



PART 1

TRIAGE:

WHAT FIRST RESPONDERS REALLY NEED

iTEK - Innovative Technologies for European Disaster Response
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Dear Reader,

Welcome to the first white paper in our two-part iTEK series bringing together the voices of first responders and the possibilities of emerging digital technologies, with the aim of improving disaster preparedness and response across Europe and beyond.

In this first paper, the focus is firmly on the field. Through exercises, surveys, and direct engagement with practitioners, we have gathered and structured the needs of first responders into clear clusters. The result is a picture of what matters most in operations today: practical, resilient solutions that truly support those at the front line.

The second paper will build on these insights, turning to the technological perspective. It will explore which technology fields are most relevant, how research and market developments are evolving, and how these can be aligned with the operational requirements identified here.

Together, the two papers are intended as companions: one rooted in the experience of those who respond, the other in the innovations that can empower them.

We hope this series provides both useful insights and a foundation for future dialogue between practitioners, researchers, and technology developers.

// BRIEFING

Over the past decades, the frequency and intensity of disasters in Europe and worldwide have increased significantly. Floods, wildfires, earthquakes, and other natural and human-made hazards are occurring more often and with greater impact, leading to loss of life, destruction of infrastructure, and severe economic consequences. In the European Union alone, wildfires caused estimated losses of €54 billion between 2000 and 2017. [1] These developments underline the urgent need for innovative disaster management solutions that enhance preparedness, response, and resilience.

While first responders and disaster relief organizations are experts in operational response, they often lack the resources, technical expertise, and structured processes necessary to identify, evaluate, and select suitable technologies. As a result, many technological solutions remain underutilized, or investments are made in systems that do not fully meet operational requirements. The absence of a systematic and independent technology assessment mechanism further exacerbates this problem.

The **ITEK project** (Innovative Technologies for European Disaster Response) [2] was launched by BIBA, @fire, ASB and SWMS to generate knowledge and guide the research process in the field of disaster technologies. Its purpose is to establish a foundation for evidence-based and needs-driven research.

BIBA – Bremer Institut für Produktion und Logistik GmbH is an engineering research institute at the University of Bremen focusing on intelligent products, processes and information and communication applications.

@fire - Internationaler Katastrophenschutz Deutschland e.V. is a volunteer-led nonprofit that responds to wildland fires (WFF) and Urban Search and Rescue (USAR) operations nationally and internationally.

Arbeiter-Samariter-Bund (ASB) is a national non-profit aid organisation providing emergency medical services, first aid training and services and are involved in the civil protection and civil defence.

SWMS Consulting GmbH is a technology consulting firm focused on innovative software and IoT solutions.

We focus on two key aspects:

1. Gaining a deep understanding of the actual needs of first responders, based on direct engagement with practitioners through workshops, exercises, and surveys.
2. Mapping the relevant technology fields and evaluation dimensions, including standards, data spaces, and integration requirements, in order to create a structured knowledge base for further research.

By combining these perspectives, we provide a steering mechanism that helps align technological innovation with the real-world demands of disaster response.

This paper presents an in-depth analysis of the operational needs and requirements of first responders, derived from field observations, interviews, and online surveys. It structures these needs into clusters that can serve as a foundation for technology-related research.

Building on these identified needs, [Part 2 of this series](#) maps the technological landscape relevant for disaster management. It reviews existing and emerging technology fields, market trends, and research approaches, and proposes measures for effective research and development.





APPROACH

This white paper is based on a structured, multi-layered research process designed to capture and systematize the real needs of first responders in disaster management. The methodology combines qualitative field engagement with quantitative data collection, ensuring that the results are both empirically grounded and analytically robust.

Field Engagement and Observation

Initial insights were gained through direct participation in disaster response exercises, professional summits, and international training events. These included large-scale disaster response simulations and specialized training and evaluation missions. By observing and interacting with practitioners in their operational environment, the research team collected first-hand accounts of technological challenges and gaps.

Workshops and After-Action Reviews (AARs)

Structured workshops with relief organizations, supported by experienced partners such as @fire and ASB, provided a platform to capture operational requirements systematically. After-Action Reviews of real-world missions and exercises offered additional perspectives, highlighting recurring challenges and unmet needs that could be addressed through technological innovation.

Surveys and Online Study

To complement the qualitative findings, an online survey was conducted targeting a broader spectrum of stakeholders in disaster management. This approach allowed the collection of comparable data across different organizations and regions, facilitating the identification of patterns and clusters of needs.

Synthesis and Clustering

The collected data were systematically analyzed and categorized into clusters of needs. These clusters represent recurring themes such as communication, situational awareness, interoperability, logistics, and responder safety. This structure provides a basis for aligning future technology assessment and research efforts with real operational demands.

Validation through Stakeholder Feedback

Preliminary findings were discussed with first responders and technology experts to validate the relevance and completeness of the identified clusters. This iterative process ensured that the results reflect operational reality rather than external assumptions.

By combining first-hand operational input with structured analysis, this approach ensures that the white paper delivers a reliable representation of what first responders actually need. The results serve as a knowledge base and compass for guiding subsequent research and technology development in disaster response.

// SITREP

Understanding the needs of first responders requires more than theoretical analysis. It demands proximity to operations, direct observation under stress, and dialogue with those who carry out disaster response in practice. To this end, iTEK engaged across a series of exercises, summits, trade fairs, and operational deployments. These engagements provided critical insights into recurring challenges, systemic gaps, and the potential role of technology in strengthening response capacity.

FIRST RESPONDER EXERCISES

Large-scale exercises and real operations offered structured opportunities to document the perspectives of practitioners,

observe challenges in real time, and identify priority areas for improvement. By participating directly in these events, the initiative was able to capture experiences from the field and translate them into evidence for research and development. The following case studies illustrate how different operational contexts revealed distinct gaps and requirements for future technological solutions.

FullEx “Achilles” – May 2024

The Achilles crisis management exercise in Epeisses/Geneva simulated disaster scenarios in an urban European setting, designed to test multi-agency coordination under a layered incident command system. Within this broader framework, the project team was able to experiment how digital dashboards and situational awareness platforms supported coordination among participating services. From our perspective, a key lesson was the importance of dynamic feedback loops. Responders repeatedly emphasized that command structures must be able to adapt quickly to rapidly changing field conditions if such tools are to deliver real operational value. One mayor issue is the possibility to scale up systems for emergency responders equally as the disaster progresses and needs to be able to scale down after the peak of the incident.

FullEx “Magnitude” – October 2024

The Magnitude [3] exercise in southwest Germany was conducted under the EU Civil Protection Mechanism as a full-scale (FSX) earthquake response scenario involving international Urban Search and Rescue teams. Within this setting, our observations focused on the operational challenges of multinational coordination. Differences in communication systems between units complicated real-time information exchange, while shifting priorities during the simulation highlighted difficulties in reallocating scarce resources. In addition, language barriers proved to be a persistent obstacle, as interpretation services were limited in their ability to keep pace with operational demands.

Large-scale Evacuation Osnabrück – November 2024

In Osnabrück, approximately 14,000 residents were evacuated during the disposal of seven unexploded bombs from the Second World War. The Arbeiter-Samariter-Bund (ASB) coordinated transport, with a particular focus on organizing ambulance capacity for vulnerable groups. From our perspective, the operation revealed how bottlenecks in information flow between coordination centers and field units can complicate evacuation management. The experience underlined the need for digital tools that streamline reporting processes and accelerate communication during large-scale civilian movements.

AirOps-Exercise – March 2025

The AirOps exercise focused on coordination between air and ground forces during wildfire response. Helicopters play multiple roles in Wildland Fire Fighting, from aerial assessment and water drops to transporting personnel and equipment. Our engagement in this context highlighted how the involvement of spe-

cialized police and military units increases operational complexity. Observations confirmed that effective and safe operations depend on close coordination across all actors, and that communication in remote terrain poses unique challenges. Tailored solutions are needed to ensure reliable information exchange under these conditions.

FullEx „Bulgaria“ – September 2025

The NATO-led Emergency management exercise in Bulgaria [4], co-organized by the Euro-Atlantic Disaster Response Coordination Centre (EADRCC) and the Bulgarian Ministry of Interior, explored civil-military coordination in a complex operational environment. From our vantage point, particular emphasis was placed on the role of secure and resilient communication infrastructures. The scenario also demonstrated how difficult it can be to translate unified command structures into joint multinational operations, given diverging national protocols and practices. These observations reinforced the importance of common standards and trusted infrastructures for effective cross-border response.



Mönchweiler, 2020



SURVEY

To complement the insights gained from exercises and operational engagements, an online survey was conducted to capture both quantitative and qualitative perspectives from first responders. The aim was to broaden the evidence base and reach practitioners across different organizations and regions, beyond the specific contexts of individual events.

The survey was deliberately designed to be simple and accessible, framed around two guiding questions: *What information is needed?* and *Which technologies is needed?* Questionnaires were made available both online and on paper, allowing distribution at events and through stakeholder networks. To foster trust and encourage openness, all responses were fully anonymized and no personal information was collected.

Between October 2024 and February 2025, a total of 68 valid responses were recorded.

The first table shows the range of organizations represented in the survey, including national relief associations, volunteer and professional fire brigades, technical agencies, and specialized units. This distribution reflects the diversity of Germany’s disaster response landscape

as well as contributions from international partners.

Composition of Audience
Professional Fire Brigade (Berufsfeuerwehr)
Volunteer Fire Brigade (Freiwillige Feuerwehr)
German Red Cross (DRK)
Malteser Hilfsdienst (MHD)
Johanniter-Unfall-Hilfe (JUH)
Arbeiter-Samariter-Bund (ASB)
Mountain Rescue (Bergwacht)
@fire – International Disaster Response Germany
German Federal Agency for Technical Relief (THW)
@fire Switzerland
Search Dog Unit (Hundestaffel)

The second table summarizes the functions and positions held by respondents, ranging from leadership and command responsibilities to medical roles, technical rescue specialists, logistics coordinators, and support staff. The categories are intended to illustrate the breadth of operational perspectives and do not imply a formal hierarchy.

Leadership & Command	Medical Roles	Technical Rescue & Specialist Roles	Operations & Logistics	Support & Other
Group/Squad Leader	Fire Brigade Medical Officer	USAR Technician	Fire Apparatus Operator	Administrative Support (Website, Documentation)
Task Force Leader	Emergency Medical Technician (EMT)	USAR Specialist	Logistics Coordinator	Volunteer Coordination
Section/Unit Leader	Paramedic (NFS - Notfallsanitäter)	USAR Coordinator	Drone Unit Member	Generalist / Allrounder
Head of Fire Brigade	@fire Medical	Despatch rider	Energy Supply Unit Member	Emergency Responder
Command Staff Leader (LUK, FaBe)		Technical Rescue Specialist (Cutting, Drilling, Measuring)	Air Operations Specialist	
Operations Manager (USAR)		Search Dog Unit (Wide Area Search)	Planning and Information Manager	
Specialist Leader for Emergency Supply & Flood Protection		CBRN Incident Commander	Command Staff - Operation (S3)	
Training Chief / Deputy Team Leader		Heavy Technical Rescue Incident	Incident Commander	
Head of Department		Technical Development Liaison	WFF Specialist	
Deputy Head of Department (WFF)		PSNV Lead	WFF team member	

In addition to the survey, a limited number of personal interviews were carried out in selected contexts to explore requirements and perceived gaps in greater depth. For example, workshops with the Fire Department of the City of Trier and the Arbeiter-Samariter-Bund Regionalverband Niedersachsen West provided direct insights into frontline practices. While such individual engagements are not statistically representative, they were valuable in validating interpretations and ensuring that the analysis remained grounded in operational reality.

STAKEHOLDER VALIDATION

To ensure that findings remained aligned with the operational reality of disaster management, an iterative validation process was applied throughout the project. This involved presenting interim insights at events and exhibitions, gathering feedback from practitioners, and comparing observations with the experiences of other stakeholders. These opportunities provided both a test for the robustness of the results and a channel to refine them based on diverse operational perspectives.

POLIZEI SUMMIT – March 2025

The 2025 MBS Polizei Summit brought together stakeholders from government, security, and emergency response with a strong focus on communication infrastructure. Within this context, discussions highlighted the need for resilient and interoperable communication systems as a backbone for effective coordination. The Ad-hoc Mobile Infrastructure (MAI), jointly developed by @fire and BIBA, was demonstrated as a practical use case. Its modular and flexible architecture attracted interest from several authorities, who emphasized the importance of adaptable systems that can be integrated into existing structures. From a validation perspective, the positive feedback confirmed the demand for robust and flexible communication solutions in crisis situations.

Humanitarian Networks and Partnerships Weeks (HNPW) – March 2025

At the Humanitarian Networks and Partnerships Weeks (HNPW) in Geneva, @fire and BIBA participated in association with the SERAG group. The event provided one of the largest global platforms for humanitarian exchange, bringing together international actors across the disaster response cycle. Within this framework, the team presented information management tools for remote expert support, both as part of the exhibition and in a

dedicated session. The exchanges confirmed the relevance of these tools for enhancing coordination across diverse operational contexts, particularly where international deployments involve cultural and linguistic complexity. From a validation perspective, the feedback underscored the importance of solutions that not only enable remote expertise to be integrated into field operations but also align with existing INSARAG (International Search and Rescue Advisory Group) structures and practices.

BLACKOUT Day – May 2025

The Blackout Workshop [5], organized by JOLA-rent with participation from local authorities, fire departments, and private-sector actors, addressed preparedness for large-scale power outages. The discussions underlined how dependent disaster management has become on continuous energy supply, and how quickly cascading effects can occur when it is interrupted. The event confirmed that resilience planning must account for alternative energy supply and communication pathways, aligning with observations from field exercises where infrastructure was compromised.

RETTmobil – May 2025

At Rettmobil 2025, one of Europe’s leading rescue and mobility fairs, the project partners jointly presented their ongoing work. The focus of the presentation was

on resilient communication architectures, showcasing how layered approaches—combining satellite links, 5G connectivity, and mesh networks—can provide robust interoperability under different conditions. The Mobile Ad-hoc Infrastructure (MAI) served as a key demonstrator, illustrating how modular systems can integrate multiple channels to maintain operational communication even when individual layers fail. Feedback from practitioners and technology providers highlighted the practical value of this approach. The strong interest reinforced the need for communication solutions that are flexible, vendor-independent, and adaptable to the varied scenarios faced by first responders.

SUMMARY

Altogether, the exercises, survey, and validation activities revealed a consistent set of priorities across the disaster management community. Above all, responders stressed the importance of resilient communication and the ability to share georeferenced situational information across organizational and national boundaries. These capabilities form the backbone of coordination in complex operations, enabling responders to adapt rapidly to evolving conditions and to work effectively despite differences in systems, protocols, or languages.



Fulda, 2025

// PLAN OF ACTION

Following the completion of the survey, all responses were systematically categorized and simplified to ensure clarity and accessibility while preserving their original meaning. Technical terms, operational abbreviations, and lengthy free-text answers were translated into clear, understandable language. Through this process, ten thematic clusters were identified for information needs and another ten clusters for technological needs.

Each cluster represents a recurring theme across multiple respondents and was analyzed in its own right, either as an information requirement or as a technological enabler. Together, these clusters provide a structured foundation for understanding operational priorities and the technologies most closely associated with them.

INFORMATION NEEDS

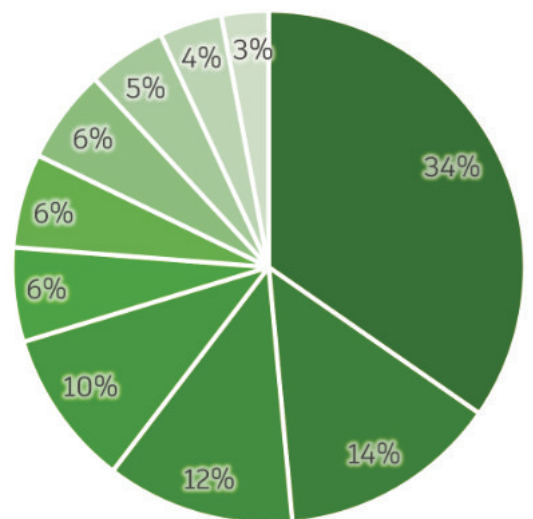
The survey responses were grouped into ten clusters of information requirements. These clusters represent the kinds of data and situational updates that first responders consider most critical for their work. While the distribution of responses varies, the emphasis lies clearly on elements that strengthen situational awareness and support decision-making under operational pressure.

Nr.	Main Information Need	Mentions	%
1	Position Tracking	35	34.7 %
2	Digital/Georeferenced Maps	14	13.9 %
3	Task Status & Mission Orders	12	11.9 %
4	Weather & Environmental Data	10	9.9 %
5	Reference Information	6	5.9 %
6	Communication & Coordination	6	5.9 %
7	Logistics & Supply	6	5.9 %
8	Hazard & Threat Information	5	5.0 %
9	Unit Readiness & Status	4	4.0 %
10	Software Standardization & Unified Systems	3	3.0 %

The survey results show a strong concentration around situational awareness. Position tracking was cited most frequently (34.7%), reflecting the need to monitor vehicles, personnel, and assets in real time. Digital maps and georeferenced situational displays (13.9%) and clear status updates on tasks and mission orders (11.9%) followed closely, together representing nearly 60% of all mentions.

Weather and environmental data (9.9%) also ranked highly, showing how much operational decision-making depends on dynamic external conditions such as wind, temperature, or water flow. Other categories - logistics, communication, and reference information (each ~6%) - were noted as important supporting functions rather than primary drivers. Finally, software standardization (3%) was mentioned only occasionally, suggesting that interoperability issues are recognized but not yet a frontline concern for practitioners.

Information needs cluster most strongly around building and maintaining a shared operational picture. Tracking, mapping, and task distribution dominate with approximately 60% of all mentions, while supportive data such as weather, logistics, and reference information re-



main essential enablers for mission continuity.

TECHNOLOGY NEEDS

In parallel to the information categories, survey responses were also clustered into ten categories of technological requirements. These reflect the tools and infrastructures that responders associate with their ability to obtain, process, and use critical information during operations. The emphasis is spread across both data acquisition technologies and the communication systems needed to deliver them reliably under field conditions.

The distribution of responses indicates a balanced demand between data acquisition and the infrastructure to deliver it. Satellite imagery (15.9%), hardware and devices (15.2%), and communication networks (13.6%) form the top tier, pointing to the need for both reliable data sources and the means to access and share them.

The middle tier includes maps and GIS tools (11.4%), environmental sensors (11.4%), and drones/UAVs (9.8%), highlighting the growing expectation of multi-layered inputs that integrate geographic, environmental, and aerial reconnaissance into a common operational picture.

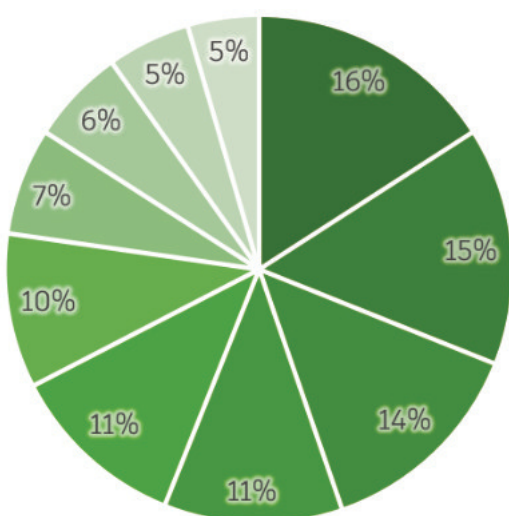
Lower-frequency mentions point to resilience considerations. Connectivity and mobile data (6.8%), GPS and tracking solutions (6.1%), and low-tech fallback

options (5.3%) reflect an awareness that infrastructures may fail in disasters, requiring redundancy. Interoperability and standardization (4.5%) were noted but ranked lowest, suggesting that while acknowledged, these issues are not yet seen as an immediate priority compared to frontline functionality.

Technological needs are distributed across two domains: first, the tools to generate situational awareness data (satellite, UAV, sensors), and second, the infrastructures that ensure this information can be delivered reliably to responders. Resilience features such as fallback solutions and interoperability are recognized but remain secondary to primary data and device requirements.

CROSS-CATEGORY INSIGHTS

A clear alignment emerges between the clusters of information needs and technological requirements identified in the survey. Information priorities concentrate on building and maintaining a shared operational picture—most prominently position tracking, georeferenced maps, and task and status updates. The corresponding technological clusters emphasize the means to generate and deliver this picture in real time, including satellite imagery, sensors and UAVs, GIS platforms, and robust communication networks. Together, the two perspectives reinforce the centrality of situational awareness as the foundation of effective disaster response.



Nr.	Main Technological Need	Mentions	%
1	Satellite Imagery	21	15,9 %
2	Hardware / Devices	20	15,2 %
3	Communication	18	13,6 %
4	Maps / GIS	15	11,4 %
5	Environmental Sensors	15	11,4 %
6	Drones / UAV	13	9,8 %
7	Connectivity / Mobile Data	9	6,8 %
8	GPS / Tracking	8	6,1 %
9	Low-tech Fallback	7	5,3 %
10	Interoperability / Standardization	6	4,5 %

This pattern is consistent with international research and capability assessments. The International Forum to Advance First Responder Innovation (IFA-FRI), for example, highlights as critical gaps the ability to *know the location of responders and their proximity to risks in real time, to detect and monitor hazards at incident scenes, and to integrate information from multiple sources into incident command.* [6] These priorities map directly onto the survey's most frequently mentioned clusters, both in terms of information needs (tracking, maps, status) and technological requirements (sensors, satellite imagery, GIS, and communication).

Similarly, INSARAG guidance emphasizes interoperable working practices, common technical language, and shared information flows across all levels of urban search and rescue. Although interoperability and system standardization ranked lower in the survey responses, their presence in the clusters shows that practitioners are aware of these requirements. The discrepancy in ranking is best explained by the fact that frontline responders tend to prioritize immediate operational functions first, while interoperability often manifests as an enabling condition that becomes critical when

scaling to multi-agency or cross-border operations.

Other international initiatives, such as the IFRC's digital transformation strategy, also underscore the importance of establishing minimum technology baselines and systematically identifying compatibility gaps. These institutional perspectives mirror the interest expressed by survey participants in vendor-independent solutions and layered communication architectures capable of maintaining functionality under degraded conditions. [7]

At the same time, the survey highlights certain needs with particular clarity. The strong emphasis on real-time tracking, georeferenced maps, and task and mission management reflects a perspective rooted in daily operational challenges. These requirements may appear straightforward but have the potential to deliver significant improvements to coordination and efficiency in the field. By capturing the views of practitioners directly engaged in disaster response, the analysis complements broader capability studies and helps to ensure that future developments remain firmly anchored in operational reality.



Sächsische Schweiz, 2022

// DEBRIEFING

Beyond the quantitative clustering, the qualitative evidence highlights several key dynamics shaping the operational and technological priorities of first responders. Above all, there is a clear convergence of information and technology around **situational awareness and communication**, which emerges as the single most critical theme. Respondents consistently stressed the need to track personnel, vehicles, and assets in real time and to maintain a clear, shared operational picture in dynamic mission environments.

A second dynamic concerns the **usability of tools**. Systems must be intuitive, aligned with operational workflows, and functional under stress. Even advanced technologies risk being underutilized if they are cumbersome to operate or poorly adapted to field conditions. User experience is therefore not a secondary concern but a decisive factor for adoption.

Finally, the responses underscored the **importance of resilience**. Although fallback solutions and system interoperability did not dominate the quantitative results, they surfaced repeatedly in interviews and validation events as indispensable when primary systems degrade or fail. Ensuring continuity through simple, reliable backups remains a prerequisite for effective operations.

The combined analysis of information needs and technological enablers yields three overarching priorities:

Situational Awareness Maps: A consolidated, georeferenced operational picture is indispensable for coordination and decision-making across agencies and command levels.

Intuitive Digital Experiences: Systems must be designed for usability under stress, enabling responders to access and act on critical information quickly and efficiently.

Unified Systems for Command and Control: Fragmented solutions need to give way to integrated platforms that enable seamless oversight and coordination.

Drawing together survey responses, field observations, and stakeholder validation, three requirements stand out as priorities for future development and operational implementation:

Standardized Information and Data Formats to ensure interoperability across agencies, units, and stakeholders, enabling consistent understanding and integration of operational data.

Unified Communication Systems that are resilient, scalable, and user-friendly, bridging organizational divides without requiring complex technical adjustments.

Resilient Low-Complexity Fallback Solutions that are lightweight, rapidly deployable, and capable of integrating with higher-level systems to maintain continuity under degraded conditions.

Taken together, the findings highlight that first responders prioritize solutions that are practical, resilient, and directly usable in the field, with situational awareness and reliable communication at their core. These requirements provide a grounded foundation for guiding future research, development, and procurement.

This white paper has focused on the operational needs articulated by first responders. Its sister publication, [the second white paper in this series](#), will turn to the technological landscape, examining which fields of innovation and development can address these needs and how resilient, interoperable data infrastructures can be built to support them.



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