, existing technology that will provide the user with what is thought of as "x-ray vision".

Portable Metal, Steel, and Concrete X-ray System (Priority: High)

Portable x-ray systems currently exist; however, x-ray technology has limitations in the US&R environment. Radiography requires nearly unlimited access to both sides of the item being examined. In a collapsed structure, this is not always possible. Additionally, x-ray technology relies on density differences between materials to provide distinct boundaries on a radiograph. Again, this is not always possible in a US&R situation. Lastly, x-rays have a finite amount of energy. They are often not able to penetrate through large thicknesses of high-density materials. Thicker, denser materials require more energy, which means the x-ray head must be larger and less portable. More importantly, there are health concerns associated with the exposure of humans to unshielded x-rays.

Geo-reference the Structure (Priority: Low)

There is a desire to use GPS technology for providing reference coordinates at a disaster scene. A desire was also expressed to be able to use GPS to guide the rescue worker to a victim previously located, rather than having to rely on painted search markings. Such uses of GPS are currently being developed. One such method is a search and mapping capability coming to fruition in the next year. Implementation is a matter of procuring the system and training personnel.

Black Box at Each Structure with Pertinent Information that is Accessible via Laptop or Wireless Technology (Priority: Low)
Many of the component technologies currently exist to make this need a reality, but there are many integration and logistics issues that must first be addressed. The need, simply stated, is to be able to access pre-disaster and post-disaster pertinent building information (structural drawings/info, occupancy, condition/stability of building sectors, building stresses, etc.) by walking up to the building with a laptop computer. Key issues are gathering the necessary information to feed into the various databases and developing the various sensor systems required for real time monitoring.

Technical Information

Intelligent Response Vehicles (Priority: High)
Current technology for communications relies on radios and the cell phone systems. In a disaster, responders must bring their own portable cell system if they want to use cell phones. Also, vehicles do not currently have laptops, PDA's, or other equipment to access information nor do they have a reliable high speed Internet connection while en route.

Across-the-board requirements for a standard technology load on all response vehicles would allow responders to access information prior to arriving at the scene so that they could be better prepared and respond more safely. The standard vehicle package should include a communication device and screen (laptop computer) with wireless communication ability. The desired features include access to information/data from multiple sources regarding contents (and Material Safety Data Sheets) of transport vehicles and storage containers related to the incident. Another desired feature is an AVL and GPS mapping, but these are low priorities.

Geographical Information System (GIS) (Priority: Low)
There is a need for a real-time, "smart" GIS that can identify what is in a building, not just that a building is there.

Capture All Information Electronically (Priority: Low)
There is a need to capture all data and information electronically including plans, notes, pictures, operations information, etc, and be able to search through the data in real time. This also should be indexable and accessible for anyone who needs specific information.

Environmentally Protected Computer Server (Priority: Low)
The server needs to be on-site or connected remotely by virtual private network connection. Also needed is a common platform so that the task forces can share data over a wireless network while on site.

Command/Supervisory

Unified Electronic Incident Command System (ICS) (Priority: High)
Currently, ICS is the accepted method for the command, control, management, and coordination of resources at the scene of an incident, such as a fire, disaster, or similar emergency situation. The ICS is a paper-driven system, and the necessary forms are available on the Internet.

An electronics system for sharing of information and data is an important need that would save a great deal of time and resources and provide the ability to look real-time at the situation status. A second part of this need is the ability to receive and categorize information and data at a central or mobile location. An electronic system accessible through the Internet would possibly be a good solution for this need. Access of the system needs to be available to all local disaster officials and senior command staff (law enforcement, fire, FEMA, etc.) An additional beneficial feature of the system would be a chat room on the Internet with video conferencing capabilities for command officials.

Traffic Direction Control (Priority: High)
Traffic control near the scene of an incident is important to allowing emergency responders access while routing other traffic away from the scene. Traffic control never reaches the federal level (exceptions being incidents involving federal property as seen at the Pentagon or an incident of "Doomsday" consequence when the military is deployed as a matter of national security). Traffic control remains the purview of local and state authorities (including National Guard) and is formulated in relation to defined need.

Inter-agency Information Access (Priority: High)
Access to information under the purview of other agencies has two components. The first component, authority to access the information, is a political issue requiring cooperation between agencies, both public and private. The Department of Homeland Security/Federal Emergency Management Agency (DHS/FEMA) US&R negotiates a memorandum of understanding with officials of the Authority Having Jurisdiction (AHJ) regarding the capacity and capability of its resources. The Federal Response Plan (FRP) establishes the relationship the US Government (USG) will maintain with the AHJ. The FRP clearly delineates USG responsibility to the state and locality and defines how assistance is rendered. The second component is the form of the information. Standardization of information formats would enhance accessibility of the relevant data, after authority has been granted. The FRP allows for the early establishment of a Multi-Agency Coordination Center, a Joint Information Center, and a Joint Operations Center. These facilities fall under the Federal Bureau of Investigation (FBI) initially as a part of Crisis – Consequence Management. Each is used (under unified command) to provide a forum for local, state, and federal emergency planners to co-locate for incident management. Pre-9/11, very few state and local officials had learned of these tools for incident management, but each is now more aware of their inherent usefulness. Many localities have now written these concepts into local and state Disaster Operations

Plans. This entire process is cumbersome and time consuming. There is a need to streamline it.

Accountability of Personnel (Priority: High)

Personnel accountability at an incident is a two-part issue:

- Ability to control ingress and egress of all people from entire incident site
  Security is an issue when entering the incident site; decontamination is an issue when leaving the site. Currently, authorized personnel are badged prior to gaining access to the incident site, so the Incident Support Team (IST) knows who is authorized to be there. However, badging is sometimes not accomplished until 36-48 hours into an incident. Ingress/egress again defaults to effective crowd control. There is also no tracking mechanism to inform IST of who is at the site at any given time.
- Response Personnel Accountability
  The T-card paper system is also used for accountability of response personnel: one T-card log is at IST, and one is at forward command. The success of the paper system depends on personnel using the system correctly. While this system is time-tested and still effective, it is a paper-based system. Designed as a part of wildfire accountability systems, it is meant for "campaign" style events where an asset is assigned to an area for the duration of an operational period. Urban disaster/emergency incidents are more fluid, and often an asset (human or otherwise) is deployed and then redeployed to countless locations during an operational period. Failure to use the system as intended during US&R events reinforces the need for real-time, electronic tracking systems.

An electronic system for accountability would allow more reliable control of personnel entering and leaving and would allow incident managers to know instantly who is at the site and who has left. This need could be summarized as a real-time automatic personnel locator similar to an AVL.

"Go/No-Go" Decision Tools (Priority: Low)

A paper system is currently used for decision-making. It is desirable to develop a "go/no go" form to prioritize data (assessment form), with electronic access preferred. The decisions covered by the form would include:

- What assets to send when?
- Send another US&R team?
- Send another IST?
- Command "Push Package"
  - Ready for deployment to reach destination within certain time of federal activation
  - Pre-positioned in environmentally controlled and secured facilities
  - Pre-configured for rapid identification and ease of distribution

Unified ICS Decision Matrix (Priority: Low)
Decisions are made based on local objectives, command strategies, and operational tactics, and each of these includes a decision-making process that causes a ripple effect through the others.

In most instances, local objectives remain broad and include saving lives, protecting property, sheltering, restoring public utilities, maintaining law and order, maintaining health and safety, clearing public access infrastructure, and so on. Unified command establishes the strategies to accomplish the objectives, and then assigned resources develop tactics to make it all happen.

The key to success is unified command, which in turn ensures complete information sharing. Officials of the AHJ set the tone for this since they possess the most knowledge of the impacted area.

Regardless of the phase of decision-making, it remains critical that each entity realizes the importance of information sharing. Under unified command, many disparate agencies are often thrust into situations and interactions for which each is not prepared. An example is that public works agencies often do not interact with health agencies. This leads to not knowing each other's needs, resulting in critical information being on hand but not shared.

The importance of critical infrastructure contained in GIS is often overlooked in the early stages of an incident, but this information plays a major role in decision-making. Many major metropolitan areas have files on infrastructure (including bridges, roadways, public utilities, etc.) as well as major structures. This information is vital during collapsed structure incidents since it provides incident commanders much detail on the impacted area. Early introduction of GIS into an incident planning process leads to better decisions at all levels.

Mobile Command Post (Priority: Low)
Major metropolitan areas and US&R have dedicated items for incident command posts. Alternatively, a recreational vehicle or tent is used as the forward or mobile command post. The mobile command post may come in boxes and require setup, including connections for power, lights, and other necessary services. This setup and preparation take time and people. A quick-deploy, mobile command post that is self-contained and quickly set up would save personnel time and energy.

Alerting/Notification System (Priority: Low)
The need was mentioned for a FEMA-wide standard of notification (nation-wide) with everyone on the same system to ensure that all information gets passed down. In the past, a telephone call-down tree was used to contact personnel during activations.

There are many electronic notification systems now coming into the commercial market. Most allow for transfer of information to an electronic device such as a cell phone, computer, or pager. It is desired to have the following features:

- Allows for the establishment of selected user groups for transmission to redundant computer locations by established system administrators. The benefit is that by creating their own user group, task force members will know that when they receive a message headed by “Alert from Emergency Area Network” that it’s from the task force and requires an immediate response or reaction.
- Ability to set up individual accounts for each person so that he/she can select a primary and secondary means of notification, such as via telephone, cell phones, PDAs, or computers.

Observations

During the course of the workshop, the following views were expressed by the practitioners:

- There is a universally recognized need within the US&R community for new/improved technologies to perform search and rescue functions more safely and effectively.
- Similar efforts to identify technology shortfalls have taken place in the past with minimal resulting technology development. Many of the workshop practitioners were supportive of this effort, yet remain skeptical about the long-term benefit.
- In general, new technology gets into the hands of practitioners in one of two ways. In the first instance, a government agency or vendor develops what it sees to be a needed technology. Such technologies are said to be "pushed" down to practitioners. Alternatively, a technology can be developed in response to a stated practitioner need. In that instance, the development of the technology is said to respond to a practitioner "pull". The methodology employed in this study is based on the premise that technologies developed in response to a stated practitioner need are more effective than technologies developed in response to what others think practitioners need.
- Technologies and equipment must be thoroughly tested and robust prior to field use. Otherwise, they become an impediment.
- Most, if not all, of the needs/functional requirements identified at the workshop were applicable across the various US&R organizations represented.

Relevance to Law Enforcement Needs

One of the National Institute of Justice’s (NIJ) objectives in funding this study was to identify common areas of technology need for potential investment. A quick comparison of the highest priority needs from this study with those of the *Inventory of State and Local Law Enforcement Technology Needs to Combat Terrorism* (Table 1) reveals a broad convergence between law enforcement and US&R technology needs.

The only three needs cited in this study that cannot be directly related to those in the *Inventory of State and Local Law Enforcement Technology Needs to Combat Terrorism*

Urban Search & Rescue Technology Needs: 10 Highest Priority Needs	**Inventory of State and Local Law Enforcement Technology Needs to Combat Terrorism**
Improved real-time data access	Priority #5: Improved interagency communications
The ability to "see" through walls, smoke, debris and obstacles	Priority #9: Improved "see-through-the-wall" capability
The ability to communicate through/around obstacles	Priority #3: Improved and more readily available secure communications
Lighter, more efficient power sources	Not explicitly stated
Improved monitoring systems, real-time, portable, multi-function devices that expand on existing detection capabilities	Priority #4: Improved means of detecting and categorizing nuclear, biological and chemical threats
Improved Personal Protective Equipment (PPE)	Priority # 7: Improved affordable protective gear
Multifunctional equipment	Not explicitly stated
Improved breaching, shoring, and debris removal	Not in Top 15: Improved wall breaching tools
Reliable non-human, non-canine search and rescue capabilities (i.e., robotics)	Priority #6: Improved robots for disarming and disabling explosive devices
Standardized equipment	Not explicitly stated

Table 1. Comparison of Highest Priority Needs with Inventory of State and Local Law Enforcement Technology Needs to Combat Terrorism

are: lighter more efficient power sources, multifunctional equipment and standardized equipment. While not explicitly called out in the inventory, these needs can be assumed to be held in common.

This broad commonality of needs should lend itself to considerable synergy in technology development with relatively minor modifications to the same basic technology to address the community-unique requirements. For example, both communities require improved PPE. Ideally, that PPE could be worn as an everyday uniform. Much of the investment in an improved firefighter turn-out coat that affords a higher degree of protection from hazardous materials might be applied to meet the law enforcement need, although law enforcement PPE would probably not need to be as flame and heat resistant. Interagency communications and incident management systems would seem to be one area where technical requirements would be very similar, as NIJ's continued funding for the APCO Project 25 standard demonstrates.

Chapter V. Conclusions

Validity of Findings

The validity of the findings of this effort is confirmed by the following three points. First, the findings coincide with previous studies regarding technology needs. Secondly, the findings came from practitioners who have experience in this field and are knowledgeable as to what technologies are needed. Finally, the major point of validation is the review and concurrence by the Expert Steering Panel (ESP).

Further Work Required

It is intended for this document to be shared with state and federal Urban Search and Rescue (US&R) agencies. The National Institute of Justice (NIJ) plans to use this document to identify technologies of interest to both the US&R and law enforcement communities. NIJ will look to develop identified technologies applicable to both communities with out-year funding. The following are recommendations for the path forward:

- It is recommended that this document be provided to the DHS/Science and Technology portfolio manager for US&R for implementation.
- It is recommended that there be a concerted, sustained multi-year US&R-focused technology development effort.
- It is recommended that there be a long-term plan with multi-year funding to reach the goals identified in this report.
- It is recommended that there be established a robustly-funded ongoing process to test and validate US&R technologies through laboratory testing and operational evaluation with practitioners.
- It is recommended that there be a continuing review of technology by practitioners.
- This study did not specifically address the needs of the Incident Support Teams (IST), and it is recommended that there be an examination of IST requirements.

Acknowledgements

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Photographs:

US&R canines at Ground Zero:	Photographed at Ground Zero
Delsar™ Life Detector:	Provided by www.delsar.com
Shirley Hammond and Sunny:	Provided by David Hammond, CA-TF3

Remotely operated vehicle:	Provided by South Florida University, www.usf.edu
Breaching training:	Taken at VA Beach Fire Training Center
Motorized ascending device:	Provided by storrick.cnchost.com
Crush pattern of wood shore:	Provided by David Hammond, CA-TF3
Typical Shoring:	Provided by David Hammond, CA-TF3
Heavy equipment in operation:	Taken at Ground Zero
Hazmat detector kit:	Provided by Draeger Safety Inc., www.afcintl.com
Dosimetry:	Provided by Thermo Electron Corporation, www.esm-online.de
ROV applying medical sensor:	Provided by South Florida University, www.usf.edu
Power Vest:	Provided by NRG Research, www.nrgresearch.com
Two-way Radios:	Provided by Motorola, www.commerce.motorola.com
Electronic Theodolite:	Provided by Nikon, www.nikon.co.jp
PDA:	Provided by HP, www.hp.com

Appendix A - Expert Steering Panel

Organization	Representative
Department of Homeland Security/Federal Emergency Management Agency (DHS/FEMA)	Dave Webb
International Association of Fire Fighters (IAFF)	Rich Duffy
International Association of Fire Chiefs (IAFC)	Chase Sargent
National Fire Protection Administration (NFPA)	Gary Tokle David Hammond Frank Florence (alternate)
National Institute for Urban Search and Rescue (NIUSR)	Lois Clark McCoy John Blitch (alternate)
Texas Engineering Extension Service (TEEX)	Tim Gallagher

Appendix B - Scenario Developers

David Hammond: CA-TF3, FEMA Operations Working Group
Jim Hone: CA-TF3, Santa Monica Fire Department
Don Kuhn: TN-TF1, Memphis Fire Department

Appendix C - Disaster Scenarios

<u>SCENARIO 1</u>: Multi-building Complex Incident

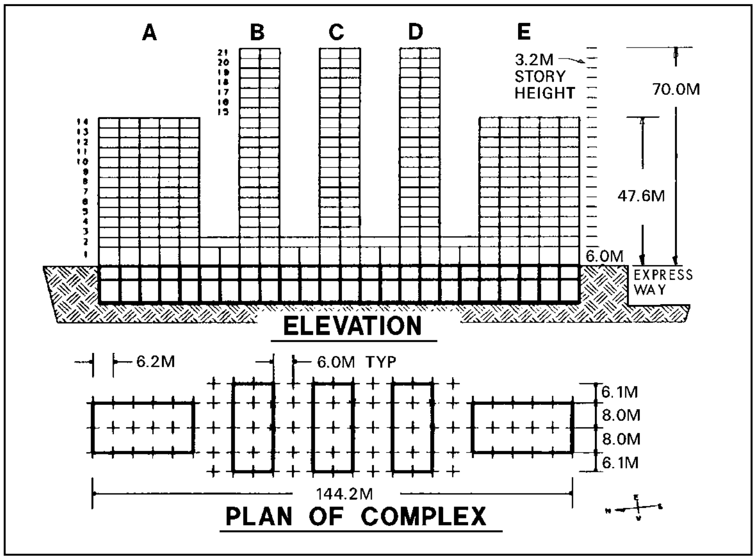
General Description
Three 21-story steel frame buildings, plus two 14-story steel frame buildings built on a large plaza. Buildings were constructed in the late 1960's. The Plaza limits heavy vehicle access. The steel framing limits radio communication.

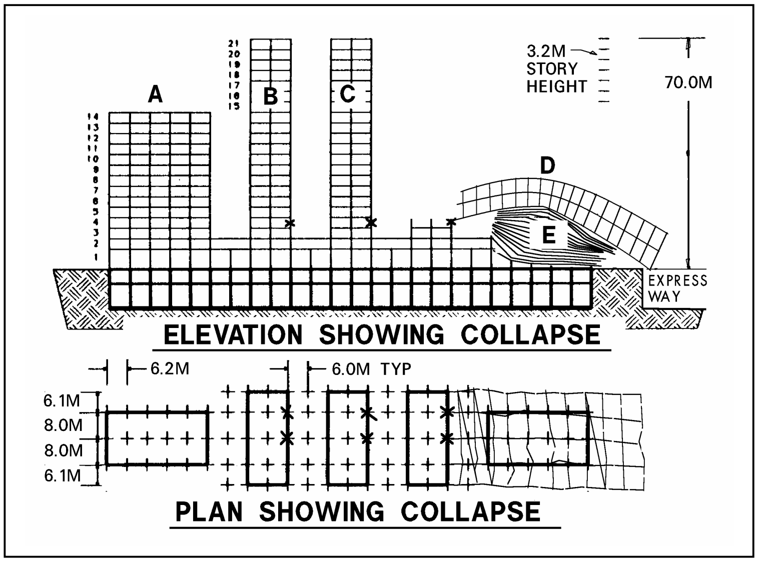
Type of Disaster
An 8.1 magnitude earthquake occurs at 1000hrs on a Wednesday, to be followed by an unknown number of aftershocks, but there is a potential for at least one magnitude 7.0 or larger aftershock within the first 96 hours.

Condition of Collapse
One of the 21-story buildings has collapsed on top of one of the 14-story buildings due to a buckled steel column. The remaining two 21-story buildings exhibit severe damage to the same steel column as the one that collapsed. A fire has started in the 14-story building.

Occupancy
All buildings were fully occupied at the time of the Quake, and the approximate numbers of occupants are:
21-Story Buildings = 500 each
14-Story Buildings = 400 each

Specific Information
- Earthquake damage is widespread, and a second alarm assignment is engaged at this site.
- Fire hydrants are not operable due to broken water mains. Water for firefighting at this site is being pumped from a reflecting pool in the area.
- All telephone communication, including cell phone communication, has been lost.
- Electrical power service has been interrupted.
- Local response has been overwhelmed, and a National Disaster has been declared.





- All available Urban Search and Rescue (US&R) Task Forces are expected to be deployed to this disaster to support the local and state response.
- Two US&R Task Forces are deployed to this site and arrive 6 hours after original quake to aid the local fire units that are in process of extinguishing the fire and conducting initial search and rescue operations.

Weather Report
- It is currently cloudy with highs in the low 70's and an overnight low of 45°F.
- Winds are currently light from the northwest.
- Weather is expected to worsen over the next few days with winds in excess of 45 mph expected by noon tomorrow, followed by rain. The rain may be heavy at first but will taper off over a two-day period.

The Local Incident Command (IC) gives the following information in an initial briefing:
- Occupants have been seen exiting the three remaining structures, but it is not known if any remain trapped inside.
- There are at least 400 people that remain unaccounted for that may be trapped in the two collapsed buildings, but many have escaped from the 21-Story building that collapsed.
- The fire is nearly under control, but many hot spots remain in the 14-story building. The local fire forces are fully engaged with the fire.
- A large aftershock occurs during the briefing, which causes the two remaining 21-story buildings to visibly sway.

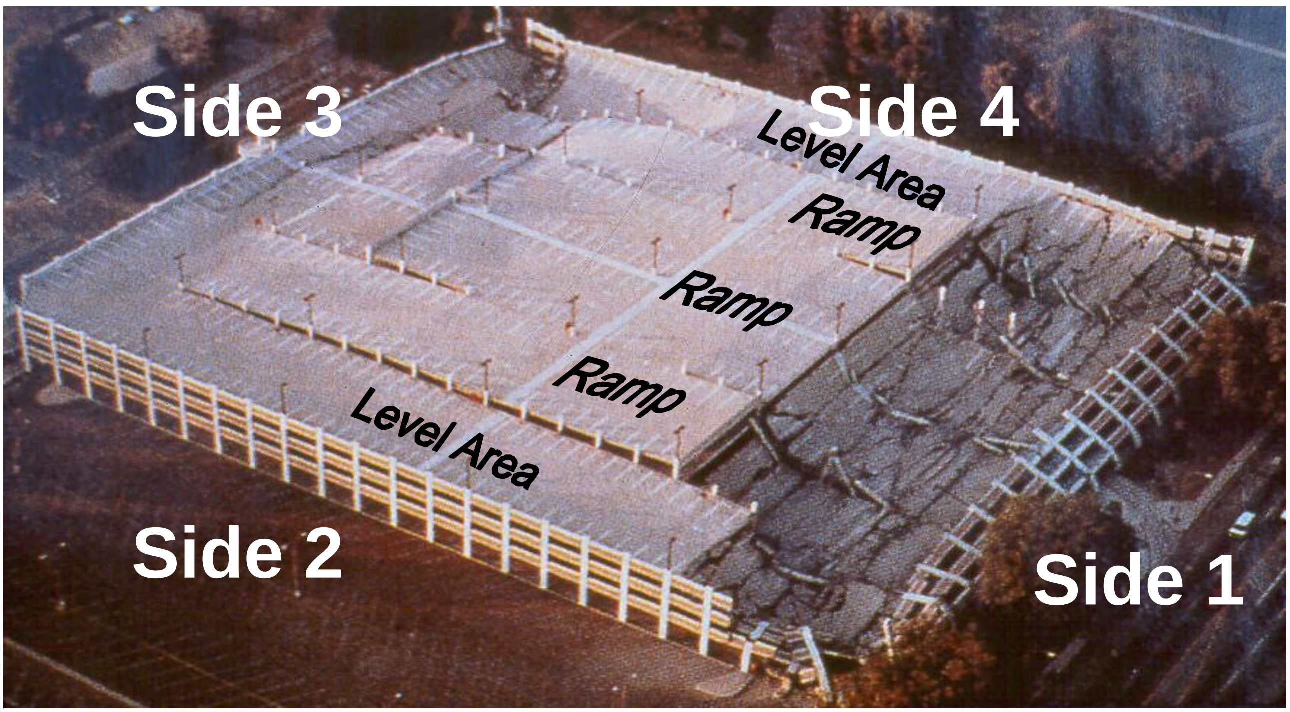
The Local IC requests the following assistance:
- Provide detailed hazard assessments for all structures and develop safety and monitoring plans.
- Conduct systematic search of all structures and develop prioritized rescue plans.
- Assess needs for heavy equipment and other materials, plus develop access and utilization plans.
- Set up viable communication system into the building and back to central command, approximately three miles through the urban environment.

SCENARIO 2: **4-Level Parking Structure Incident**

General Description
4-Level concrete parking garage at a large shopping mall
374' x 360' concrete structure consisting of a pre-cast concrete exterior frame, pre-cast concrete columns and beams, with post-tensioned concrete slabs.
The garage has a capacity of 500 cars per level.

Type of Disaster
An 8.4 magnitude earthquake occurred at 1300hrs on a Saturday and was followed by several aftershocks, but there is a potential for at least one magnitude 7.5 or larger aftershock within the first 96 hours.

Condition of Collapse
Interior columns near the front and rear of the structure have collapsed. Some of the exterior frame has been pulled in, and the adjacent slabs have draped down on top of parked cars. The slabs continue to shift and settle as aftershocks occur. Gasoline and battery acid have been spilled in the areas of the collapse. No fires have started.



Occupancy
Parking structure was reported to have been nearly full. Structure has 2000 car capacity.

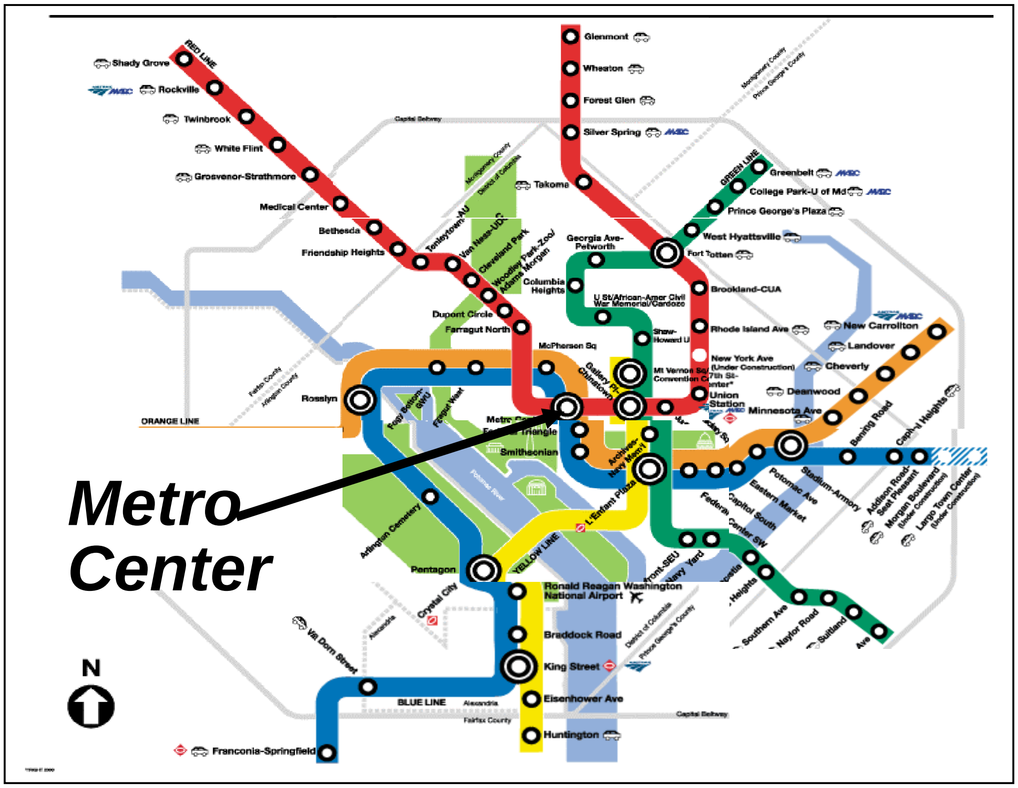
Specific Information
- Earthquake damage is widespread, and no response units have been dispatched to this structure.
- Other structures in the shopping center have also been severely damaged with many being trapped. The major focus is on those structures at this time.
- All telephone communication, including cell phone communication, has been lost.
- Electrical power service has been interrupted.
- Local response has been overwhelmed, and a National Disaster has been declared.
- One Urban Search and Rescue (US&R) Task Force is assigned to this site and arrives 8 hours after original quake. There are no other US&R assets available, and coordination with the Incident Support Team is not expected to occur for several days. Re-supply is expected to be available within 72 hours, but not before.

Weather Report
- It is currently sunny with highs in the low 90's and an overnight low of 55°F.
- Winds are currently light from the northwest.
- Weather is expected to get hotter with highs near 100°F and lows in the 60's. Winds may increase to greater than 35 mph as the temperature increases.

The Local Incident Command (IC) requests the following:
- Commence Search and Rescue operations, and report back to Local Command, which is located approximately five miles away.
- As the Task Force arrives, a large aftershock occurs, and an additional area of the floor slab collapses.
- The Task Force has been informed that it cannot expect much support from other US&R units.

SCENARIO 3: **Explosion in Underground Rail Transportation System**

General Description
Washington D.C. Metro underground rail transportation system. Normal daily commuter use of the system exceeds 100,000. The underground transportation system is located 30 feet below grade and limits radio communication.



Street Panorama View

Type of Disaster
An explosion occurs inside the Metro Central main transfer terminal at 1700 hrs on a weekday during rush hour.

Condition of Collapse
The primary blast affects both the train and the transportation tunnel. The blast causes the tunnel roof and upper street level to collapse inward forming a crater approximately 50-feet in diameter. A large

section of the train and a 2,000 gallon above ground diesel storage tank for an emergency generator are on fire inside the main tunnel. The fires are producing a large volume of thick black smoke that is traveling through undamaged connecting tunnels and up through the open crater to the street area above. Three passenger cars and one panel truck have crashed into the tunnel through the crater in the middle of the street.

Occupancy
Train = 250
Main Transfer Terminal = 1,000
Three passenger cars and one panel truck = 7

Specific Information
- Rush hour vehicle traffic severely delays local and mutual aid emergency response into the area.
- All telephone communication, including cell phone communication, has been lost in a 10 square block area.
- Electrical power, natural gas, and water services have been interrupted in a 5 square block area.
- During the past week, local news reporters have been detailing law enforcement investigations into threats of a potential "dirty bomb" attack in the city.
- Victims are exiting through the main transfer terminal egress system.
- Smoke is causing people to evacuate connecting underground sub-stations and local businesses at street level near the crater.
- Local emergency resources have requested two Federal Emergency Management Agency/State Urban Search and Rescue Task Forces to assist.

Weather Report
- Partly cloudy with a temperature of 60°F and an overnight low expected to be 48°F.
- Winds are currently light at 3 mph from the northwest.

Task Forces receive the following information from the local Incident Command (IC) at the initial briefing 12 hours later:
- Local resources have rescued and transported more than 300 victims to local and surrounding hospitals.
- More than 200 victims are known dead. Some have been removed to a temporary morgue, but most remain in the tunnel area.
- The number of live victims trapped inside the impact area is unknown.
- The fire has been extinguished; however, some hot spots exist throughout the impact area.
- Some buildings near the impact area have been searched, but marking and mapping efforts are inconsistent.
- Some of the buildings adjacent to the impact area appear to be leaning towards the crater. Most of these buildings are older 3- to 4-story unreinforced masonry type buildings.

The local IC requests the following assistance:
- Provide detailed Hazard Assessments for the tunnel and all structures within one block of the impact area.
- Assess the impact area for "dirty bomb" residue and other weapons of mass destruction products.
- Develop safety and monitoring plans in coordination with local resources.
- Conduct a systematic search of the tunnel and all structures within one block of the impact area.
- Develop a prioritized rescue plan with local resources.
- Assess needs for heavy equipment, demolition, and other construction related materials.
- Set up a viable communication system with the Incident Command Post and inside the tunnel.

<u>SCENARIO 4</u>: Airfreight airliner transporting radioactive material crashes into an airport terminal.

General Description

Chicago, O'Hare International Airport Terminal 1 with more than 150,000 people moving through the airport each day during holiday season. The airport terminal is a 2- and 3-story steel frame structure. The floors are concrete fill on metal decking. The exterior walls are a combination of glass panel walls in metal frames, insulated metal panels, and 6" thick pre-cast concrete panels. The terminal is equipped with modern fire sprinkler and fire alarm systems. A passenger tunnel, 20' below grade, moves large volumes of people from Gates B to C in Terminal 1. An Air National Guard Fighter Squadron with F-15 aircraft is located at the eastern end of the airport.

Type of Disaster

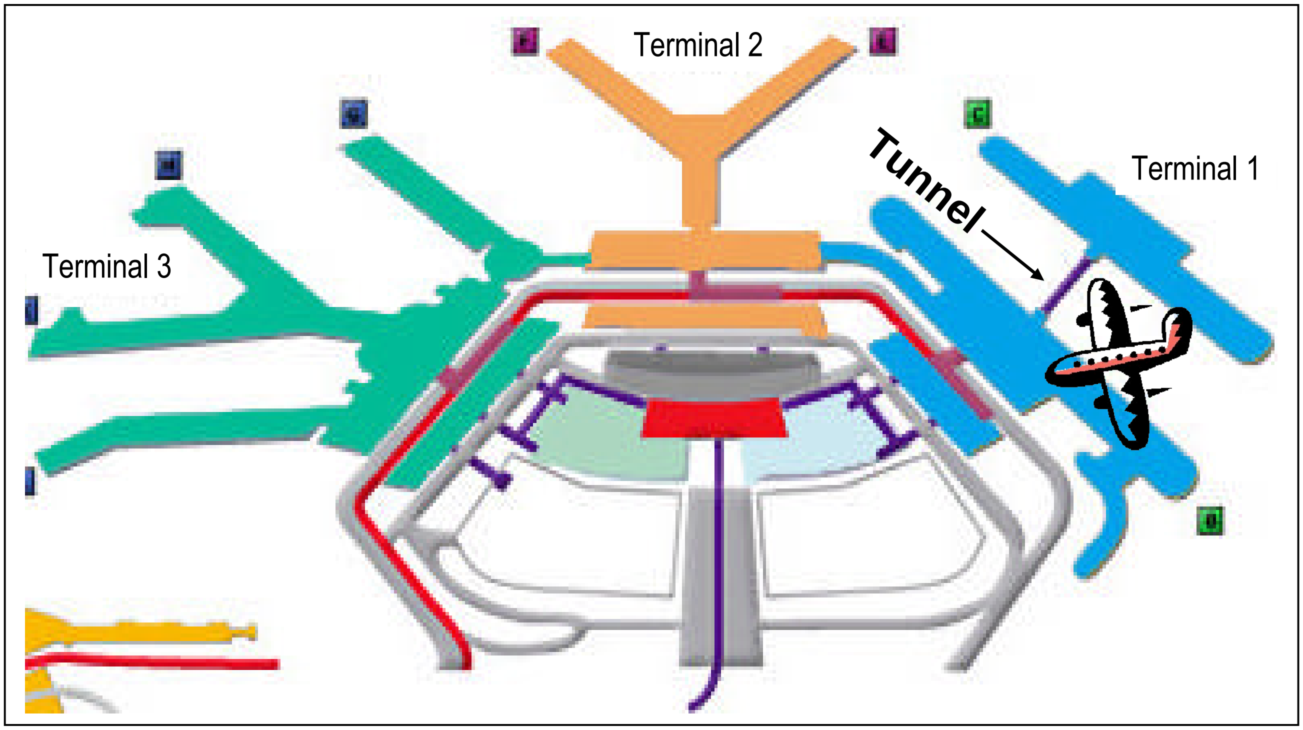
On Wednesday before Thanksgiving, at 1600 hrs, a Boeing 767 airfreight airliner loses control for an unknown reason while attempting to land and crashes into airport terminal, United Airlines Terminal. In addition to mail and other packages, the aircraft was carrying 150 lbs. of Cesium 137 (Cs 137) in 30 individual 5 lb. containers. Several of the containers have broken open, spreading their contents over a wide area.

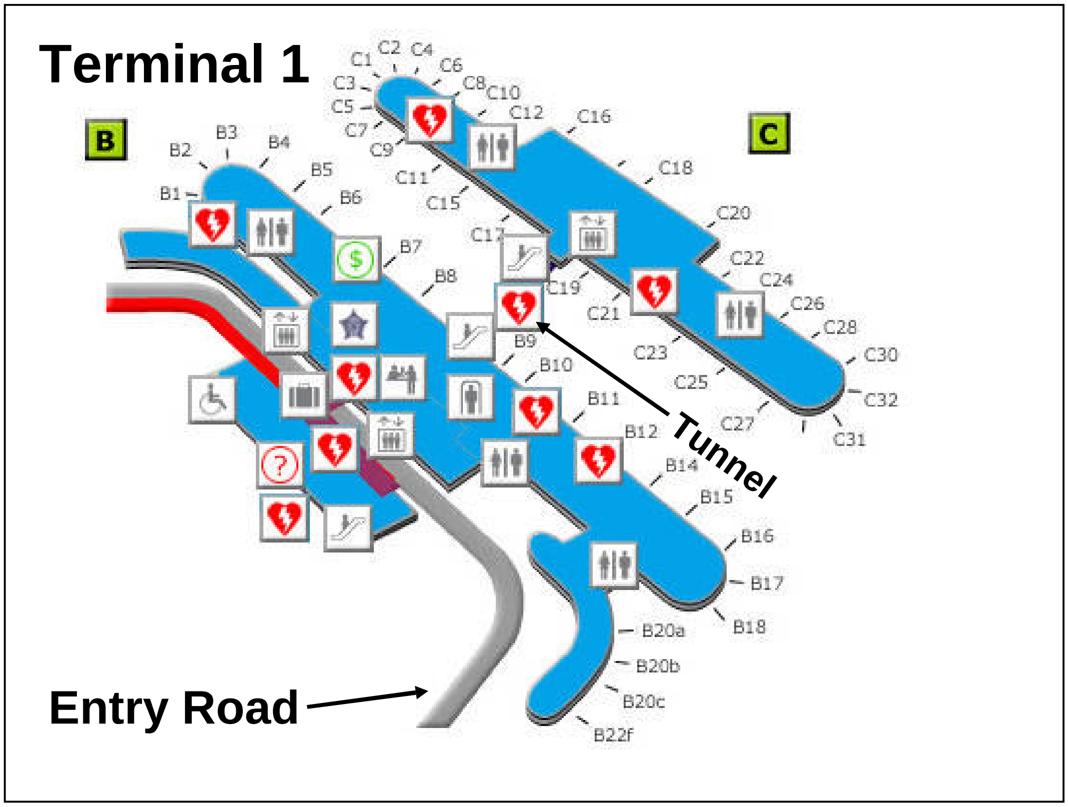
Condition of Collapse

The steel, glass, and concrete structure has sustained significant damage to the majority of the structure. The fire sprinkler system is damaged beyond repair and is ineffective. The fire causes the steel structure to weaken in several places, and secondary collapses occur. The plane crash ruptures a 12" water line and a 24" sewer line which allows their contents to spill uncontrollably into the below grade passenger tunnel system.

Occupancy

Airliner = 4   Airport Terminal = 12,000





Specific Information

- At the time of the crash, the aircraft was carrying less than 2,000 lbs. of fuel, which ignites upon impact with the terminal.
- Local and mutual-aid emergency response plans are activated, and the fire is extinguished in less than 2 hours with the assistance of the aircraft rescue and firefighting vehicles and firefighters from the Air National Guard Squadron.
- A multi-casualty incident is declared, and pre-planned resources are requested and deployed.
- The airport shuts down all runways and diverts all inbound aircraft to other airports.
- The Air National Guard Squadron scramble and launch their aircraft as a precaution against additional aircraft that might be intending to crash in the area.
- The Federal Aviation Administration, the National Transportation Safety Board, and the Federal Bureau of Investigation arrive on site and begin the investigation with local law enforcement.
- Local emergency resources have requested four Federal Emergency Management Agency/State Urban Search and Rescue Task Forces to assist.

Weather Report

- Sunny with a temperature of 70°F and an overnight low expected to be 52°F.
- No measurable wind.

Task Forces receive the following information from the local Incident Command (IC) at the initial briefing 24 hours later:

- Local resources have rescued and transported more than 1,000 victims to local and surrounding hospitals.
- More than 2,000 victims are known dead. Some have been removed to a temporary morgue, but most remain in the main terminal area. The number of live victims trapped inside the impact area is unknown.
- The fire has been extinguished, however, some hot spots exist throughout the impact area.

- Radiation monitors have detected significantly high readings in at least 10 areas in the impact area.
- Local resources are currently working on at least 20 different locations with confirmed live victims.

The local IC requests the following assistance:

- Provide detailed hazard assessments for the main terminal and the passenger tunnel.
- Assess the impact area for pockets of unburned jet fuel, radiation, and other biological/chemical hazards.
- Develop safety and monitoring plans in coordination with local resources.
- Conduct a systematic search of the main terminal and the passenger tunnel.
- Develop a prioritized rescue plan with local resources.
- Assess needs for heavy equipment, demolition, and other construction related materials.
- Setup a viable communication system with the Incident Command Post and inside the below grade tunnel system.

<u>SCENARIO NO. 5</u>: Hurricane strikes a major metropolitan city

General Description

A major metropolitan US city is located on the shores of the Gulf of Mexico. It is 180 square miles in area and has a population of 500,000 people. The highest elevation of the city is 15' above sea level, and the lowest elevation is 4' below sea level.

Type of Disaster

A Category 5 hurricane strikes the major metropolitan city on the shores of the Gulf of Mexico. Sustained wind speed of the hurricane at time of landfall is 160 mph with wind gusts of 185 mph. Tidal surge is 20 feet. Rainfall is 10" within 6 hours. The most significant damage to the city is more than 50 square miles in area.

Condition of Collapse

More than 25,000 high-rise, low-rise, and single-family structures have completely collapsed or are significantly damaged. An additional 100,000 buildings have sustained some form of damage. All general construction categories have differing degrees of damage including light frame, heavy wall, heavy floor, pre-cast concrete and steel frame.

Occupancy

City at time of hurricane landfall = 350,000

Specific Information

- Previous hurricane warnings proved false, so most of the city's inhabitants did not evacuate as requested by government officials. Nearly 150,000 people are now homeless.
- Several large groups of "spontaneous volunteers" are attempting search and rescue efforts within their own communities.
- The tidal surge has deposited 5' of standing water one mile inland.
- All utilities and telecommunications are inoperable within the 30 square mile impact area.
- The local airports and marinas are closed due to extensive damage and large debris fields.
- Nearly all street signs and other forms of community identification have been removed by the high winds.
- A Federal disaster has been declared, and 20,000 National Guard troops have been deployed into the area.
- Local emergency resources have requested 12 Federal Emergency Management Agency/State Urban Search Rescue Task Forces to assist.
- The war in the Middle East has made the availability of military cargo aircraft almost non-existent.

The six Task Forces who have been able to arrive on site receive the following information from the local Incident Command (IC) at the initial briefing 24 hours later:

- Local resources have rescued and transported more than 2,000 victims to local and surrounding hospitals.
- More than 5,000 victims are known dead. Some have been removed to temporary morgues throughout the city, but most remain in the collapsed structures and debris fields.
- The number of live victims trapped inside other structures and debris fields is unknown because the entire impact area has yet to be searched.
- Several fires are burning in the area and cannot be extinguished because of inaccessibility caused by the standing water from storm surge.
- Local resources are currently working on at least 40 different locations with confirmed live victims.

The local IC requests the following assistance:

- Provide detailed hazard assessments of the 30 square mile impact area.
- Assess the impact of hazardous materials and other biohazards submerged or floating in the standing water.
- Develop safety and monitoring plans in coordination with local resources.

- Conduct a systematic search of the impact area in coordination with local resources and the National Guard.
- Develop a prioritized rescue plan with local resources for the larger structures where multiple live victims are known to be trapped.
- Assess needs for heavy equipment, demolition, and other construction related materials.
- Setup a viable communication system with the Incident Command Post and the other more remote impact areas.
- Assist with establishing more multi-casualty immediate treatment and transport sites into the Emergency Support Function 8 system.

Scenario 6:
Explosion with chemical agent release at large indoor arena located next to a large outdoor coliseum

General Description
The Arena is a round 3-story structure with pre-cast concrete sloped seating and level post-tensioned concrete floors supported on steel beam framing. The roof structure is a clear-span, "Bicycle Wheel" structure with steel cables that support pre-cast concrete segments that span the concert hall area. There is a large concrete, circular tension ring that surrounds the entire structure, which is supported on decorative concrete columns. The adjacent, outdoor coliseum is a multi-tier concrete structure, with steel beam supporting the elevated, pre-cast concrete seating.

Type of Disaster
On a Friday at approximately 2030 hrs, calls were received at the local fire communications center in Center City reporting some type of "big explosion" at the convention center. On this particular day, the local chapter of a Muslim sponsored organization was hosting a concert benefiting the Relief Fund for Afghanistan. Earlier, information had been received by local law officials that there was also a large gathering of Skinheads in the adjoining community of Troubleton. Some phone threats that morning hinted that the concert would not be a peaceful one, and extra security was assigned to the area by the local Sheriff.

Condition of Collapse
Upon arrival, fire and police responders reported that the structure is on fire with large amounts of smoke. The entire roof structure has collapsed onto the seating areas, and 30% of the upper seating levels have collapsed on the north side.

Occupancy
The Arena has a capacity of about 20,000 people depending on the stage set-up. This was a "sold-out" conference. The adjacent coliseum has a seating capacity of 60,000, but only about 20,000 were expected for the major league baseball game that started at 1900 hrs.

Specific Information

- Many injured victims are complaining of nausea, vomiting and diarrhea.
- Some of the victims have a runny nose, eye irritation and blurred vision.
- Some victims report people inside who do not appear to be injured but are unconscious or appear to be dead.

Weather Report

- Clear with a temperature of 64°F and an overnight low expected to be 48°F.
- Winds are mild at 10 mph from the southwest.

The local Incident Command (IC) gives the following information in an initial briefing:

- The fire has been extinguished, and surface victims have been removed to the hospital.
- The cause of the explosion has not been determined.
- The source of the nausea, vomiting, diarrhea, runny nose, eye irritation and blurred vision has not been confirmed; however, preliminary testing by the local hazmat team is showing positive for lethal nerve agent (VX).
- Your assignment is to search the building for the nearly 5000 missing victims and stabilize the structure to allow the investigation to follow.

The local IC requests the following assistance:

- Provide detailed hazard assessments for the convention center.
- Assess the area biological/chemical hazards.
- Provide technical assistance to local hazmat team with technical decontamination procedures.
- Develop safety and monitoring plans in coordination with local resources.
- Conduct a systematic search of the Arena.
- Develop a prioritized rescue plan with local resources.
- Assess needs for heavy equipment, demolition, and other construction related materials.
- Setup a viable communication system with the Incident Command Post.

Appendix D - Workshop Facilitators

A list of potential facilitators was compiled by the expert panel, and the selected facilitators from that list included:

CA-TF3	Harold Schapelhouman Menlo Park Fire Department
CA-TF3	Frank Fraone Menlo Park Fire Department
CA-TF3	David Hammond Structural Engineer
CA-TF1	Rick Warford LA Fire Department
TN-TF1	Don Kuhn Memphis Fire Department
TX-TF1	Tim Gallagher Texas Engineering Extension Service
VA-TF2	Chase Sargent Virginia Beach Fire Department
VA-TF 2	Steve Cover Virginia Beach Fire Department

Appendix E - Workshop Participants

Practitioners from FEMA Teams

AZ-TF1	Mike Worrell (Communications)
CA-TF1	Rory Rehbeck (Technical Search)
CA-TF2	Frank McCarthy (Communications)
CA-TF3	Pat Grant (K9 Search)
CA-TF5	Larry Kurtz (TIS)
CA-TF7	Geoff Miller (Plans)
CA-TF7	Scott McKenney (Medical)
CA-TF8	Hernando Garzon (Medical)
CA-TF8	Jeff Frazier (Plans)
CA-TF8	Rich Leap (Hazmat/WMD)
FL-TF1	Keith Tyson (TIS)
FL-TF1	Tom Quinn (Plans)
IN-TF1	Anne McCurdy (K9 Search)
MA-TF1	Steve Clendenin (Hazmat/WMD)
MA-TF1	Alan Fisher (Engineering)
MO-TF1	Paul Boenish (Engineer)
NY-TF1	John O'Connell (Rescue)
OH-TF1	Jack Reall (Plans)
TN-TF1	Tom Powell (TIS)
TN-TF1	Billy Freeman (Communications)
TX-TF1	Bert Withers (Technical Search)
TX-TF1	Gary Parker (Communications)
TX-TF1	Pete Keating/TAMU (Engineering)
VA-TF1	Andy Hubert (Logistics)
VA-TF1	Dewey Perks (Command)
VA-TF1	Teresa MacPherson (K9 Search)
VA-TF1	Craig Luecke (TIS)
VA-TF2	Wayne Black (Logistics)
VA-TF2	Mike Brown (Command)
VA-TF2	Dr. David Cash (Medical)
WA-TF1	Lafond Davis (K9 Search)

Appendix E (continued)

Practitioners from Non-FEMA Teams

California Office of Emergency Services (CAL-OES)	Mike McGroarty (Command)
Michigan Urban Search and Rescue (MUSAR)	Ron Zawlocki (Rescue)
NC-TF1	Jeff Dulin (Hazmat/WMD)
FL-TF3	Todd Livingston (Rescue)
Can-TF-1 (Canada)	John Willcox (Medical)
Belvoir (Army)	Kenneth Noe (Technical Search)
NJ-TF1	Jim Riley (Command)
NJ-TF1	Brian Juncosa (Engineering)
Virginia Heavy Tactical Rescue (VA HTR)	Chuck Swecker (Rescue)
Chemical Biological Incident Response Force (CBIRF) (Marines)	Michael Dean (Hazmat/WMD)
CBIRF	Thomas Dillon (Technical Search)
University of South Florida	Robin Murphy (Robotics)