Pacific Northwest
NATIONAL LABORATORY

PNNL-35880

Emergency Management of Tomorrow Research – Task 3B Research and Development Community Awareness

Eliciting Emergency Management Stakeholder Input

April 2024

Samuel Ortega
Maren Disney
Chelsea Sleiman
Jon Barr
Ann Lesperance
Rachel Bartholomew
Jessica Gray
Nick Betzsold

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

This report was prepared for the U.S. Department of Homeland Security under a Work-for-Others Agreement with the U.S. Department of Energy, contract DE-AC05-76RL01830, IA 70RSAT23KPM000025.

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <https://www.ntis.gov/about>
Online ordering: http://www.ntis.gov

PNNL-35880

Emergency Management of Tomorrow Research – Task 3B Emergency Management Research and Development Community Awareness

Eliciting Emergency Management Stakeholder Input

April 2024

Samuel Ortega
Maren Disney
Chelsea Sleiman
Jon Barr
Jessica Gray
Nick Betzsold
Rachel Bartholomew
Ann Lesperance

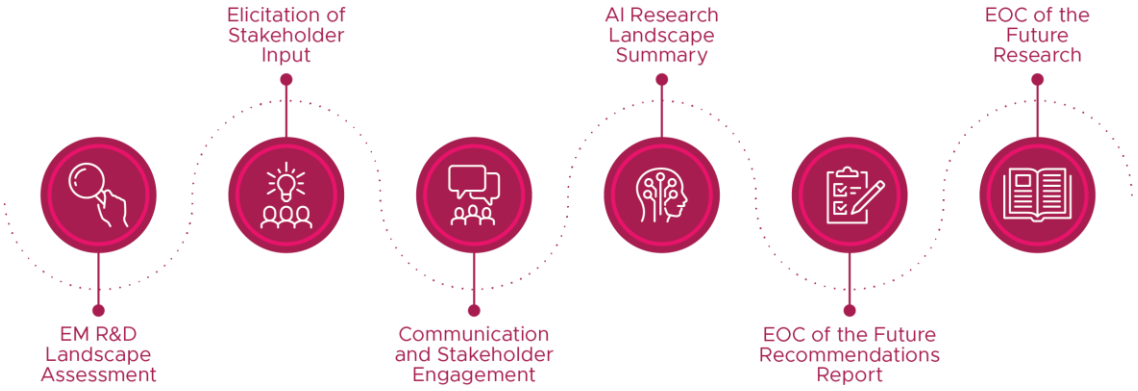
Prepared for
the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99354

About the Emergency Management of Tomorrow Research

The Department of Homeland Security (DHS) Science and Technology Directorate (S&T) is partnering with Pacific Northwest National Laboratory (PNNL) to execute the Emergency Management (EM) of Tomorrow Research (EMOTR) program to identify current EM research, elicit capability needs from EM practitioners, and identify where technology, such as artificial intelligence (AI), may benefit the future of EM and emergency operations centers. The project is delivering a phased and iterative approach to inform future research, development, and investments for the EM community.

This report details the methodology, analysis, and insights of interviews and focus groups conducted as part of the task to elicit stakeholder input. Feedback from this task will help shape future EMOTR research, analysis, and recommendations. To learn more about this task or others within the EMOTR scope, contact emotr@pnnl.gov.



Summary

As a foundational component of the EMOTR program, PNNL conducted outreach to the EM research and development community to establish a comprehensive understanding of ongoing initiatives, existing capability gaps, unaddressed research endeavors, and the efficacy of research in addressing EM needs. PNNL conducted interviews and focus groups connecting with EM researchers and operational personnel nationwide. The following is a summary of themes that emerged, highlighting the interdisciplinary nature of crisis informatics research, the importance of addressing gaps in information dissemination and technology implementation, and the need for human-centric approaches in EM.

Challenges

- Mis/disinformation on social media and information equity, agility, and integrity.
- Data integrity and network security concerns regarding AI/machine learning (ML) applications for emergency responders.
- Gaps in human-centric research and needs of emergency response personnel.

Artificial Intelligence

- Need for AI and ML analysis for detecting a crisis and improving communication.
- Further exploration of AI applications in security, spectrum analysis, and network access.
- Need for human-in-the-loop systems and trust networks involving AI agents.
- Lack of access to and availability of data is a hindrance in using AI in EM, particularly in the private sector where data access is tightly controlled, limiting the ability to leverage AI for response efforts.

Emergency Operations Center Evolutions

- Need to integrate social media analytics and AI for crisis detection and response.
- Emphasis on expanding common operating pictures, zero trust architecture, and cloud solutions.
- Need to integrate a blend of in-person, virtual, and hybrid operations to be adaptable to diverse disaster scenarios and enhance response effectiveness.

Future Trends and Opportunities

- Further exploration is needed of emerging technologies such as AI/ML, cloud solutions, and unmanned aerial systems for emergency response.
- Importance placed on the integration of cybersecurity in emerging systems.
- Need for improved testing mechanisms, particularly in real emergency scenarios.

These themes emerged repeatedly during discussions, highlighting their significance in the EM R&D community. This report summarizes PNNL's overall approach, outcomes, and analysis of the interviews. This information aims to assist DHS S&T in making informed decisions for future EM R&D.

Acronyms and Abbreviations

AI	Artificial Intelligence
DHS	Department of Homeland Security
DOE	Department of Energy
EM	Emergency Management
EMOTR	Emergency Management of Tomorrow Research
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
ML	Machine Learning
NASA	National Aeronautics and Space Administration
OEM	Office of Emergency Management
PNNL	Pacific Northwest National Laboratory
PR	Project Responder
R&D	Research and Development
S&T	Science and Technology

Contents

1.0 Introduction

As part of the Emergency Management (EM) of Tomorrow Research Program (EMOTR), sponsored by the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), Pacific Northwest National Laboratory (PNNL) is leading a three-part task to elicit input from both the EM stakeholder and research and development (R&D) communities in a collaborative and interactive way. Task 3, " Elicit Emergency Management Stakeholder Input," comprises three sub-tasks implementing structured engagements:

- Task 3A, "Current State of Practice: Emergency Management Information Sharing," developed a baseline understanding of current practice and impediments to information sharing.
- Task 3B, "Emergency Management Research and Development Community Awareness," conducted outreach to the EM R&D community to establish a comprehensive understanding of ongoing initiatives, existing capability gaps, unaddressed research endeavors, and the efficacy of research in addressing EM needs.
- Task 3C, "Emergency Management Research and Development Community Coordination," fostered a dialogue with EM R&D stakeholders to encourage collaboration, increase transparency, reduce overlaps, and increase overall efficiency of research investments in EM.

Task 3 engagements took the form of interviews, roundtables, and focus groups. These engagements were guided by previous and concurrent EMOTR tasks designed to assess current research in EM, elicit capability needs from EM practitioners, and identify where technology, such as artificial intelligence (AI), may benefit the future of EM and emergency operations centers (EOCs). Together, EMOTR outreach tasks are eliciting, analyzing, and summarizing EM R&D needs and priorities as defined by EM practitioners and will be followed by suggestions for areas of research underrepresented in the current research ecosystem that are fit for EM community awareness.

This report summarizes Task 3B, "Emergency Management Research and Development Community Awareness." The results of tasks 3A and 3C are available in separate reports available by request to emotr@pnnl.gov.

Figure 1. EMOTR Task 3B engages the EM R&D community to build awareness of and better understand capability needs in key aspects of technology development, including interoperability, standards, enterprise architecture, and transition impediments.

Task 3B sought to collect individual stakeholder input via interviews and focus groups (in-person and virtual) to develop a baseline

understanding of the ongoing research efforts within the EM R&D community. This task sought to validate findings from the EMOTR Task 2 Landscape Assessment[1] of EM research and elicit technology gaps and capability needs from the EM community using a structured elicitation approach. Stakeholders for this task included EM R&D personnel representing government and academic research institutions and operational personnel from private and public EM organizations This report summarizes the stakeholder input, including capability gaps, barriers, and suggestions for future R&D, in the areas of interoperability, standards, enterprise architecture, and transition impediments (Figure 1).

2.0 Methodology

PNNL leveraged best practices from its First Responder Roadmap Project,[2] where the team developed a formal methodology for stakeholder engagement and expert elicitation. PNNL led technology visioning exercises to elicit feedback from the EM R&D community regarding the current state of EM research programs and their effectiveness.

The goal of connecting with the EM R&D community was to build a baseline understanding of the current efforts of the research community, identify capability needs, and validate previous EMOTR findings. PNNL leveraged the EMOTR Task 2 Landscape Assessment to identify existing research programs and identify experts whose research aligned with EMOTR areas of interest.

2.1 Protocol

PNNL developed an interview protocol to provide a structured framework for consistent information gathering, maintaining alignment with the overall project objectives while allowing for in-depth exploration of relevant topics. The interview protocol consisted of a suite of questions targeting the effectiveness of current research programs, assessing their effectiveness, and identifying gaps and potential research areas warranting further consideration (See Protocol in Appendix A). One-on-one interviews with technical researchers were crucial to gaining an in-depth understanding of their research within the context of EM. Using a structured set of questions, these interviews provided valuable insights into the theoretical frameworks, methodologies, and potential applications of their work in real-world emergency scenarios. Additionally, conducting focus groups with operational practitioners served to validate and contextualize the findings from the interviews. By involving those directly serving in EM operations, the interviews and focus groups explored how identified research efforts align with practical needs and can effectively address challenges faced in the field. This comprehensive approach identified gaps in current research and made practitioners aware of the current state of EM research, which can ultimately lead to more effective EM strategies and solutions.

Interviews were conducted via teleconference with the EM R&D interviewee, PNNL EMOTR task lead, and PNNL note-taker. Interview content is summarized in this report without attribution to facilitate a more open conversation.

[1] Sleiman, C., Thomas, K., Gray, J. Schroeder, J., Disney, M., Alsabagh, H., Ortega, S., Bartholomew, R., Lesperance, A. (2024). “Emergency Management of Tomorrow Research Landscape Assessment.” Pacific Northwest National Laboratory. PNNL-35649

[2] Funded by DHS S&T in fiscal year 2024, the First Responder Capability Roadmap connected with first responders nationwide to understand their capability needs and create an actionable framework for strengthening capabilities and technology.

Additionally, PNNL conducted two focus groups in February 2024 with representatives from city, county, state, and private EM organizations:

- An in-person focus group convened in Boulder, Colorado. The event facilitated face-to-face interactions with structured discussions moderated by experienced facilitators and fostered a conducive environment for open dialogue.
- A virtual focus group leveraged online platforms and video conferencing tools to enable remote participation from geographically dispersed stakeholders. The virtual session maintained a similar level of engagement and interaction as in-person meetings, with participants joining from various locations via their electronic devices.

Each focus group was asked to respond to eight questions, covering the EMOTR themes of interoperability, standards, systems architecture, and transition challenges. Detailed protocols for the in-person and virtual focus groups are in Appendix B and Appendix C, respectively.

2.2 Stakeholders

With a clear focus on engaging stakeholders from diverse geographical areas, PNNL orchestrated targeted outreach efforts for both a local and national audience. Stakeholders for this task included EM R&D personnel such as representatives from government and academic research institutions and city, county, state, and private EM organizations across the United States. Leveraging relationships cultivated over time along with new partnerships established at conferences or through grassroots connections made during previous EMOTR tasks, PNNL reached out to key stakeholders to disseminate information about the focus group, inviting participation from individuals and organizations invested in the local and national EM community.

2.2.1 EM R&D Interviewees

A guiding source for PNNL's outreach to the EM R&D community was the EMOTR Task 2 Landscape Assessment, which is available separately from this report.[1] Analysis of the assessment findings allowed PNNL to identify current research initiatives and EM R&D researchers relevant to the EM mission and of potential interest for this elicitation task. The research clusters derived from the Task 2 Landscape Assessment (Figure 2) informed the strategic selection of participants whose research aligned closely with these predominant categories. This approach facilitated a targeted identification of experts whose work intersected with the areas of interest relevant to the EM mission.

[1] Sleiman, C., Thomas, K., Gray, J. Schroeder, J., Disney, M., Alsabagh, H., Ortega, S., Bartholomew, R., Lesperance, A. (2024). "Emergency Management of Tomorrow Research Landscape Assessment." Pacific Northwest National Laboratory. PNNL-35649

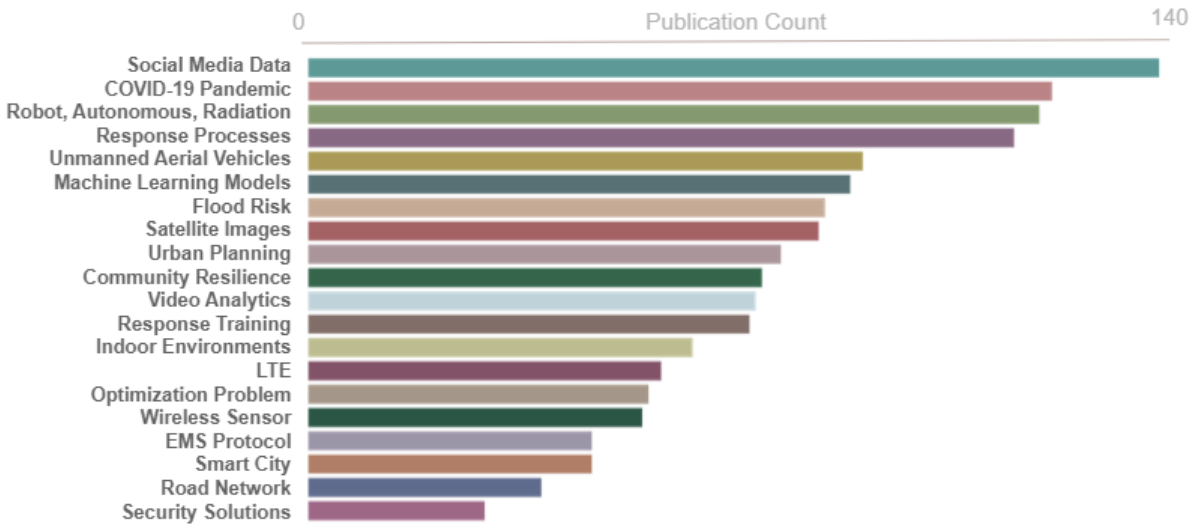


Figure 2. Top Research Clusters from EMOTR Landscape Assessment

2.2.2 Focus Group Participants

To identify focus group participants, PNNL leveraged long-standing relationships with the EM community via previous research and outreach efforts for DHS S&T collaborations and via the Northwest Regional Technology Center.[1] PNNL strategically leveraged attendance at conferences such as the International Association of Emergency Managers and the National Homeland Security Conference to establish connections within the EM space. Ultimately, PNNL identified 23 operational stakeholders within academia, the public sector, and the private sector dispersed throughout the nation.

2.2.3 Nationwide Outreach

Together, interviewees and focus group participants (in person and virtual) hailed from the following universities and research organizations across the nation (Figure 3):

Universities:
- Carnegie Mellon University
- George Mason University
- Indiana University
- Kansas State University
- University of Colorado Office of EM (OEM)
- University of Florida
- University of Wisconsin – Madison
- Vanderbilt University – Institute for Software Integrated Systems

Federal Government:
- Idaho National Laboratory
- National Aeronautics and Space Administration (NASA)

Private Corporations:
- Cascadia Region Earthquake Workgroup
- Moderna

Cities:
- Arvada, CO

[1] PNNL stewards the Northwest Regional Technology Center, a virtual center enabling homeland security solutions through outreach to emergency responder communities, federal, state, and local agencies, and private sector stakeholders. Learn more at http://www.pnnl.gover/projects/nwrtc.

- Broomfield, CO
- Boulder, CO
- Denver, CO
- Seattle, WA
- Thornton, CO

Counties:
- Arapahoe County, CO
- Boulder County, CO
- Hamilton County, OH
- Larimer County, CO
- Sacramento County, CA
- Weld County, CO

State Organizations:
- California Governor's Office of Emergency Services
- Colorado Department of Transportation EM
- Colorado OEM
- Colorado State Fire Chiefs Association
- North Central Region Healthcare Coalition EM Program

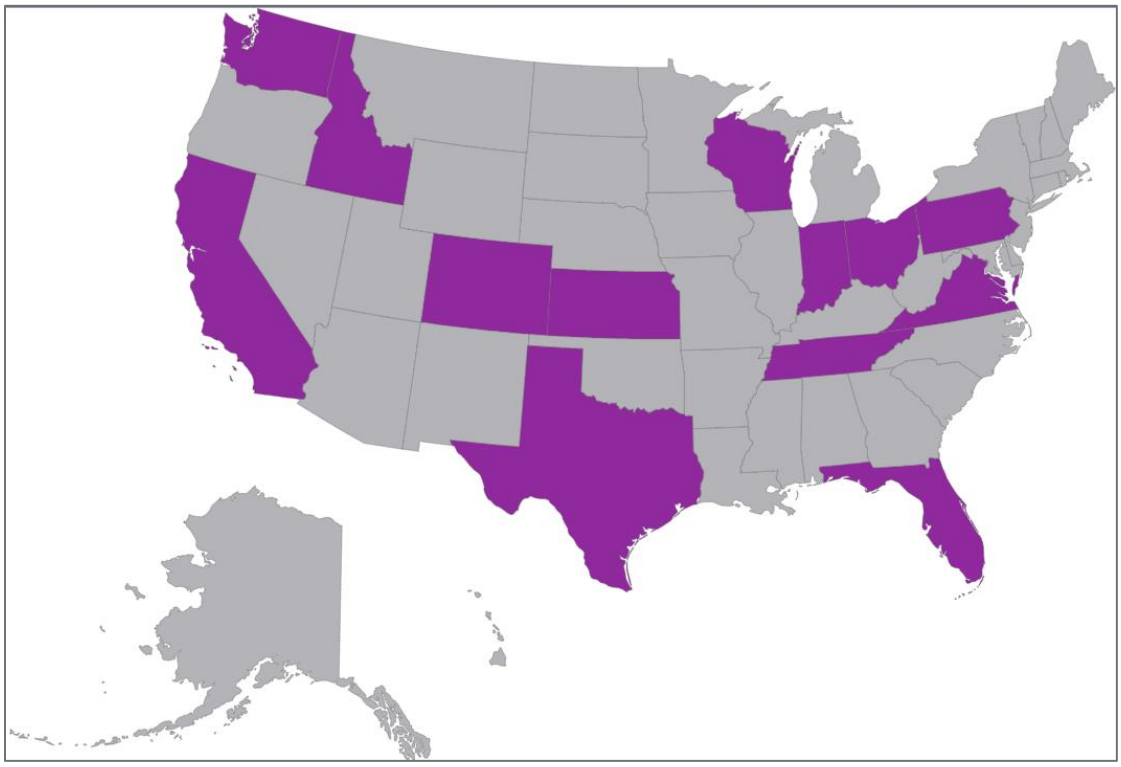


Figure 3. PNNL interviewed EM R&D stakeholders from across the nation in a series of structured interviews and focus groups.

PNNL's outreach approach combined targeted engagement with broader dissemination efforts, pursuing inclusivity and diversity. By harnessing the power of conferences and long-standing connections, PNNL effectively facilitated dialogue and collaboration among stakeholders, ultimately enriching the research process and driving meaningful outcomes.

2.3 Definitions

Four focus areas—transition impediments, system architectures, interoperability, and standards—were outlined as priorities for input by DHS S&T to guide EMOTR outreach and maintain consistency across discussions, PNNL utilized DHS S&T's existing resources to establish definitions for the key terms:

- **Transition Impediments:** Encompasses the challenges and barriers associated with deploying new technology and arising from the integration of new systems or platforms, leading to compatibility issues or disruptions to the current infrastructure.
- **System Architectures:** Outlines the organizational structure, relationships, and workflows to effectively align resources and capabilities through integrated, multidisciplinary analysis focused on improving interoperability, promoting industry standards, and minimizing the impacts of transition impediments.
- **Interoperability:** Highlights the capability of systems, technologies, and processes to seamlessly communicate, share information, and integrate into existing infrastructure for effective collaboration across diverse entities and platforms.
- **Standards:** Encompasses established formal and vetted protocols and guidelines that enable consistency and interoperability across various EM and response aspects.

2.4 Limitations

To maintain compliance with the Paperwork Reduction Act[1] to minimize the burden from the collection of information, interviews were limited to no more than nine stakeholders engaging in EM R&D. Furthermore, the interviews were not meant to achieve consensus from stakeholders but rather to elicit feedback from a broad array of EM R&D personnel to inform future research and investment.

To allow for engagement by a geographically distributed group of stakeholders, PNNL also held a virtual focus group in addition to the in-person focus group in Boulder, Colorado. While the virtual option may have presented limitations to engagement due to potential technological barriers and the lack of face-to-face interaction, it ultimately allowed PNNL to reach a broader audience. By eliminating geographical constraints and accommodating the busy schedules of stakeholders, the virtual format facilitated participation from individuals who might have otherwise been unable to attend in person. Despite the challenges, the virtual approach expanded the scope of outreach, enabling the team to gather insights from a diverse range of EM R&D stakeholders. Lastly, interviews were scheduled for 30 minutes to make the best use of participants' valuable time and limited availability.

3.0 Summary of Interviews

The following section provides a summary of insights from the outreach conducted to the EM R&D community. Inputs and analyses are included without attribution of individuals to maintain anonymity.

3.1 Research and Development Activities: Feedback from Researchers

The following is a summary of key insights garnered from interviews with researchers conducting EM R&D at leading research institutions with relevance to the EMOTR mission

[1] DHS. 2022. Paperwork Reduction Act Burden Reduction Initiative. https://www.dhs.gov/sites/default/files/2022-05/Burden_Reduction_Initiative_Memo_Final%20PDF%20CIO%20signed.pdf

space. PNNL selected researchers based on relevance in the EMOTR Task 2 Landscape Assessment findings and via grassroots networking during other EMOTR outreach.

3.1.1 Idaho National Laboratory

The current research focuses on wireless communications, with a particular emphasis on 5G technology, millimeter wave applications, and communications security. Key trends identified include the prioritization of maximizing coverage and security for first responders, as well as the encouragement of open systems at the national level. Research endeavors aim to enhance communications and security for emergency responders, with a specific focus on addressing gaps in securely utilizing 5G. AI and machine learning (ML) are being explored to reinforce security measures and optimize spectrum usage, potentially aiding in identifying and mitigating network interference. Key research priorities for the next decade include enhancing communications systems for first responders, conducting applied research for security, and anticipating and addressing emerging threats through scenario-based approaches.

3.1.2 National Aeronautics and Space Administration

As a government agency operating under the jurisdiction of the U.S. federal government, NASA plays a role in advancing scientific knowledge, technological innovation, and space exploration for the benefit of the public and the advancement of society. PNNL interviewed EM practitioners from NASA to gain insights into their contributions to EM R&D. Below are key focus areas of the discussion:

- NASA is adapting its technology to support emergency response efforts and aims to facilitate operational testing of its innovations.
- They fund small businesses working on applicable technologies through Small Business Innovation Research programs and collaborate with public and private entities.
- Operating within the Technology Readiness Level 4-6 range, NASA conducts nationwide workshops, addressing cascading disasters as future challenges.
- The "valley of death" between research and operational use, cybersecurity concerns, and data integration issues persist.
- They are working on projects like Open Data Integration and Advanced Capabilities for Emergency Response Operations to integrate data and guide aircraft usage during emergencies, focusing initially on wildfires and subsequently on hurricanes and other hazards.

3.1.3 Carnegie Mellon University

Researchers in the Carnegie Melon University Software Engineering Institute within the Computer Engineering Response Team Division's Monitoring and Response Directorate apply architecture-centric approaches to systems-of-systems to analyze and identify potential risks to improve their cybersecurity posture. The group manages situational awareness within the division, emphasizing security aspects of zero trust and designing systems to identify concerns and enhance risk assessments. Trends highlighted included zero trust and cloud technology, while research gaps focused on behavior analytics and trust in change, specifically the integration of AI in security strategies and cloud environments.

3.1.4 George Mason University

PNNL engaged with the Humanitarian Informatics Lab within the Department of Information Sciences and Technology at George Mason University, a research institution at the forefront of exploring various aspects of EM, including data integration, public education, risk perception, and the application of emerging technology. Below are key focus areas of the discussion:

- The researchers are focused on AI/ML pipelines to filter social media information and improve accessibility to relevant data.
- The identified gaps include policy issues, public perception challenges, and social-technical hurdles surrounding AI/ML applications, with a notable disconnect between social/behavioral research and data integration efforts in EM.
- The research aims to close gaps in understanding public behavior and perception of risk while leveraging technology to enhance decision support systems.
- The recommendations include enhancing community connections, fostering partnerships, and bridging the gap between research and operations.
- The priorities for future research include data integration, early warning systems, and understanding the dynamics of emerging threats.
- The research aims to contribute to more effective and informed EM strategies through interdisciplinary collaboration, technology integration, and community engagement.

3.1.5 Indiana University

Discussions with the University of Indiana's Crisis Technologies Innovation Laboratory unveiled a notable disparity between the advanced technological tools utilized in informatics work and the resources accessible within EOCs. From these conversations, key themes emerged, emphasizing the critical requirement for customizable information and automation tools to aid emergency managers in streamlining data organization. Moreover, discussions highlighted significant challenges in information management within EOCs, underscoring the critical necessity for intermediary systems. These systems are essential to facilitate the smooth dissemination of vital information across all phases of EM, ensuring that relevant data reaches decision-makers promptly and accurately. Below are key focus areas of the discussion:

- Evaluate options for innovative designs for EOCs, considering how technology and infrastructure can be optimized to enhance operational effectiveness.
- Optimize redundancy strategies, such that backup systems and processes are robust and reliable, thereby minimizing the risk of failure during critical moments.
- Develop comprehensive training programs tailored for emergency managers. These programs should equip them with the skills and knowledge to navigate traditional and emerging threats, enabling a proactive and effective response to any crisis.

3.1.6 University of Florida

Discussions with the University of Florida's Department of Urban and Regional Planning primarily focused on urban resilience and crisis informatics to understand the current R&D initiatives in EM. The department's work delves into integrating risk and crisis communication within EM, employing a bottom-up approach by analyzing online user responses to disasters and emergencies reported on social media platforms such as Twitter. This interdisciplinary

research aims to develop simulations, ML predictions, and culturally relevant risk communication strategies. Identified trends in research include urban resilience, crisis informatics, and ongoing efforts to combat misinformation on social media during crises. Gaps in information equity, agility, and integrity emphasize the need for improved warning and risk information delivery formats and content to reduce misinformation. Additionally, challenges in testing concepts were mentioned, highlighting the need for pilot platforms such as tabletop exercises to test EM strategies. Regarding future research priorities, enhancing information equity, agility, and integrity remain a key focus, along with exploring emerging trends such as augmented reality/virtual reality for risk communication and scenario simulation for emergency response preparedness.

3.1.7 University of Wisconsin – Madison

The discussion with the University of Wisconsin–Madison emphasized the importance of human-centric research in understanding the needs of emergency response personnel. Collaborating with professionals in the field emerged as a vital approach to developing or enhancing technologies for EM. Ongoing projects focus on the future of work in AI and integrating new technologies into emergency response scenarios. Areas for future research include human performance under extreme conditions and human-centered AI training for emergency responders. Challenges in seamlessly integrating humans with technology, particularly in high-stress environments like EOCs, were highlighted. Additionally, understanding human-AI interactions and trust dynamics within emergency response teams emerged as critical areas for future research. Overall, the conversation emphasized the multidisciplinary nature of EM research and the need to address the human-centric approach alongside technological advancements.

3.1.8 Vanderbilt University

The discussion with Vanderbilt University highlighted the importance of leveraging AI to enhance EM, particularly in the context of 9-1-1 and 3-1-1 phone calls. The School of Engineering aims to address various challenges in labor shortages, mental health support during emergency calls, and efficient resource allocation. Projects include automating non-emergency 3-1-1 calls and assisting call takers in dispatch decisions. They are also interested in integrating AI into emergency communication workflows and improving situational awareness through technologies like drones. Research in generative AI is also a priority for enhancing EOCs by leveraging large language models for prediction tasks. Generative AI models, such as GPT (Generative Pre-trained Transformer), have demonstrated remarkable capabilities in understanding and generating human-like text based on input prompts. In an EOC setting, these models can analyze vast amounts of textual data, including incident reports, social media updates, and news articles, to generate predictive insights regarding potential hazards, resource needs, and community response frameworks. By training these models on historical data and continuously updating them with real-time information, EOCs can improve their situational awareness, anticipate emerging threats, and make more informed decisions. Moreover, generative AI can assist in automating routine tasks, such as drafting incident reports or updating stakeholders, allowing emergency responders to focus on critical decision-making and resource allocation.

3.1.9 Kansas State University

Discussions with Kansas State University's National Agricultural Biosecurity Center highlighted challenges emergency managers face in response to agricultural disasters and animal disease

outbreaks. Unlike traditional rapid-response scenarios, these emergencies unfold over longer time scales, requiring a shift in preparedness and response strategies. Key challenges include resource management, continuity of business operations, and managing routes for animal movement during crises. Bridging the gap between traditional emergency responders and agricultural personnel is essential, highlighting the importance of education and training initiatives that integrate Incident Command System principles with farming practices. However, access to crucial data remains a significant barrier, particularly in industries like poultry farming, hindering efforts to leverage AI for emergency response. Future research priorities include improving biological threat surveillance systems, understanding the impact of natural disasters, and enhancing response capabilities for emerging threats in cyberbiosecurity.

In exploring diverse research initiatives across various institutions, several key themes and approaches have emerged, underscoring the dynamic landscape of EM and the multifaceted challenges it entails. From leveraging cutting-edge technologies like AI to addressing labor shortages and enhancing situational awareness in emergency communication workflows, to the imperative need for customizable information and automation tools within EOCs, the interviews reflected a comprehensive effort to enhance preparedness and response capabilities. Novel approaches such as integrating risk communication within social media platforms and employing generative AI models for predictive analytics demonstrate a forward-looking approach to addressing emerging threats and enabling resilient crisis management frameworks. Furthermore, the emphasis on interdisciplinary collaboration, community engagement, and bridging the gap between research and operational personnel underscores a holistic approach to the future of EM. As emergency managers continue to navigate the evolving risk landscapes and increasingly complex scenarios, these concerted efforts reflect a commitment to innovation, adaptability, and resilience that forms the foundation of effective EM strategies.

3.2 Effectiveness of Technology: Feedback from Emergency Managers and Operators

The following is a summary of the focus groups conducted with EM operational personnel. PNNL conducted two focus groups, one in person in Boulder, Colorado, with more than 15 participants from cities, counties, and the state of Colorado, and the other virtual, conducted via Microsoft Teams, with seven participants from private organizations, cities, and states from throughout the country. Both focus groups leveraged in-person and virtual collaboration tools that offered advantages in terms of accessibility and inclusivity, allowing a diverse range of stakeholders to contribute to the discussion and provide valuable insights on research strategies and potential solutions for enhancing EM capabilities (Figure 4). EM personnel participated in a guided, collaborative discussion that sought to determine the effectiveness of current research in closing EM capability gaps in consideration of interoperability, standards, enterprise architecture, and transition impediments.

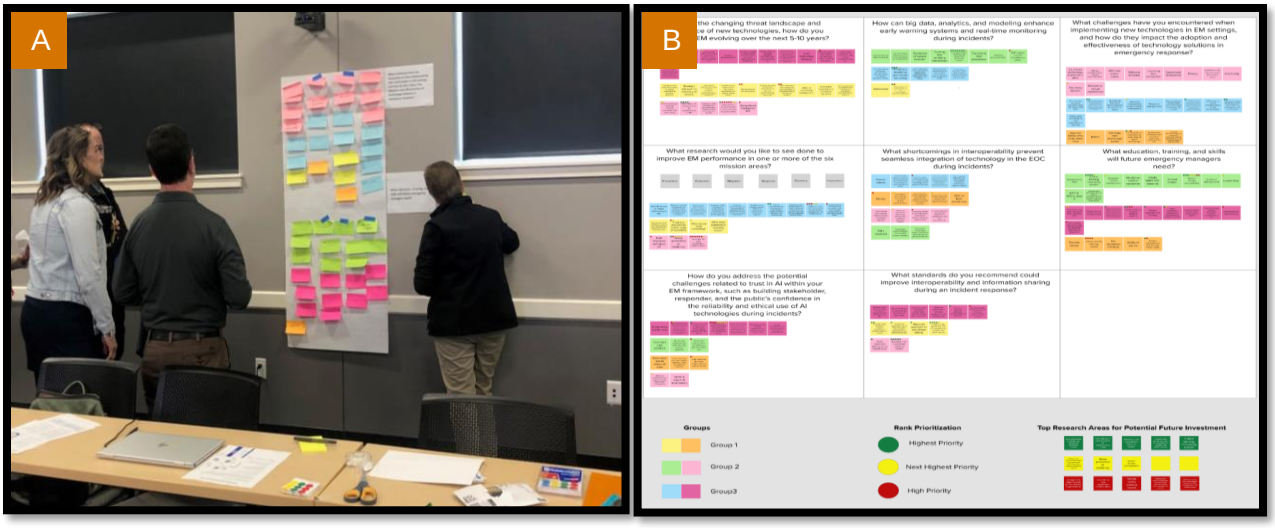


Figure 4. Representative activities from both the in-person (A) and virtual (B) focus groups. Figure 4A highlights participant interaction at the in-person focus group held in Boulder, Colorado. Figure 4B highlights Mural, an online collaboration tool that PNNL used to capture input and facilitate discussion during the virtual focus group.

3.2.1 In-Person Focus Group

In Boulder, Colorado, PNNL co-hosted an in-person focus group with the Office of Disaster Management for the City of Boulder and Boulder County for operational EM personnel to evaluate the efficacy of existing research in addressing capability gaps within EM. Throughout four rounds of guided collaboration, participants in each group discussed their contributions to the questions addressing interoperability, standards, enterprise architecture, and transition impediments. Following each discussion, the large group collectively reviewed and discussed the key takeaways such that insights were captured and understood. Key points from each round of collaboration are summarized in Tables 1-4. Detailed in-person focus group protocols are available in Appendix B.

Table 1. Key Takeaways from Focus Group Round One

Focus Group Round One Takeaways	
Debate on Standardization	Participants were divided regarding the necessity of standardization, with some advocating for it while others opposed it.
Technology Interoperability	Despite the abundance of available technology, focus group participants cited persistent issues with interoperability, cost, and licensing.
Concerns about Technology Overload	Participants cited concern that technology can overwhelm operations, leading to the creation of an "Office of Everything."
Stand-alone Cyber Capability	EOCs should have stand-alone cyber capabilities rather than relying solely on an Emergency Manager.

Table 2. Key Takeaways from Focus Group Round Two

Focus Group Round Two Takeaways	
Low-Orbit Satellite Imagery	Participants suggested the use of low-orbit/low-satellite imagery in EM to aid in disaster assessment, search and rescue operations, evacuation route monitoring, damage assessment, early warning systems, and environmental monitoring.
Trust Challenges	Trust issues persist regarding emerging technology, specifically AI, and the necessity for policies and products to address it while also considering potential misuse by bad actors.
Integration Challenges	Participants highlighted the difficulty of integrating software with existing tools and emphasized the importance of password management and future skills development.
Importance of Standards and Regional Approaches	Increased advocacy is needed for developing standards for interoperability and adopting a regional, county-wide approach for data-sharing and AI agreements.

Table 3. Key Takeaways from Focus Group Round Three

Focus Group Round Three Takeaways	
EOC Constraints	EM is stretched thin, with EOCs often managing multiple simultaneous responses and recoveries.
Technology Impact on EOCs	Implementing new technology may push EOCs beyond their intended capacities.
Innovative Training Methods	Creative training methods can be explored for EOC personnel, such as utilizing holograms for historical fire training.
Call for Increased Federal Investment	Increased federal investment could enable the development, testing, and deployment of technology solutions at the local level.

Table 4. Key Takeaways Regarding Applications for AI (Rounds One, Two, and Three)

Applications for AI (Rounds One, Two, and Three) Takeaways	
Situation Reports	AI can aid in planning by generating situation reports.
Exercise Development	AI can assist in building exercises and injects for training scenarios.
Predictive Analytics	AI has potential applications in predictive analytics for emergency response planning.

3.2.2 Virtual Focus Group

In addition to the in-person focus group, PNNL organized a virtual focus group with operational EM personnel to assess the effectiveness of current research in addressing EM capability gaps, focusing on interoperability, standards, enterprise architecture, and transition impediments. Detailed virtual focus group protocols are available in Appendix C. Table 1 summarizes key areas and opportunities identified during the virtual focus group.

Table 1. Key Takeaways from the Virtual Focus Group

Virtual Focus Group Takeaways	
Emphasis on Social Science in EM	• Participants emphasized the importance of understanding human-centric approaches in EM. • Validating AI was discussed regarding understanding and predicting human behavior during emergencies.
Utilization of AI in EM	• Participants discussed various applications of AI in EM, including emergency communications, providing information to first responders, deconfliction of documents, and reconciling data. • AI could be a tool to bridge the gap between technological advancements and practical application in emergencies.
Challenges and Opportunities in Integrating Technology	• Challenges included policy, privacy concerns, integration, and interoperability issues. • Better collaboration between researchers, operators, and funding sources could benefit the effective integration of new technologies.
Improving Adoption of New Technology	• Suggestions included reducing repetitive tasks, showcasing data to demonstrate value, providing adequate training, and building trust in new technologies among the public.
Interoperability Challenges and Solutions	• Difficulties in interoperability during response and recovery were highlighted, such as translation issues and disconnect between stakeholders. • Recommendations included using open standards and licensing to improve interoperability and information sharing.
Future Directions in EM Research	• Research areas discussed included community resilience, social/behavioral influences, risk modeling, and improving communication and data integration. • Participants expressed a need for continued focus on understanding human behavior, improving technology integration, and enhancing public trust in emergency information.

3.2.3 Focus Group Prioritization

Following the in-person and virtual focus group sessions, participants engaged in providing real-time feedback, prioritizing key areas of research for future investment and exploration. The top-ranked research areas identified during these discussions encompassed a wide range of critical topics, including:

- **Different Model for EOC Management (All Mission Areas)** - Participants emphasized the need for a departure from conventional command and control methodologies toward more innovative models capable of addressing all mission areas effectively. This transition aligns with broader efforts to enhance the resilience and adaptability of EM systems.
- **Change from Surge Concept to Core Division of Government** – Participants concurred regarding the need to transform the surge concept into an integral component of governmental divisions. This transition underscores the importance of embedding resilience and preparedness measures as fundamental elements within government structures.
- **Augmented Reality/Virtual Reality Capabilities** - The exploration of augmented reality and virtual reality technologies emerged as a priority for enhancing emergency response capabilities. Integrating augmented reality and virtual reality into training programs and operational procedures can provide immersive, realistic simulations to facilitate better decision-making and preparedness.

- **Systems Integration (Systems-of-Systems)** - Addressing the complexities of modern emergencies requires a comprehensive approach to systems integration. Participants stressed the importance of developing interconnected systems-of-systems to streamline information sharing, coordination, and resource allocation across various response agencies and stakeholders.
- **Low-Orbit Space Satellites** - Participants highlighted the potential of low-orbit space satellites for enhancing communication and situational awareness during emergencies. Moving away from reliance on terrestrial towers can improve resilience and coverage, especially in remote or disaster-affected areas.
- **EM Staffing, IT Core Group for AI/Cybersecurity in EM** - Recognizing the evolving nature of emergencies and technology, participants underscored the importance of staffing EM agencies with dedicated IT core groups focusing on AI and cybersecurity. This ensures proactive measures to address emerging threats and leverage technological advancements effectively.
- **Develop New Operational Planning Model** - Participants advocated for the development of innovative operational planning models tailored to contemporary EM challenges. This includes incorporating dynamic factors such as cascading events, critical thinking, and ethical considerations into planning processes.
- **County-wide Agreement with Municipalities, Private, and Public Sectors** - Establishing county-wide agreements encompassing municipalities, private entities, and public sectors emerged as a critical priority. Such agreements facilitate seamless coordination, resource sharing, and collaboration across jurisdictional boundaries during emergencies.
- **Redefine the National Preparedness Goal's 32 Core Capabilities**[1] - Participants suggested revisiting and redefining the existing core capabilities framework to better align with evolving EM paradigms and challenges. This entails identifying and prioritizing capabilities essential for modern emergency response and preparedness.
- **Address Ethical Challenges and Standards Driving AI Policy and Processes** - Acknowledging the growing role of AI in EM, participants emphasized the need to address ethical challenges and establish standards guiding AI usage. This supports responsible and ethical deployment of AI technologies in decision-making processes.
- **System Design Management** - Enhancing system design management emerged as crucial for optimizing the efficiency and effectiveness of EM systems. This includes designing systems that are adaptable, resilient, and capable of addressing evolving threats and challenges.

By prioritizing these research areas and suggestions, stakeholders hope to influence the advancement of the capabilities and resilience of EM systems, ensuring better preparedness and response to future crises. Additionally, participants unanimously agreed that the efficacy of ongoing research efforts is not the primary concern. Instead, the prevailing challenge lies in enabling accessibility and awareness of the research community's findings to facilitate the development of practical tools applicable in real-world scenarios rather than remaining solely theoretical. The top categories outlined in the Task 2 Landscape Assessment received concurrence among operational personnel, aligning with the key areas they prioritize for future research endeavors.

[1] FEMA. Mission Areas and Core Capabilities. https://www.fema.gov/emergency-managers/national-preparedness/mission-core-capabilities

4.0 Key Insights

Collectively, research and operational personnel interviewed and who participated in the in-person and virtual focus groups identified the following potential opportunities for future R&D efforts:

- **Integration of Emerging Technology** - Technology advancements, particularly in AI, data analytics, and remote sensing, offer promising avenues for enhancing decision-making workflows during emergencies. Developing AI-driven decision support systems tailored to specific contexts can provide real-time insights, enabling practitioners to make more informed and timely decisions in dynamic crises. Furthermore, the integration of AI and emerging technologies such as drones, Internet-of-Things sensors, and satellite imagery can significantly improve situational awareness and facilitate rapid assessment of disaster impacts, thus improving response coordination and resource allocation.
- **Update Frameworks and Protocols** - Refining interdisciplinary frameworks and legacy protocols to promote collaboration among diverse stakeholders, including government agencies, nonprofit organizations, private sector entities, and local communities. Legacy EM protocols require updating due to evolving societal dynamics, technological advancements, and emerging threats. The traditional one-size-fits-all approach may not adequately address the complexities of modern hazards, such as cyberattacks, climate change-induced disasters, and pandemics.
- **Focus on Scalability and Adaptability** - Potential research endeavors should prioritize the development of adaptable and scalable EM strategies to be responsive to evolving threats, demographic shifts, and climate change impacts. This involves conducting scenario-based planning exercises, modeling complex systems dynamics, and integrating scenario forecasting techniques to anticipate emerging risks and vulnerabilities.
- **Enable Human-Centric Approaches** - The human-centric approach of emergency managers during emergencies should investigate the psychological impacts of high-stress situations, including decision-making under pressure and coping mechanisms, while examining the role of communication, leadership styles, and organizational dynamics in effective crisis management. Additionally, research should explore the influence of external pressures, such as political considerations, public expectations, and the importance of diversity, equity, and inclusion in EM leadership. By addressing these areas, researchers can provide valuable insights into the complexities of EM decision-making and develop evidence-based strategies to enhance the resilience and effectiveness of emergency response efforts.

5.0 Conclusion

Across the EMOTR Task 3B interviews and in-person and virtual focus groups, research and operational personnel engaged in discussions regarding the effectiveness of current research and explored future opportunities to close the EM capability gaps, with a focus on interoperability, standards, enterprise architecture, and transition impediments. Key insights, priorities, and recommendations from their feedback are as follows:

- **Transition Impediments** - To overcome technology transition impediments when implementing new technologies such as AI, data analytics, and remote sensing in EM, comprehensive training and education programs should be required for personnel. These programs help emergency managers and responders build the necessary skills to use the

technology in dynamic crises. Pilot programs and testing before full-scale deployment allow for potential issues to arise early on, enabling adjustments to better align with operational needs. Collaboration with technology developers, research institutions, and stakeholders provides valuable resources and expertise, facilitating successful integration. Flexibility and adaptability are crucial as technology evolves rapidly, requiring emergency managers to remain open to new advancements and adjust strategies accordingly. Additionally, community engagement, transparent communication, and federal support concerning the benefits and usage of technologies foster trust and acceptance among stakeholders.

- **Enterprise Architecture** - Future R&D efforts in enterprise architecture for EM can explore several avenues to address capability gaps and enhance response capabilities. Integrating emerging technologies such as cloud computing, Internet of Things, and big data analytics into the architecture framework can facilitate real-time data collection, analysis, and decision-making processes. Additionally, research is needed to inform interoperable standards that promote seamless integration and communication among diverse systems and stakeholders. Exploring the application of AI/ML algorithms within the architecture can enhance predictive capabilities, optimize resource allocation, and improve overall response coordination.
- **Interoperability** - Future R&D efforts focused on interoperability for EM hold significant promise in addressing capability gaps and enhancing overall response effectiveness. One key area of exploration involves advancing interoperable communication systems and data exchange platforms tailored to the dynamic needs of emergency responders. Developing standardized protocols and technologies that enable seamless information sharing among diverse agencies and jurisdictions can facilitate more efficient coordination and decision-making during crises. Additionally, research is needed into interoperable Geographic Information Systems tools, which can integrate spatial data from multiple sources to provide comprehensive situational awareness and support resource allocation efforts. Finally, exploring innovative training programs and exercises designed to enhance interoperability among multidisciplinary response teams can help refine operational procedures and foster a culture of collaboration.
- **Standards** - Future R&D of standards holds immense potential for addressing capability gaps in EM. One critical area for exploration is the integration of emerging technologies, such as AI, ML, and unmanned aerial vehicles, into existing emergency response systems. Research can focus on developing standardized protocols for using these technologies in various aspects of EM, including rapid situational assessment, resource allocation, and decision support. Standards can promote interoperability among diverse response agencies and jurisdictions, enabling seamless communication and data sharing during crises. Standardized protocols for information sharing help relevant information reach the right stakeholders promptly, enhancing situational awareness and enabling more informed decision-making during emergencies. By establishing clear guidelines for data exchange and communication, these standards can help optimize resource allocation and improve response efficiency.

5.1 Next Steps

This task sought to elicit stakeholder input from interviews and in-person and virtual focus group input to understand the effectiveness of current research in closing EM capability gaps in consideration of interoperability, standards, enterprise architecture, and transition impediments. Figure 5 Figure 5 highlights key priorities and areas of research for improving EM functions, as was discussed in nine interviews and two focus groups with EM R&D personnel.

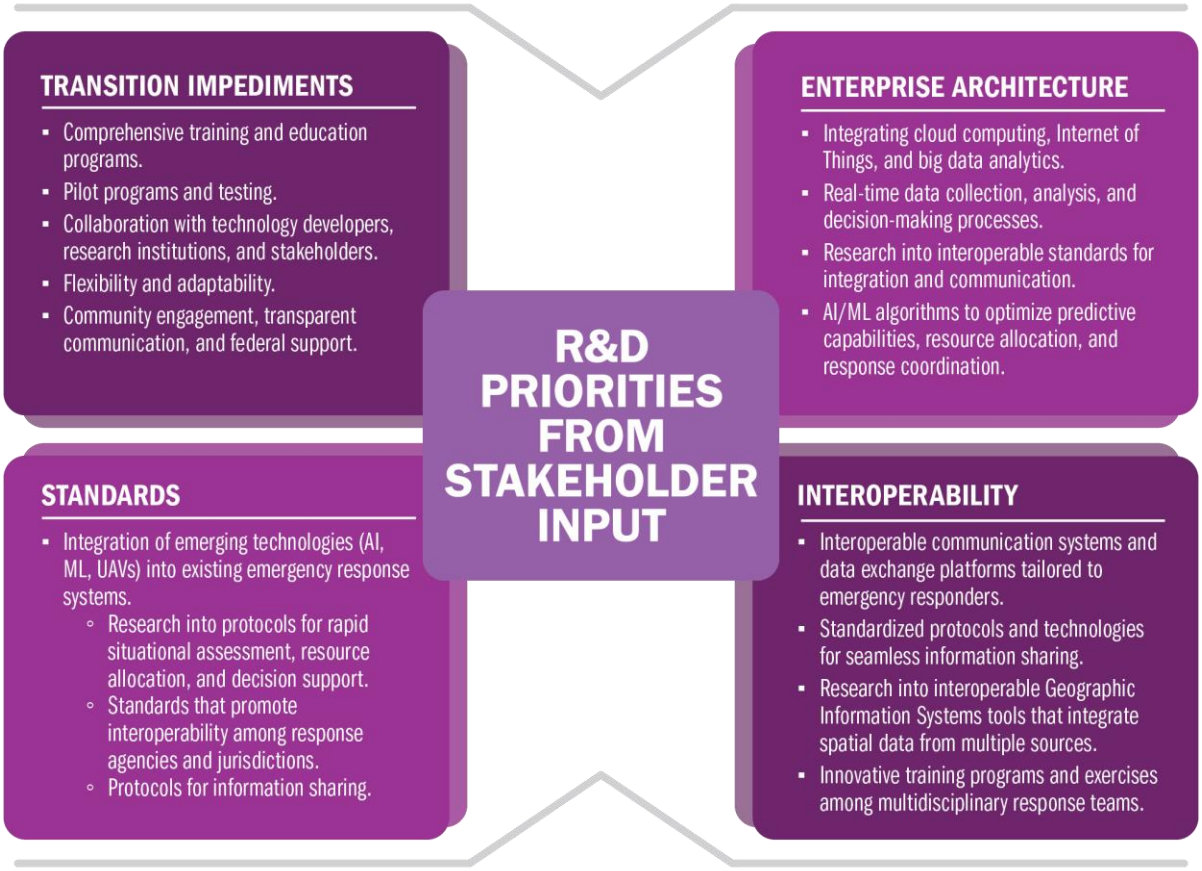


Figure 5. EMOTR interviews and focus group discussions identified key priorities and areas of research for addressing capability gaps in consideration of interoperability, standards, enterprise architecture, and transition impediments.

Insights from this task will guide future EMOTR outreach and elicitation efforts. These efforts will further refine priority technology gaps and capability needs to include outreach to EM operational personnel to review ongoing research programs, assess their effectiveness, identify gaps, and connect with EM R&D stakeholders to foster community coordination around research needs underrepresented in the current research ecosystem. The combined outputs of this guided elicitation will help DHS S&T inform future research and investments.

Appendix A – EM Researcher Interview Questions

EM Researcher Interviews
Interview overview:

- 30 minutes
- 2 people; one to lead discussion; other to capture and summarize interview input.

To better understand the research needs in the emergency management community, Pacific Northwest National Laboratory (PNNL), with support from the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), is conducting interviews to understand **how research impacts operational functions**. The objective is to gain insight into the current research landscape and identify and review ongoing research initiatives to assess their effectiveness and identify persisting gaps.

Interview Questions

1. Can you provide a brief overview of your current research, highlighting the specific areas or topics you are investigating relevant to emergency management?

2. Regarding your research, how do you ensure that your work is applicable and beneficial for practitioners and policymakers involved in emergency management?

3. How has the integration of technology, such as artificial intelligence or data analytics, influenced the way emergency management tools are researched and implemented?

4. What role do interdisciplinary collaborations (life sciences, engineering, social sciences, policy, etc.) play in advancing our understanding of effective emergency management strategies?

5. What do you see as the top research priorities in emergency management for the next decade? Within those priorities are there any specific research efforts you see as promising? How do these align with the evolving landscape of risks and threats?

6. Considering the dynamic nature of emerging threats, such as bioterrorism or cyber threats, where do you see gaps in research that hinder our ability to anticipate and respond effectively to these evolving challenges?

7. In your opinion, what emerging trends or developments in the field of emergency management are not adequately addressed by current research, and where do you see opportunities for future exploration?

8. How has the increasing frequency and intensity of natural disasters impacted the direction and emphasis of emergency management research, and what implications does this have for future preparedness efforts?

9. Are there specific cultural or social factors that are recognized as significant influencers in the success or failure of emergency management initiatives? If so, how does this shape research agendas?

Appendix B – In-Person Focus Group Protocol

Goals

- To validate the Emergency Management of Tomorrow Research (EMOTR) landscape assessment and elicit new or previously unidentified technology gaps and needs from the emergency management community in a collaborative and interactive manner.

- The project's scope is unclassified and is not anticipated to impinge on any classified areas; however, there is the potential that some input may possibly need to be marked FOUO once conversations have occurred, so we just want everyone to be cognizant of that as we work through this process.

Protocol – 2.5 Hours Total

To foster a comprehensive discussion, PNNL formulated questions targeting the key areas of interoperability, standards, enterprise architecture, and transition impediments, as outlined in the statement of work. Employing a "gallery walk" format, participants moved through the conversation, providing insights and feedback in real time. PNNL gathered input from participants by separating the larger group into three smaller groups and employed flip charts to record their thoughts and ideas as they navigated through each question within the "gallery." For efficiency and structured engagement, participants were given a time limit of 10 minutes to respond to each question and an additional 3 minutes for providing a readout to the group. After completing all four stations with two questions each, participants were given 15 minutes to review answers from their colleagues and prioritize them using green, yellow, and red dots. In this scale, green dots indicated participants' highest priority for near-term research. To facilitate continuous engagement and updates, post-event, the PNNL team utilized the Mural virtual whiteboard platform, allowing participants to contribute and review information seamlessly. This approach enabled the team to gather diverse perspectives and valuable input from frontline EM practitioners, enhancing our understanding of the practical challenges and opportunities in bridging capability gaps within the field.

Preparation – 40 minutes

Background/Objective **– 15 minutes**

- Background/Context Information – 10 minutes
- Goals of Workshop – 5 minutes
    - Describe the desired outcomes of the engagement.
        - To validate the EMOTR Task 2 Landscape Assessment and elicit new or previously unidentified technology gaps and needs from the emergency management community.

Icebreaker/Introductions **– 25 minutes**

- What is your favorite tool in your emergency management toolbox?

Main Topic Review – 80 minutes

Gallery Walk **– 80 minutes**

- **Gallery Walk**: Split the 18 participants into three groups of six and direct each group to a different station; four stations with two questions each. Upon arriving at the station, each team writes comments for the question posed at the station – *10*

minutes per question; 3 minutes to review the question; 5 minutes to answer the question; 2 minutes to report out.

- **Rotate to New Station and Add Content**: The group then rotates, clockwise, to the next station. At the new station the group adds new comments with their assigned colored post-it notes – *10 minutes per station; 3 minutes to review the question; 5 minutes to answer the question; 2 minutes to report out*.

Questions

The Future of Emergency Management

1. Given the changing threat landscape and influence of new technologies, how do you foresee EM evolving over the next 5-10 years?
2. How can big data, analytics, and modeling enhance early warning systems and real-time monitoring during incidents?

Current State of Emergency Management Research

1. What research would you like to see done to improve EM performance in one or more of the five mission areas?

    - Prevention
    - Protection
    - Mitigation
    - Response
    - Recovery

2. What education, training, and skills will future emergency managers need?

Operational Challenges

1. What challenges have you encountered when implementing new technologies in EM settings, and how do they impact the adoption and effectiveness of technology solutions in emergency response?
2. How do you address the potential challenges related to trust in AI within your EM framework, such as building stakeholder, responder, and the public's confidence in the reliability and ethical use of AI technologies during incidents?

System Architecture, Interoperability, Standards

1. What shortcomings in interoperability prevent seamless integration of technology in the EOC during incidents?
2. What standards do you recommend could improve interoperability and information sharing during an incident response?

Prioritization/Next Steps – 30 minutes

Prioritization – 20 minutes

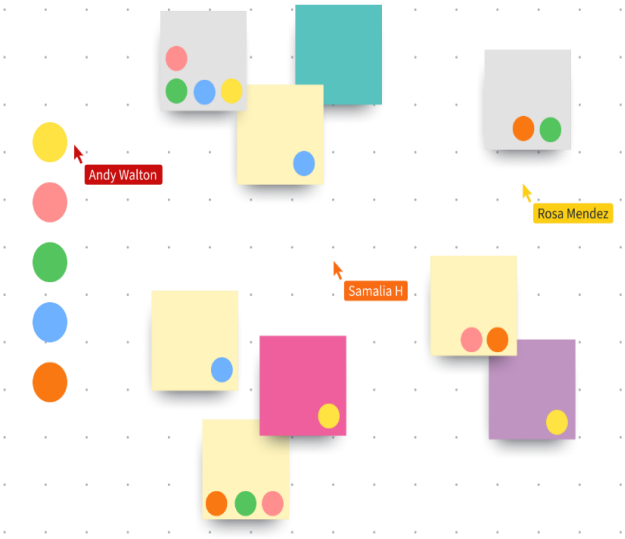
Each question set will be displayed on the wall. Then, participants are given a few dot stickers or varying colors (green, yellow, red) to place on the idea(s) or options they want to highlight as being a top priority. The discussion points with the most dots next to it is ranked high priority, based on the dot color scheme. It allows participants to voice a preference for multiple options, which can then be analyzed on the back end by the PNNL team.

1. Give each participant a set of dot stickers

Each participant will receive three green, three yellow, and three red dots – the colors correlate to the prioritization level of each participant.

2. Clarify voting constraints

Before prioritization, explain that we are holding a vote to prioritize the topics to help DHS S&T identify and provide research insights in emergency management requirements.



3. Prioritization

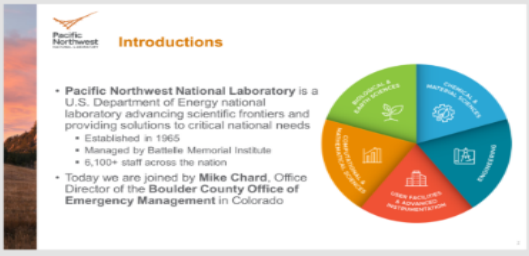
Each person sticks their dots on one or more options – the PNNL team will then analyze these on the back end and map them to the four areas highlighted by DHS S&T.

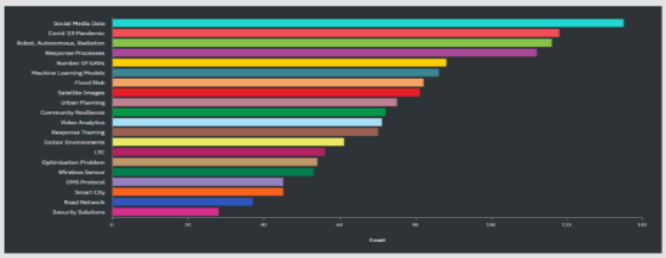
Closing/Next Steps – 10 minutes

Below are screen captures of the Mural board the PNNL team used for the virtual focus group. Mural is a digital workspace platform that facilitates remote collaboration and visual thinking. It provides a virtual canvas where teams can brainstorm, plan, and work together in real time, utilizing various tools, templates, and integrations. Access to the final EMOTR Mural board is available upon request to emotr@pnnl.gov.

Boulder, Colorado EMOTR Focus Group

What is your favorite tool in your emergency management toolbox?





Given the changing threat landscape and influence of new technologies, how do you foresee EM evolving over the next 5-10 years?

How can big data, analytics, and modeling enhance early warning systems and real-time monitoring during incidents?

What challenges have you encountered when implementing new technologies in EM settings, and how do they impact the adoption and effectiveness of technology solutions in emergency response?

What research would you like to see done to improve EM performance in one or more of the six mission areas?

What shortcomings in interoperability prevent seamless integration of technology in the EOC during incidents?

What education, training, and skills will future emergency managers need?

How do you address the potential challenges related to trust in AI within your EM framework, such as building stakeholder, responder, and the public's confidence in the reliability and ethical use of AI technologies during incidents?

What standards do you recommend could improve interoperability and information sharing during an incident response?

Groups

Group 1

Group 2

Group3

Rank Prioritization

Highest Priority

Next Highest Priority

High Priority

Top Research Areas for Potential Future Investment

Appendix C – Virtual Focus Group Protocol

Goals

- To validate the Emergency Management of Tomorrow Research (EMOTR) landscape assessment and elicit new or previously unidentified technology gaps and needs from the emergency management community in a collaborative and interactive manner.

- The project's scope is unclassified and is not anticipated to impinge on any classified areas; however, there is the potential that some input may possibly need to be marked FOUO once conversations have occurred, so we just want everyone to be cognizant of that as we work through this process.

Protocol – 2.5 Hours Total

To foster a comprehensive discussion, PNNL formulated questions targeting the key areas of interoperability, standards, enterprise architecture, and transition impediments, as outlined in the statement of work. Leveraging operational personnel's expertise, asking about challenges faced, examples encountered, current approaches, and envisioned improvements in each area, ensured comprehensive insights for filling capability gaps effectively. These questions were designed to elicit specific, actionable feedback from operational personnel, enabling PNNL to pinpoint key issues and develop tailored solutions aligned with operational realities. With targeted questions to cover the four focus areas, PNNL facilitated the discussion using its proven Innovation Foundry virtual ideation approach, allowing participants to contribute insights and feedback in real time. Using the Mural online virtual whiteboard platform, PNNL facilitated continuous engagement and allowed participants to update information seamlessly. This approach provided valuable perspectives from frontline practitioners, enhancing understanding of the practical challenges and opportunities in closing capability gaps within EM.

Preparation – 40 minutes

Background/Objective **– 15 minutes**

- Background/Context Information – 10 minutes
- Goals of Workshop – 5 minutes
    - Describe the desired outcomes of the engagement.
        - To validate the EMOTR Task 2 Landscape Assessment and elicit new or previously unidentified technology gaps and needs from the emergency management community.

Icebreaker/Introductions **– 25 minutes**

- What is your favorite tool in your emergency management toolbox?

Main Topic Review – **100 minutes**

- Question Review – 1 hour 20 minutes (10 minutes per Question)
- Mural Introduction and Orientation (5 minutes)

Questions

The Future of Emergency Management

1. Given the changing threat landscape and influence of new technologies, how do you foresee EM evolving over the next 5-10 years?
2. How can emerging technologies like AI and machine learning revolutionize emergency management?

Current State of Emergency Management Research

3. What current or future technologies enhance effectiveness over 1 or more of the 5 mission areas?

    - Prevention
    - Protection
    - Mitigation
    - Response
    - Recovery

4. What research would you like to see done to improve EM performance in one or more of the five mission areas?

    - Prevention
    - Protection
    - Mitigation
    - Response
    - Recovery

Operational Challenges

5. What challenges have you encountered when implementing new technologies in EM settings, and how do they impact the adoption and effectiveness of technology solutions in emergency response?
6. How do we improve adoption of new technology for EM?

System Architecture, Interoperability, Standards

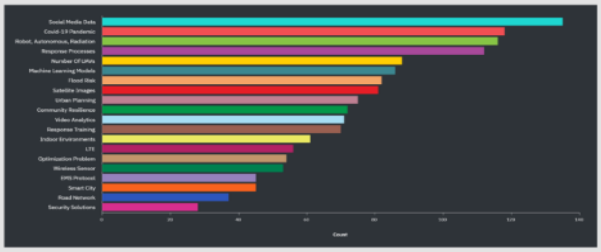
7. Can you highlight examples where interoperability has been difficult during response and recovery?
8. What standards do you recommend could improve interoperability and information sharing during an incident response?

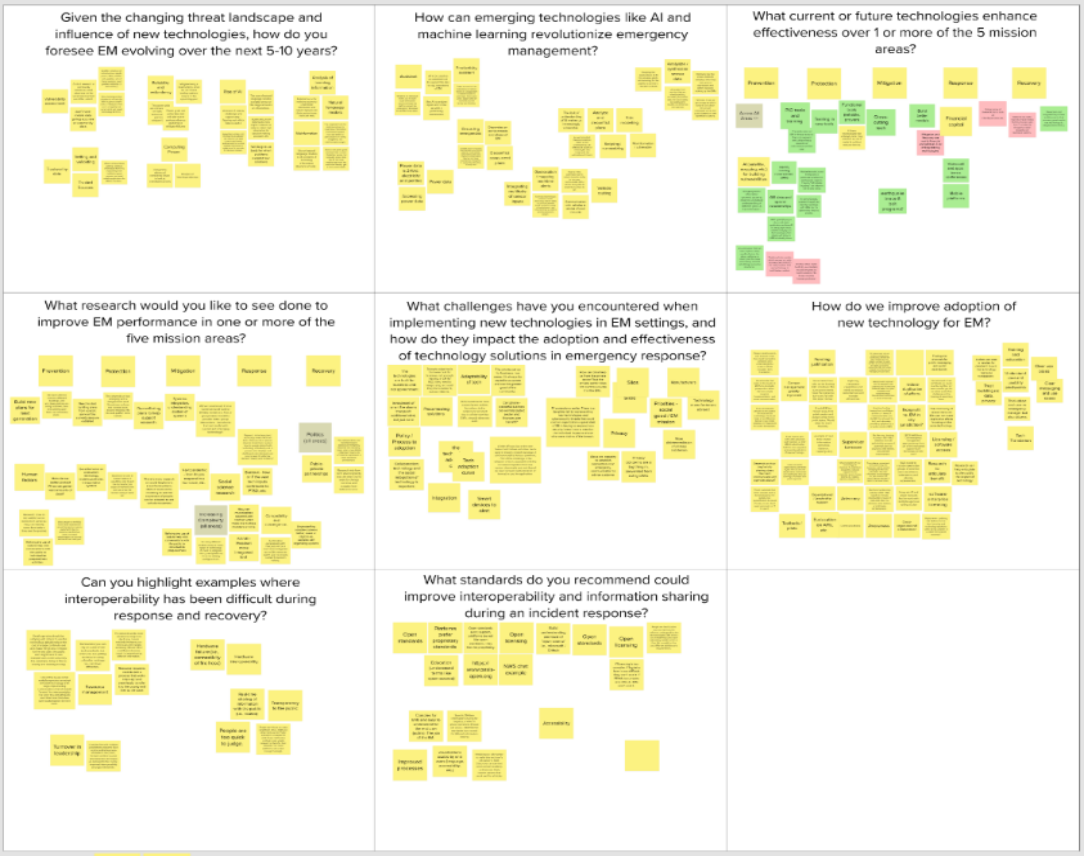
Closing/Next Steps – 5 minutes

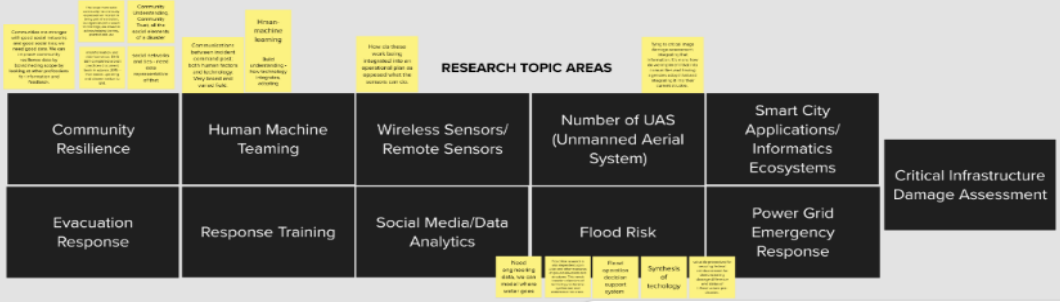
Below are screen captures of the Mural board the PNNL team used for the virtual focus group. Mural is a digital workspace platform that facilitates remote collaboration and visual thinking. It provides a virtual canvas where teams can brainstorm, plan, and work together in real time, utilizing various tools, templates, and integrations. Access to the final EMOTR Mural board is available upon request to emotr@pnnl.gov.


Pacific Northwest National Laboratory
• Pacific Northwest National Laboratory (PNNL) is a U.S. Department of Energy national laboratory advancing scientific frontiers and providing solutions to critical national needs
▪ Established in 1965
▪ Managed by Battelle Memorial Institute
▪ 6,100+ staff across the nation
• PNNL has a long-standing history of supporting the Department of Homeland Security with science and technology, research, and stakeholder engagement to benefit emergency management and first responder missions


Emergency Management of Tomorrow Research
Project Breakdown:
• EM R&D Landscape Assessment
• Elicit EM Stakeholder Input
• Communications
• AI Research Landscape Summary
• EOC of the Future Recommendations Report
EMERGENCY OPERATIONS CENTER OF THE FUTURE
COORDINATION
FUTURE OF EMERGENCY MANAGEMENT
APPLIED RESEARCH
FUTURE THREATS RESEARCH




Given the changing threat landscape and influence of new technologies, how do you foresee EM evolving over the next 5-10 years?
How can emerging technologies like AI and machine learning revolutionize emergency management?
What current or future technologies enhance effectiveness over 1 or more of the 5 mission areas?
What research would you like to see done to improve EM performance in one or more of the five mission areas?
What challenges have you encountered when implementing new technologies in EM settings, and how do they impact the adoption and effectiveness of technology solutions in emergency response?
How do we improve adoption of new technology for EM?
Can you highlight examples where interoperability has been difficult during response and recovery?
What standards do you recommend could improve interoperability and information sharing during an incident response?


RESEARCH TOPIC AREAS
Community Resilience
Human Machine Teaming
Wireless Sensors/ Remote Sensors
Number of UAS (Unmanned Aerial System)
Smart City Applications/ Informatics Ecosystems
Critical Infrastructure Damage Assessment
Evacuation Response
Response Training
Social Media/Data Analytics
Flood Risk
Power Grid Emergency Response

Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354

1-888-375-PNNL (7665)

www.pnnl.gov