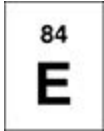


# DISASTER RESPONSE

User Needs Review and Project  
Considerations for Improving Disaster  
Response Data Pipelines

---

**Element** | **84**



## Element 84, Inc.

210 North Lee Street  
Suite 203  
Alexandria, VA 22314

+1 (703) 650-5490  
element84.com

## Authors and Contributors

Jeff Siarto  
jeff@element84.com

Colby Fayock  
colby@element84.com

Dan Piloni  
dan@element84.com

# Summary

With the growth of ubiquitous remote sensing data and the processing and storage power to handle it—disaster relief agencies and first responders are increasingly relying on this information to perform their jobs. Near real time, high-quality satellite imagery is already being used throughout the disaster monitoring and response infrastructure, but the experience of using this data when deployed in a disaster zone is unreliable.

One of the core pain points with disaster response teams is the infrastructure of the areas they're working in. Often these teams are deployed in areas that have limited infrastructure to begin with, which is made worse by the disaster itself. This includes accessible roads and bridges, reliable WIFI, 3/4G cell service, and electrical infrastructure. This inconsistent infrastructure often means teams only have the data they take into the field and what they collect in the field. It can be difficult to get updated data, models, and other information when situations change on the ground (e.g. downloading a new set of satellite imagery showing aftermath) and there is often no way to process new, local data in the response areas to feed back into the map for additional insight (this often has to be sent back to a regional headquarters for processing). Because of the lack of infrastructure, technology solutions that rely heavily on an active, high-bandwidth internet connections become unreliable.

New software, hardware, and data solutions are being introduced on a regular basis, but are rarely coordinated and developed with larger goals in-mind. Often solutions that are used in the disaster response space are adaptations of open source projects that have other priorities. Organizations like Red Cross and MSF are forced to adapt or bring in custom development to make them work for their mission.

There are many projects, large and small, that can be started in the near-term to make the user experience of dealing with data in a disaster response situation easier and more efficient. They include testing hardware in the field that's capable of enough storage and compute to be less reliant on external infrastructure, working on systems to allow easy ingest of in situ data from various sources, and building information portals to coordinate open source and volunteer efforts in this space.

# Background

In 2018, American Red Cross responded to 21 international disasters. Half of the teams were technology and communications specialists deployed to areas with limited infrastructure. **Often, the lack of a reliable power, mobile service, or internet infrastructure was exacerbated by the disaster itself.** Responding to disasters in these areas poses a challenge for teams trying to get reliable data on their surroundings. **Improving technology to support localized mapping, in-situ monitoring, and communication is key to improving outcomes of field teams.**

Over the past decade, major steps have been taken to improve the technology options for deployed teams in disaster zones. Projects like OpenStreetMap<sup>1</sup> (and its portable version POSM<sup>2</sup>), Field Papers<sup>3</sup>, and HOT Export Tool<sup>4</sup> have all helped create better offline data and toolsets for first responders. As interest in this technology increases, it will become more important to coordinate efforts, focus on user needs, and build systems that work together to make the user experience better for field teams.

This paper is aimed at providing a high-level overview of the core user needs in the disaster response technology space. It also provides a framework for moving forward with projects that make data analysis and manipulation in the field easier and more user friendly. It is not a comprehensive look at the entire technology landscape surrounding disaster relief and response—rather a first step in setting user standards for projects moving forward.

## Methods

Interviews of key stakeholders related to disaster response were conducted in October and November of 2018 by Element 84. Interviewees included staff from relief agencies like American Red Cross and Médecins Sans Frontières (MSF/Doctors Without Borders). Technologists and software developers in the mapping and disaster relief space were also interviewed along with companies and nonprofits that have provided software services or built open source projects that are used in this space. After gathering all of the interview results, below are the most common challenges that were raised:

1. Lack of high-speed or functioning communication infrastructure in disaster zones and developing countries.

---

<sup>1</sup> <https://www.openstreetmap.org>

<sup>2</sup> <https://github.com/posm/posm>

<sup>3</sup> <http://fieldpapers.org>

<sup>4</sup> <https://export.hotosm.org/en/v3/>

2. Lack of information dashboards for communicating local and regional needs surrounding a disaster response effort.
3. Software and services are not always purpose-built for disaster response and lack the detail and specifics needed for the disaster response space.
4. Small user experience issues can cause big headaches when dealing with technology and users in the field.

All other data was sourced from publicly-available information and is cited in-line using footnotes. Quotes and personas were built from actual interviews but do not contain any personally identifiable information or verbatim interview transcripts.

## Gaps and Pain Points

### Infrastructure

The largest obstacle to providing data and communications in a disaster zone is infrastructure. In some cases there is no reliable power, internet, or mobile service and teams can be cut off from their regional coordination hubs (often in the closest major city) for days or weeks. Map and remote sensing data is often large and receiving up-to-date information in the field can be cumbersome if not impossible.

#### HQ-to-Regional-to-Field Communications

Most aid organizations are structured with a main headquarters along with regional offices in major cities throughout the world to coordinate localized efforts. Teams deployed to disaster zones typically communicate through their regional office. If this communication link is broken, the teams are on their own—vital data can't get in or out. This two-way communication gap prevents ground teams from getting up-to-date data on the changing situation or crisis. Likewise, regional and global organizations have little insight into what is happening on the ground. This communication issue is not unique to disaster response, but poses one of the largest challenges to building a more data-centric system for field teams and volunteers.

### Information Pipelines and Dashboards

Organizations are lacking clear and up-to-date dashboards to help them assess disaster response effectiveness and on-the-ground needs. Part of this problem is simply the lack of reliable data infrastructure during a disaster. Dashboards can be designed and data views planned, but if nothing is coming back from the field the dashboards aren't helpful. Additionally, regional support teams are often concerned with a larger catalog of

information sources, including social and traditional media. These sources could be better integrated with in-situ data to provide a more complete picture to regional support staff.

## Software Vendor Reliability

Disaster response software and hardware projects are generally funded through government agencies and nonprofits. Other contributions are made by volunteers and open source software developers donating time to projects (sometimes personally and sometimes as an employee of the sponsoring company). Funds available for these projects are limited and project teams and commitments often change. Although great software and hardware solutions have been developed, most have little coordination or thought outside of the specific problem they've set out to solve. The ecosystem is a collection of small, sometimes underfunded projects.

Project and feature focus of software vendors also plays a role in reliability for disaster response. Many of the mapping projects used by field teams are not wholly focused on providing those feature sets—they have other priorities and development responsibilities as well. This can lead to “making the best” of software that wasn't intentionally designed for disaster response.

## Small User Issues Can Cause Big Problems

Disaster response technology is difficult because you're trying to fit tech into a situation that it wasn't designed or optimized for. This becomes apparent in small ways that can have a large impact on the success of an engagement. For example, imagine trying to coordinate a group of people connecting devices to a local network. Many of those individuals could get warnings about how they're not connected to the internet, even though they're connected to the wifi network and able to participate on the local network. Coordinators now have to go troubleshoot devices that may or may not already be working correctly.

Small user experience issues can hamstring an effort even if they have the best data at their fingertips. It's important to remember who the target user of a technology may be and to consider the environment in which they operate. You can then build scenarios into the corresponding project personas so that software and hardware developers can better empathize with end users.

## Limited tooling and data

The lack of cohesive tooling to update and maintain in-situ and provided data needs to improve to reduce the reliance on a “phone home” connection. It's often hard to know what data you'll need before you get some on-the-ground information. With current systems,

you have what you initially load up and take with you. If your bounding box was too small or if you don't have the right imagery, getting new data can be difficult.

Better tooling would allow teams to take larger datasets into the field and subset and manipulate that data in the field. They could also contribute back to the dataset with in-situ observations from field works, drones, and other mobile and local devices.

## Proposed Benchmark Personas

**Author's note:** Perspectives for each persona are paraphrased or written based on findings from past interviews and research. All actual quotes and references are placed in the footnotes.

### Field Operations

Field Operations is the core user for most of the hardware and software development in this space. They are going to be interacting with the technology first-hand and in sub-optimal situations. They will also be responsible for coordinating and training local authorities and volunteers to use the equipment and tech. These individuals are sometimes volunteers but also work for regional and international aid organizations. Success depends on hardware, software, and people all working together under less-than-ideal conditions.

#### Key Attributes

- May not specifically be a technologist; Could specialize in GIS, disaster coordination, in-situ mapping, etc.
- Limited infrastructure resources (slow to non-existent wifi and cellular; unreliable power grid or generators).
- Requires simple solutions and technology that doesn't create its own problems; often analog methods are best.

#### Perspective

We didn't realize we'd be coordinating an IT help desk when 100s of people were trying to get information over our local network but were receiving a pop-up warning telling them they were not connected to the internet. Try to explain the difference between having wifi access

and internet access to a group of people stuck in an airport during a natural disaster.

## Regional Coordinators

Regional Coordinators are the lifeline for Field Ops and the main go-between for communicating with the organizations headquarters. They are often heavily affected by the communication infrastructure in the disaster zone as they have few options for getting updates to and from Field Ops. Regional Coordinators need reliable and up-to-date information to more efficiently coordinate relief efforts.

### Key Attributes

- May not specifically be a technologist; Could specialize in relief management, logistics, or other coordination roles.
- Needs quick access to high-level information; Not as interested in specific remote sensing data.
- Heavily affected by the infrastructure status of the disaster zone and the amount of information that gets out.

### Perspective

We lack reliable dashboards that not only bring us important data about our ground teams but integrate that data with other sources like social media and local in situ teams separate from our organization.

## Contributing Developer

Contributing Developers are the engineers, software developers, designers, and project managers that design and work on the systems related to disaster response efforts. They could be open source contributors or be working on contracts for governments and relief organizations. Contributing Developers also work for companies that build related software whose primary purpose is not disaster response (e.g OpenStreetMap).

### Key Attributes

- Expert in their primary focus area (interface design, dev ops, etc) but may lack knowledge of the specific needs and requirements of the disaster response community.
- Not always aware of competing services and solutions.



- Generally interested in contributing to a specific project or feature within a project as a part-time open source contribution.

### Perspective

It's difficult to get feedback because of the way that things are set up... If it's working well we don't get any feedback. If it's working poorly a lot of times people just put it aside and we don't know where we're missing the mark.

## Volunteer

Volunteers contribute to the overall mission of disaster response but are not Contributing Developers. They may help process data, tag images, or work with on-the-ground teams. They have a secondary relationship with the technology that's used on the ground but often have to interface with these systems to contribute to a project.

### Key Attributes

- Often lacks training and expertise in disaster relief. Seeking to help as a hobby or way of giving back.
- Often assigned to one specific task in the larger effort (e.g. tagging images for content and metadata).

### Perspective

I'm a bit of a weather nerd and I like to help the Cyclone Center categorize and tag remote sensing images of storms. I feel good about contributing to a larger cause and it scratches my itch to be an armchair climatologist.

## Technology

There are many successful projects ongoing and in the works that contribute to a growing ecosystem of disaster response technology. These projects would likely form the foundation of any unified system and represent the major initiatives in this space.

## Software

### OpenStreetMap

OpenStreetMap (OSM) is a community-driven, editable map of the world that can be used in software, hardware, and websites free of charge. OpenStreetMap includes data about roads, buildings, addresses, shops and businesses, points of interest, railways, trails, transit, land use and natural features.

- <https://www.openstreetmap.org>

### POSM

Portable OpenStreetMap (POSM) is a hardware and software solution for using OSM offline for weeks or months at a time. It aims to solve the connectivity issues often found in disaster response situations.

- <http://posm.io/docs/posm/intro/>

### OpenDataKit

OpenDataKit (ODK) is a suite of open source software for collecting, managing, and using data in resource-constrained environments. OpenDataKit comes in two flavors: ODK1 and ODK2 depending on your needs, customization and technical skill.

- <https://opendatakit.org/>

### OpenMapKit

OpenMapKit (OMK) is an extension of OpenDataKit allowing users to create professional quality mobile data collection surveys for field data collection.

- <http://openmapkit.org/>

### OpenDroneMap

OpenDroneMap (ODM) is an open source command line and GUI tool for taking images shot from drones, kites, and balloons and turning them into two and three dimensional geographic data that can be used in combination with other geographic datasets.

- <https://www.opendronemap.org/>

### EventKit

EventKit is a web application that provides workflows to make it easier to access geospatial data. It reduces the time necessary to find and process remote sensing data for use in GIS applications like ArcGIS.

- <https://home.geointservices.io/>

## HOT Export Tool

The Humanitarian OpenStreetMap Team (HOT) Export Tool is a web service that can extract up-to-date OSM data in various file formats. This data can be used in offline system that can't access OSM services in the field.

- <https://export.hotosm.org/en/v3/>

## Field Papers

Field Papers allows in-situ teams to mark up and do their field research on paper maps and then sync them to a digital mapping solution after the fact to digitize observations. This service is extremely useful when field teams lack the ability to download and upload on the fly due to their wireless or cellular connection.

- <http://fieldpapers.org/>

## Mapillary

Mapillary is a platform that helps you build maps from street-level imagery and uses computer vision to extract map features and detect objects automatically.

- <https://www.mapillary.com/>

## Hardware

### Amazon Snowball Edge

Amazon Snowball Edge (SBE) is a portable storage and compute solution that allows you to run a localized version of your AWS infrastructure in the field. They can be provisioned through the typical AWS interface and offer full integration with cloud services you may already have set up.

- <https://aws.amazon.com/snowball-edge/>

### POSM Hardware

Although not custom developed, Portable OpenStreetMap requires a recommended set of hardware to run properly in the field. This gear is mostly storage and network access with compute power being very limited.

- <http://posm.io/docs/posm/setup/#hardware>

## Field Tech Docs

In addition to the resources listed above, American Red Cross also publishes field tech documentation which highlights more software and best practices: <http://posm.io/docs/>

# Project Considerations

With limited resources and budgets, it's important to consider projects and goals that are achievable in the short and mid-term. Building a complete end-to-end system and testing it enough to feel confident in it working correctly would be a large undertaking—likely by multiple organizations. It's more realistic to plan for small efforts and projects that all contribute to a larger goal. Listed below are several relatively independent efforts that would each provide additional insight into disaster response needs and support.

## Analytical Toolkit

**Goal:** Improve the ability of first responders to answer questions using remote sensing and in-situ data in the field.

With the compute power of the Amazon Snowball Edge and software like EventKit it becomes possible to build more analytical toolkits that can be used in-situ. This could transform what is usually a data collection operation into one where it's possible to build conclusions from the data in real time. Better analytical tooling would also allow for dataset manipulation in the field (subsetting a larger bounding box) and more integration with GIS applications.

## SBE Pipeline Field Test

**Goal:** Test the feasibility and user experience of a basic SBE pipeline using current technology and software.

There are enough working parts to test a simplified, end-to-end deployment of the Amazon Snowball Edge with POSM and some basic tooling. There are existing trigger services and data pipelines that could be used to process the remote sensing data but software would need to be built to automate the deployment of POSM and the related toolsets.

A pipeline field test would need to be focused on stitching together the various existing solutions and testing the feasibility and user experience of dealing with the SBE in the field. The user interface would take a back seat in this project as the main focus would be to test the viability of the end-to-end solution.

## User Interface Workshop

**Goal:** Learn more about what user interfaces are effective for disaster response field work.

One of the major features that doesn't exist and is not being developed in some way is a unified user interface for regional and field teams to interact with the system via their laptop and mobile devices. Given how susceptible the overall system can be to small user experience issues, it's important to be thoughtful and deliberate when designing the end-user interfaces for the field teams.

This process would also allow for a high-level architecture overview to be developed and better understanding of the final application could be worked out. This effort could help coordinate teams around a common goal and offer up a unified look and feel to speed up development and build familiarity with the new interface.

## Detailed Architecture Study

**Goal:** Build a detailed pipeline architecture and Agile stories to help organize and coordinate a larger development effort.

Just as the user interface workshop would help develop the overall interaction patterns, a detailed architecture study would allow teams to identify missing architecture pieces within the system. Combined with the SBE field study, this would give the community a good idea of what will work and what is realistic to build in the near term. Also like the UI workshop, this could help to direct the efforts of the larger community. A detailed architecture study could also provide a framework and prioritization for smaller projects that could be executed by open source groups.

## DR Technology Resource

**Goal:** Create an online resource outlining current efforts in disaster response technology and software.

In addition to planning and strategizing around the actual software, hardware, and interfaces that need to be built—some attention should be paid to the community coordination and effort as well. Building an online resource that attempts to bring all of the open source projects, people, and communities together would help to develop more tightly-coupled solutions.

## Next Steps

Continued, coordinated effort is needed to make remote sensing and in-situ data more accessible and user-friendly to teams deployed in disaster areas. The community should

support some general standards and protocols, scenario and (non disaster) field testing, and investment in open source tools to further improve the availability and useability of new software and hardware. Because major progress has already been made with projects like POSM and the reliable availability of remote sensing data—small, coordinated efforts can produce big steps forward in disaster response field data use.