

# Current Domain Challenges in the Emergency Response Community

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## ABSTRACT

This paper describes the development of a framework targeted to technology providers to better understand the grand domain challenges of the emergency response and management community (EM). In developing this framework, Pacific Northwest National Laboratory (PNNL) researchers interviewed subject matter experts (SMEs) across the EM domain and corroborated these findings with current literature. We are presently examining relationships and dependencies within the framework. We anticipate that a thorough understanding of these gaps and dependencies will allow for a more informed approach to prioritizing research, developing tools, and applying technology to enhance performance in the EM community.

## Keywords

Precision information environments, domain challenges, gap analysis, resource management, situational awareness, decision support, communications, data access, knowledge transfer.

## INTRODUCTION

This paper provides an overview of the first phase of a gap analysis of the emergency response and management (EM) community conducted in late 2009 to identify potential improvements in EM that could be provided through the application of current or future technologies. PNNL researchers interviewed 24 subject matter experts (SMEs) across the EM domain. To ensure that the analyses reflected a representative view of the community, the SMEs were selected from a variety of geographic areas, variably sized communities (urban, suburban, and rural), and from local, county, federal, and private organizations (Barr, et al., 2010). Researchers also examined recent and relevant after-action reports from emergency exercises and U.S. Government Accountability Office reports. A thorough understanding of these gaps should enable a more holistic and informed approach to applying and aligning technology and prioritizing research and development that we anticipate will improve performance in the EM community. SMEs were selected based on recommendations provided by the leadership team from the Northwest Regional Technology Center for Homeland Security, other SMEs, and researchers with domain expertise (Barr, et al., 2010). The format of the interviews was semi-structured, allowing the SMEs to discuss areas of EM that they felt needed the most improvement. Notes from these interviews were compiled and organized into topical areas, or “domain challenges”. Through this effort, PNNL personnel organized the gaps into six major categories: *Information Collection, Sharing, and Dissemination; Communications; Information Security; Analysis and Decision Support; Situation Awareness; and Knowledge Transfer*. Each major category was further broken down into more detailed areas of focus.

## INTERVIEWS

Interviews with SMEs were instrumental in identifying domain needs, which led to the development of the domain challenges (or gaps) outlined below. Researchers found that SMEs desired the ability to discover and understand information that they currently lack; for example, providing accurate ground truth and quickly showing the effects of proposed actions. SMEs also wanted to make sure that they were making use of the

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existing knowledge base (i.e. not reinventing the wheel). Additionally, SMEs desired a capability to easily and appropriately apply the knowledge base to current situations (e.g. through lessons learned, exercise information, after action reports, training procedures, etc.). However, SMEs wanted information reduced to only that which assists in making informed decisions, allowing them to quickly access pertinent information and understand how the situation is changing, enabling timely, informed decision making. Central to managing a rapidly changing and expanding emergency situation is to ensure that all participants know their roles and responsibilities. Assisting SMEs in understanding roles and responsibilities enables a situation-wide understanding of who is responsible for a set of actions, who is expected to provide specific deliverables and the timelines associated with these actions and deliverables. SMEs also expressed a need to make sure that pertinent information or tasks do not “fall off the radar” as new information arrives. Based on the needs discussed by SMEs during the course of the interviews and a review of relevant reports, researchers identified the following six fundamental domain challenges facing the EM community.

## DOMAIN CHALLENGES

### Information Collection and Dissemination

The fast pace and critical nature of EM requires the ability to access and share information efficiently and effectively. We identified two primary gaps in this area: *Data Access* and *Organizational Information Sharing*. EM personnel often have difficulties obtaining the information they need (GAO, 2009a). This is due to several fundamental problems: lack of awareness that the information exists; not knowing who controls the information; and the inability to access the information or having access but in a format that is not understandable. Personnel also frequently find that information is not shared across organizations, often due to insufficient trust between organizations (GAO 2009b,c).

### Communication

Emergency communications are essential within and across EM agencies and jurisdictions throughout the lifecycle of an incident (GAO, 2009d). EM communications systems during a catastrophic disaster must be able to meet internal and external emergency communication requirements. Communication gaps identified by SMEs and by the literature review can be organized into three categories: *organizational (or internal) communication*; *external (or public) communication*; and *technology and infrastructure*. Internal communication challenges primarily relate to the difficulties inherent in shifting to the more dynamic, ad-hoc management style associated with disaster response from day-to-day centralized decision-making. The domain challenge of communications also encompasses the challenges associated with verbal communications (e.g., ease of use, perishability, challenge to capture and structure information, etc.) External communication challenges emerge from the need to disseminate clear, reliable, and trustworthy information to the public in order to mitigate public fear and stress, and allow the public to better respond to an incident. In addition, communication to effectively gather information from the public is critical to enhancing situational awareness and decision-making. (Poulson, 2007). The challenges associated with technology and infrastructure include: rapid deployment of communications systems for the EM community; management of the impacts on infrastructure from excessive demand for the same communication resources (radio channels, cell bandwidth, etc.); and the loss of communication resources because of damage to portions of the infrastructure (GAO, 2009e).

### Information Security

Maintaining the appropriate level of security for sensitive information is an important component of emergency management as it allows EM personnel to respond to emergencies without worry that unauthorized parties will be able to use information inappropriately. Information security, as defined here, can be broadly broken down into two topic spaces: *threat-based security* and *handling-based security*. Threat-based security concerns include threats such as cyber attacks (from non-discriminating malware to targeted attacks). Handling-based security deals with information shared by agencies that will not be handled appropriately, leading to information loss, information confusion, or the dissemination of inaccurate information. Information security measures designed to mitigate threats also make it difficult for those with legitimate operational needs to access information. Varied security protocols at different agencies further complicate the issues of information security and legitimate access to information. (GAO, 2007a).

### Analysis and Decision Support

Analysis and decision support are essential to managing the complex environment of an emergency. Analysis involves evaluating information that has been collected and drawing conclusions about the information to enhance decision making. Gaps associated with analysis and decision support were broken into the following categories: *information relevance*; *role ambiguity*; *decision making with limited information, expertise, resources and time*; and *coordinated decision making*. Information relevance deals with situations in which the value of information may be lost or unrecognized (Barr, et al., 2010, GAO, 2007b). Role ambiguity exists when individuals or organizations are uncertain of their job duties and level of authority; this leads to increased individual stress and a variety of inefficiencies that negatively impact EM effectiveness (Barr, et al., 2010, McShane and Von Glinnow, 2000). Given the possibility of communications being compromised, unavailability of staff members, and agencies handling their own concerns before communicating with other agencies, decision makers must be able to make the best decisions possible with available information. SMEs stated that they currently lack trusted predictive models and tools that can assist in situations where decision makers are constrained by information, expertise, resources, and/or time (Barr, et al., 2010). Coordinated decision making gaps relate to the difficulties of effective communication within and among stakeholder organization(s) or group(s). Additionally, coordinated decision making gaps include effective communication with policy makers and receiving relevant information from outside organizations about impacts to relevant communities.

### Situation Awareness

Situation awareness is a cognitive state that reflects the real-time understanding of an environment and its relation to pertinent goals. Situation awareness is significantly related to performance for those who have the technical and operational capabilities to take advantage of it (Endsley, 1995). PNNL researchers divided gaps related to situation awareness into three categories: *dynamic situations*; *resource status*; and *geographic visualization*. Dynamic situations often create increasingly complex environments, making it difficult to maintain good situation awareness (GAO, 2009c, Endsley, 1995). SMEs expressed a need to have better situation awareness of resource status (location and well-being of personnel, as well as status of personnel activities) to more effectively manage the situation. Geographic visualization concerns with current geographic information systems are that they are complicated and require a considerable level of expertise to operate. There is also a lack of a common geographic interface and iconography for information integration. Without common iconography, it is difficult to have a shared operational picture for situation awareness.

### Knowledge Transfer

In the EM community, effective knowledge transfer is critical within the operations, multiple handoffs, and shift changes that occur during the course of an event. Knowledge transfer is the communication of knowledge between individuals and organizations (e.g., from logistical details to organizational best practices). We divided knowledge transfer gaps into three categories: *shift changes*; *organizational memory*; and *training*. During shift changes, situation awareness can be degraded or lost due to lack of detailed knowledge transfer. Gaps exist in organizational memory when experienced staff members leave and new staff members join the organization. Similarly, gaps exist in organizational memory with respect to the documentation and understanding of organizational lessons learned and best practices. Training gaps relate to shortcomings in two broad and overlapping categories: training for technical skills and for cognitive skills.

### INTERDEPENDENCIES

A number of interdependencies exist between the major gap categories. Understanding these interdependencies will allow the technology provider to prioritize efforts and examine the problem in a more holistic manner. For example: to address Information Collection and Dissemination concerns, an appropriate level of trust in the information recipient is required by the information owner, which is captured under Information Security (GAO, 2009b,c). Similarly, good Situation Awareness is dependent on appropriate information obtained through Information Collection and Dissemination. Geographic visualization, associated with Situation Awareness, is hampered by several factors, including expertise required to operate systems (Knowledge Transfer), access to geo-located data (Information Collection and Dissemination), and the time required to generate a visualization of the situation (GAO, 2003). Effective training (Knowledge Transfer) and Communication is required to take advantage of good Situation Awareness and properly act on information obtained from Analysis and Decision Support tools. Analysis and Decision Support also relies heavily on understanding the current state of the situation (Situation Awareness).

## CURRENT WORK

Current work is expanding upon these results by interviewing a broader range of SMEs including representatives of private industry that are critical for response and/or recovery as well as private and public organizations responsible for the well-being of large groups of people (e.g. schools, factories, hospitals). We will continue to work with stakeholders to validate the domain challenges and interdependencies through observations of exercises and operations center activations and by engaging key members of the emergency response community in regular workshops. We expect that the next phase of research will provide further detail to our framework and validate that the identified gaps are representative of the larger community response. We anticipate the creation of a detailed graphic representing domain challenges, detailed areas of focus, and interdependencies during this next phase. This graphic will be vetted with SMEs.

## CONCLUSION

The domain challenges/gaps outlined in this work point to a fundamental desire of the EM community to do their jobs better, faster, and, if necessary, with fewer resources. Needs identified by SMEs included the ability to discover and understand information, ability to understand how proposed actions will impact a situation, the ability to leverage the existing knowledge base and apply it appropriately to current situations, the ability to reduce information to only that which is critical to making informed decisions, ability to understand roles and responsibilities, and maintaining access to all relevant information, not just the most recent information. These needs informed the development of the gaps and challenges outlined above, addressing several topic areas relevant to EM and revealing abundant opportunities for improvement. By researching and identifying these needs, PNNL has developed a framework to better understand where technology can contribute to improved EM operations. This understanding should assist in working toward identifying future solutions and help us better understand where technology can strategically contribute to improved operations. We anticipate that this work will be used by stakeholder and developer communities to develop a common understanding of goals, so as to better align community requirements and technology development for emergency response and disaster management.

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