Digitalizing Disaster Management: Enhancing Emergency Response with the Responding Lab

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Abstract

The present article outlines the challenges and objectives of the "responding Lab" project, which aims to enhance disaster management through digitalization and technology integration. In Germany, civil protection is largely defined by the federal structures of the states, sometimes complicating the integration of new technologies. The project's goal is to provide emergency responders with a user-friendly and robust video system that facilitates efficient decision-making, even without existing infrastructure or cloud connectivity.

The concept includes standardized scouting and documentation of large-scale damage situations, incorporating the use of drones and real-time image data transmission to respond more effectively to emergencies. The responding Lab promotes the exchange between science and emergency services to translate current insights into applicable concepts. Activities such as participating in large exercises and real deployments complement the research, while results and data are made available to users.

In summary, the responding Lab serves as a bridge between technological advancement and practical application in emergency management, enhancing crisis management efficiency through research findings and real-time testing.

Keywords: Digitalization, Disaster Management, Drone Technology, Real-time Data, Research Transfer

1. Introduction

Emergencies and crises are often complex, dynamic, and time-sensitive. Due to the nature of emergencies, leaders must make decisions based on diffuse information. Command systems and tools are meant to support them in this. Command systems are undergoing a fundamental renewal through advancing digitalization.

Large parts of the integrated civil protection system in Germany fall under the legislative competence of the federal states and are the responsibility of local authorities. These structures sometimes complicate the adoption of technological advancements and innovations, such as the widespread general digitalization progressing in many areas. Particularly in the management of large-scale damage situations, there would also be a need for standardizing interfaces and tactical frameworks. [1] [2]

2. Responding Lab

One goal of the responding Lab is to offer emergency responders a video system that is very easy to use and robust. Often, incident commanders must make quick deployment decisions without having a visual picture of the situation. [3] Modern video transmission technology is often difficult to operate and, due to the deployment of various modern technologies, not very robust against extreme external influences.
The system being developed at the Institute of Rescue Engineering and Civil Protection (IRG) allows a single person to set up a network where anyone with the right access, regardless of platform, can access available image data. These image data can be pictures and videos, independent of the camera technology used. The data are stored locally, so responders can operate without cloud connectivity even if the infrastructure is lacking or destroyed.

Another aspect where the challenges of digitalization become particularly evident is the assessment of large-scale incident areas. Here, a standardized approach for step-by-step situation assessment and the documentation and further processing of individual results, including handover and processing progress, is needed.

Such developments could be supported through targeted exchanges between emergency response actors and scientific institutions. To promote this transfer, the “responding Lab” project will establish a corresponding unit that can help translate the current state of science and technology into viable deployment concepts during exercises and operations. At the same time, research data can be generated, insights gained, and research ideas derived with an extraordinarily high practical relevance. These results are to be made available to end users so that new concepts can be utilized or innovative technology can be procured purposefully.

The technology can be loaded onto a car. The concept envisions that the system can later be operated by untrained personnel with simple one-button operation. All components are designed to withstand the toughest external conditions.

Figure 1: The whole system of Responding Lab: Vehicle and Container with Drones and modern Measurement and Communication Technologies

3. Concept for Assessing Large-Scale Damage Situations

In the international context, the INSARAG Guidelines, such as the Assessment, Search and Rescue (ASR) Levels described in Manual B, offer a defined basic structure for scouting measures in broad areas [4]. However, a generally accepted, unified approach for the universally applicable steps of broad-area search and sector search does not exist.

The guidelines mention the possibility of comparing data collected during broad-area searches with additional data gathered before the occurrence of the damage. Uniform data formats and collections, as well as documentation of relevant parts from the INSPIRE directive, also seem helpful for this purpose.
To ensure a comprehensive organization of aid measures, rapid, extensive, and structured broad-area assessment of the damage scope is deemed necessary. This also serves to divide the entire damage area into appropriate sectors. Following the creation of sectors, they should be assessed with greater detail to identify all work sites as thoroughly as possible. This fundamental principle is meant to ensure that no deployment sites or even entire locations are missed.

A standardized scheme is needed for documenting the results of this search to guarantee the handover and continuation of damage sites and to prevent information loss during deployment.

4. Simulated Real Deployment Highlights of the Potential of these Technologies

The research project "Sensor Systems for Locating Trapped People in Collapsed Buildings" (SORTIE) is conducted by the Albert Ludwigs University of Freiburg (project coordination), the IRG at TH Köln, the Fraunhofer Institute for Physical Measurement Techniques, the Friedrich-Alexander-University Erlangen-Nuremberg, the University of the Bundeswehr in Munich, and the German Federal Agency for Technical Relief. Additionally, the Indian Institute of Technology, the Indian Institute of Science, Amrita Vishwa Vidyapeetham private university, the Indian Ministry of Home Affairs, the National Institute of Disaster Management, and the National Fire Service College were partners involved in the project. [5]

In a large-scale exercise, the responding Lab played a significant role.

Figure 2: Drone searching for buried victims


Figure 3: Responding Lab within large-scale exercise

In the BMWK-awarded project “Integrated system for semi-autonomous rescue of drowning victims with UAV and deployment boxes near shore (GUARDIAN)”, the responding Lab also successfully organized and conducted a large-scale final exercise [6].

Figure 4: GUARDIAN-Drone carrying rescue buoy

Figure 5: Prof. Mudimu presenting the GUARDIAN-Drone

As part of a large-scale water emergency landing exercise by German Armed Forces paratroopers, the IRG, in collaboration with the DLRG Bad Zwischenahn, conducted another successful test under real conditions. In August 2024, the responding Lab spent two days with the 270th Airborne Engineer Company at the DLRG. Insights were gained on integrating drones into the video system during the exercise.

Figure 6: Responding Lab staff operating the new video platform

Forest Fire Exercise of the Mönchengladbach Fire Department

The Hardter forest is the largest contiguous forest area in the city. The mixed forest is also home to about 200 residents. In the Hardter forest, which is also a recreation destination, there is the Herzpark, a youth hostel, the Wilhelm-Kliewer-Haus, the Paul-Moor-School, and gastronomy businesses. The impacts of climate change are leading to increased forest fire dangers, even in North Rhine-Westphalia. Forest fires such as those in 2020 in the district town of Gummersbach or in the Viersen district in the National Park De Meinweg confirm the dangers. The increase in drought years and storm events leads to a higher amount of deadwood in the forests.

During a large forest fire exercise of the Mönchengladbach Fire Department, the responding Lab evaluated parts of a video system under development.

Figure 7: Responding Lab within a forest fire exercise

5. Successful Transfer to Emergency Response in Real Deployments

The responding Lab is a member of the Drone Working Group of Rhein-Kreis Neuss. Due to the institute's excellent network, the responding Lab was involved in three deployments of the German Federal Agency for Technical Relief in 2024. Two components were mainly used:

Drone-assisted rapid mapping and rapid deployment of a wireless mesh-network. This occurred during a diving operation at Barmen Lake.

Figure 8: Divers from German Federal Agency for Technical Relief cooperating with responding Lab

Figure 9: All-Terrain capabilities of the responding Lab

Additionally, in erecting the largest temporary bridge in post-war Germany in Linnich.

Figure 10: Responding Lab integrated into the incident command post

Figure 11: Fully erected temporary bridge

Furthermore, a digital twin of a landscape was created during a dyke overflight. This generated insights that facilitated the association of floodwater levels with alarm thresholds. Initial approaches were developed for a decision-making tool on which digitalization process is most appropriate in emergency management under different conditions. Data from aerial images, multispectral images, and LiDAR were compared.

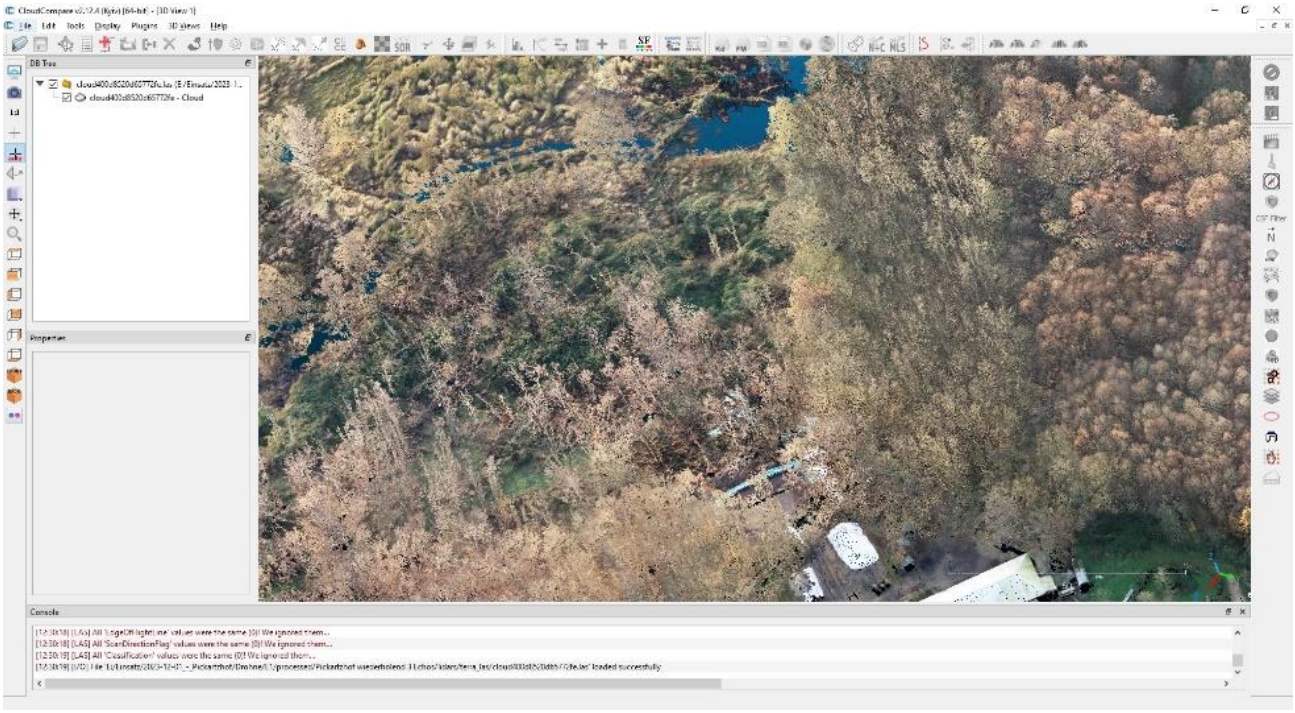

Figure 12: Digital twin of a flood protection facility

6. Conclusion

The responding Lab offers an opportunity to complete a technology transfer into emergency management while allowing scientists to be safely integrated as spontaneous helpers in real damage situations. A separate research project is being pursued for this.

A concept for a SEG (Rapid Deployment Unit) research unit is to be developed. This way, other universities could follow the example of TH Köln.

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