Title: Putting 20 Million People “On the Map”: Evolving Methods and Tech Tools

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Biography of Presenting Author:

Emily Eros is an urban planner with a background in geographic information systems (GIS) and international development. As a GIS Officer at the American Red Cross, she is responsible for a variety of mapping, information management, and data visualization projects to support international programs and disaster responses – including the new West Africa mapping project. Emily holds a masters degree in city planning from MIT and a bachelors in geography from Dartmouth.

Abstract: Accurate maps play a critical role in understanding human communities, particularly in post-disaster settings and for populations at risk. While open geospatial data has become more common over the past decade, additional work is necessary to map vulnerable communities before a disaster or crisis occurs. As part of their Missing Maps project, the American Red Cross and its partner organizations are actively working to map 20 million of the world’s vulnerable people by 2017, creating open map data for anyone to access, use, and update. This paper (1) describes the project’s remote and field mapping methods, (2) outlines the technical tools developed for the project, (3) highlights how humanitarian and development organizations can adapt these tools and methods to other initiatives, and (4) explores current challenges and research questions surrounding mapping initiatives focused on the Global South. In doing so, this paper provides an overview of current trends in crowdsourced mapping and emerging data collection methods, with the aim to share tools and experiences with others in the humanitarian community.

Keywords: participatory mapping, Volunteered Geographic Information, OpenStreetMap, Missing Maps

Full Paper:

Introduction

Accurate maps play a critical role in understanding human communities, particularly for populations at risk. Maps help individuals to understand their surroundings, locate features of interest, plan routes and journeys, and conduct broader-scale processes such as urban planning and disaster response. In crisis situations specifically, basemaps and geospatial data act as key tools for first responders and NGOs to visualize damage assessments; assess infrastructure, hazards, and demographics; plan local and larger-scale emergency response activities; and share information amongst relevant actors. A lack of maps and geographic data can prevent lifesaving resources from meeting those in need. For this reason, mapping is a core component of the Red Cross’ disaster response efforts.

Much of the Global North has been mapped with incredible detail. With an Internet connection or a smartphone, individuals can instantly access detailed address information, building footprints, transit information, and locations for health facilities, public services, and businesses. This is still not the reality for billions of people in vulnerable areas, however. Popular services such as Google Maps lack information for much of the Global South; many communities exist as simply a place name and perhaps a collection of roads. Other communities are absent entirely. Even when a community is mapped at a detailed level, information published without an open license (e.g. many web-maps and PDF maps) offers limited value to humanitarian actors. A user often cannot download the information, combine it with other datasets, and create and share products from it. Thus, the user is essentially viewing a picture of data rather than accessing the data directly. The same is true for mapping products created by government agencies and other traditional mapping authorities, who have traditionally operated on a retail model of distribution and often do not release their data for free and open use (Goodchild and Glennon 2010).

The rise of OpenStreetMap (OSM) has greatly improved this situation for humanitarians. Often described as “the Wikipedia of maps” (Heinzelman and Waters 2010), OSM is a free online map and geospatial database whose data can be viewed, edited, downloaded, and used by anyone with an Internet connection. While there are several other
geographically-focused examples of what academics refer to as Web 2.0 (Vossen and Hagemann 2007), crowdsourcing (Howe 2008), or volunteered geographic information (Goodchild 2007), OSM is the most prominent platform, with a community of over two million registered users (OSM Contributors 2016). Data quality and quantity vary by region, but previous studies of locations such as the UK (Haklay 2010), Ireland (Ciepluch et al. 2010), France (Girres and Touya 2010), and Iran (Forghani and Delavari 2014) confirmed that the data are generally of high quality.

OSM plays an important role for many humanitarian organizations as their primary source for base map data and primary platform for new data creation. At the time of the 2010 Haiti earthquake, for example, only rudimentary maps were widely available. Within hours of the earthquake, over 600 OSM users around the world began rapidly tracing satellite imagery to create a detailed map of the country, which disaster response and relief agencies used as an important tool in relief and recovery efforts – both in the immediate aftermath and in the years to come (Soden and Palen 2014, Zook et al. 2010). A nonprofit called the Humanitarian OpenStreetMap Team (HOT) was formed as a result. HOT coordinates the creation and distribution of mapping resources to assist humanitarians responding to crises and disasters around the world (Neis and Zielstra 2014). The group played a key role in organizing similar mapping efforts after the 2013 Typhoon Haiyan in the Philippines (Palen et al. 2015), the 2014 West African Ebola outbreak (Cassano 2014), the 2015 Nepal earthquake (Sneed 2015), and countless other small-scale disasters and for communities at risk.

In addition to post-disaster mapping, OSM has also acted as a platform for mapping disaster-prone communities in vulnerable areas. Map Kibera led to the grassroots mapping of Kenya’s biggest slum community (Hagen 2011). HOT launched a large-scale community-based effort to map Jakarta and other parts of earthquake-prone Indonesia (Soden et al. 2014). A World Bank Open Cities project prompted detailed mapping of the central Kathmandu Valley, which led to the creation of a local non-profit, Kathmandu Living Labs (ibid.). These efforts have been highly successful in building communities of skilled, engaged OSM contributors who generated valuable data, which played a key role to responders following floods in Indonesia and the 2015 Nepal earthquake.

Despite these successes, the communities home to billions of people remain “off the map”. Because of the digital divide and differences in levels of development, geographic information “is usually least available where it is most needed” (Sui et al. 2013: 5). For the humanitarian community, further efforts are needed to pre-emptively generate baseline data before major crises occur. Recognizing this need, the American Red Cross, in partnership with the Humanitarian OpenStreetMap Team (HOT), the British Red Cross, and Médecins Sans Frontières UK, launched an innovative project called Missing Maps, which aims to put 20 million vulnerable people on the map by 2017 – adding the communities in which they live to OSM, where the data are openly available for use and revision. This represents a targeted effort to conduct widespread pre-disaster mapping without limiting focus to a particular geography.

This paper (1) describes the Missing Maps project’s remote and field mapping methods, (2) outlines the technical tools developed for the project, (3) highlights how humanitarian and development organizations can adapt these tools and methods to other initiatives, and (4) explores current challenges and research questions surrounding mapping initiatives focused on the Global South. In doing so, this paper provides an overview of current trends in crowdsourced mapping and emerging data collection methods, with the aim to share tools and experiences with others in the humanitarian community.

Remote and field mapping methods

As of January 2016, a year after the project’s launch, Missing Maps has mapped an estimated eight million people. The majority of this progress involved remote mapping efforts. The American Red Cross and its partners host and support mapping parties (“mapathons”) in cities around the world, often working with university groups or even private corporations who are interested in bringing people together and training them how to trace buildings and roads from satellite imagery in order to map a vulnerable area.

This engagement strategy is modeled after mapping parties and “crisis camps” held by HOT, KLL, the World Bank, and other organizations (see Soden et al. 2014). Missing Maps is unique, however, in its unprecedented number of events and its geographic reach. Figure 1.1 shows the locations of Missing Maps mapathons and areas mapped from the project’s launch in November 2014 until the time this article was written, in January 2016. Partners have hosted a total of 166 mapathons across all six continents, resulting in over 6,000 attendees making 20 million edits to OSM. Outside of mapping parties, volunteers also remotely contribute to mapping tasks.
Missing Maps continues to build momentum, with additional partners recently joining the project (CartONG, MSF-Canada, Netherlands Red Cross).

Fig. 1.1: Missing Maps mapathons and target mapping areas, as of December 2015

Remote tracing efforts very quickly result in basemap data for the area of interest. Over a matter of days, a community can go from a blank spot on the map to a detailed collection of buildings and roads (see Fig. 1.2 for an illustration of mapping results in a suburb of Harare, Zimbabwe). This gives humanitarian agencies necessary data to plan and organize their community development and disaster preparedness/response activities.

Remote mapping rapidly produces data but faces certain limits. Building and road outlines provide a baseline of physical infrastructure information for humanitarians, but additional information is necessary to make the map more complete and useful. It is impossible to tell from satellite imagery where hospitals, schools, water and sanitation facilities, community landmarks, and physical hazards are located. Moreover, local community engagement is important in order to promote sustainability and a sense of ownership over the map data. Therefore, the American Red Cross began to increasingly focus on the second step of its mapping efforts: field-based activities.

To date, the American Red Cross had led Missing Maps field trainings in Bangladesh, Colombia, Ecuador, Rwanda, South Africa, Tanzania, and Zimbabwe. For each field visit, remote volunteers map the area of interest, then a team of staff visit the local area and spend two weeks working with local Red Cross volunteers in order to explain about the mapping project, train the volunteers in necessary processes and technology, and organize the fieldwork. The team consults local officials and Red Cross staff and volunteers to solicit their input on data collection priorities, which often include water points, waste disposal sites, and building or road conditions. Staff mentor the volunteers to help them edit and upload the resulting data. After the project, they leave equipment behind with the local Red Cross in order to enable future mapping efforts. Because areas of interest are selected based on current project locations and needs, the data add immediate value to resilience projects, community assessments, and other ongoing activities.
Short field projects provide a valuable opportunity to engage local communities and add contextual data to the map. However, engagement based on bursts of international travel poses challenges in terms of sustainability. It can be very difficult for organizations to foster long-term engagement and support local mappers without an embedded presence in the community. Past experience suggests that, even when local volunteers received extensive training and staff left equipment behind for the volunteers’ use, limited mapping activities continued independently after the site visits concluded. This prompted the team to consider additional strategies to increase community engagement and sustainability.

As one response to these challenges, the American Red Cross began a more embedded approach in West Africa, where it recently launched a mapping hub in Guéckédou, Guinea – the epicenter of the 2014 Ebola outbreak. The hub is a physical office location with equipment, four technical staff, administrative support, and training facilities. Its purpose is to act as a base for specific mapping projects and to host community meetings, conduct outreach events, and offer training modules designed to boost basic computer skills and build up a large community of volunteers with skills in various mapping and data-gathering technologies. As volunteers become more experienced, they will play a larger role in leading these activities and taking on new mapping projects in their communities.

The hub’s initial focus is to support the rapid mapping of all communities within 15 kilometres of the international borders shared between Liberia, Guinea, and Sierra Leone – focusing on water, sanitation, health, and public amenities in each community. The fieldwork is being carried out by volunteers on motorbikes, equipped with a smartphone app (OpenMapKit) and other technical tools. Resulting data will be shared with decision makers, humanitarian workers, and community stakeholders to ensure they are well aware of water, sanitation, health, and community resources before and during the next regional crisis—helping them to make data-driven programming decisions and potentially preventing or slowing the spread of infectious disease during future disease outbreaks. In the long-term, the hub represents an investment into more sustained engagement and will act as a place for cross-border, cross-organization collaboration for improved data management and coordination.

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1 Data source: OSM contributors
Moving forward, the American Red Cross and its partners continue to pursue opportunities for sustained engagement, and will continue to evaluate their methods in order to respond to challenges and promote best practices.

**Technical tools**

For remote mapping, Missing Maps trains volunteers in OSM using the iD editing interface, which most mapathon participants have easily learned within a few minutes of instruction. The team also produces a gif-based training webpage for each mapping that provides a reference and examples for volunteers who are not sure how to classify a feature\(^2\). As volunteers gain experience, we encourage the use of the Java OSM editor (JOSM), which is a faster and more robust editing interface than iD but can also be more difficult for beginners to learn.

Beyond these existing tools, the American Red Cross began new efforts to gamify remote mapping and keep trained volunteers engaged between disasters. The team is currently developing an online tracking tool and API that will compile stats and metrics for each Missing Maps volunteer, which will feed into user profile webpages with badges for different achievements and “levels” the mapper has reached. In addition, the tracking tool will help the Missing Maps team to identify dedicated and experienced remote volunteers who may be interested in hosting their own mapping events in their communities. The sites will launch in spring 2016.

A combination of high- and low-tech tools facilitate field mapping. The team’s primary tool is OpenMapKit, an Android app the American Red Cross developed that enables a user to pre-download the OSM map of an area, shows the user’s GPS location, and enables him/her to simply tap on a building or feature in order to add information about it. When an object is tapped, a brief set of questions will appear, asking the user what sort of object this is (e.g. school, residential building, health facility) and for any other relevant information. These fields are determined based on community priorities and created at the outset of the mapping project, using OpenDataKit forms. Volunteers upload their mapping results from the mobile devices, and the data are added to OSM, where staff review the additions for quality control. Teams can easily map thousands of buildings in a week using this method.

When the use of mobile phones presents security concerns, or other factors necessitate an alternative method, the American Red Cross uses paper-based mapping tools (such as Field Papers, a tool which enables users to print map pages for an area, annotate the pages by hand, and then scan/edit/upload the annotated information to OpenStreetMap). These tools are freely available and can be used by other agencies to map the areas in which they work.

In addition, the American Red Cross recently developed new tools to facilitate OSM editing in areas with unreliable connectivity. Humanitarians in general have become increasingly reliant on cloud-based tools for use in increasingly remote areas. For mapping projects specifically, users previously needed an Internet connection to use OpenMapKit in order to download map areas at the beginning of a project, and then to upload data into OSM at the end of each day. Field Papers also requires an Internet connection to prepare map atlases. Reliable Internet access on a daily basis is not realistic for many areas in which the Red Cross works.

With this in mind, the American Red Cross created a new tool: Portable OSM (POSM). POSM combines an offline OSM API, Field Papers, OpenMapKit, a captive portal, and many new enhancements to the OSM workflow. POSM runs on very inexpensive hardware (costing less than $300), with the intent of enabling it to run on small embeddable devices such as a Raspberry Pi. Users are able to download an area of interest, easily configure the portable server, work offline in the field (using OpenMapKit, iD Editor, and JOSM), and then return to a connected environment and sync all changes back to OpenStreetMap. With this new technology, users can conduct mapping fieldwork for upwards of a month at a time without connecting to the Internet; the offline servers provide the necessary support to download mapping areas in preparation for fieldwork, and then to store the data when it is uploaded from mobile phones.

**Applications and potential development impacts**

Missing Maps’ intent is to enable local communities and humanitarian organizations to collect useful geospatial information. Accordingly, the field mapping methods described above use low-cost devices (basic smartphones), rely on applications that are easy to learn, and use free and open source software. All of the technical tools mentioned in the previous section are freely available for public use. This includes tools developed by others (iD

\(^2\) Example: https://gist.github.com/emilyeros/3d4d01d87a81ef74ca94
editor\textsuperscript{3}, JOSM\textsuperscript{4}, OpenDataKit\textsuperscript{5}, Field Papers\textsuperscript{6}) and those developed by the American Red Cross (OpenMapKit, POSM\textsuperscript{7}). Various training materials exist for the former, and new materials are being developed for the latter; an instructional website is under development for OpenMapKit\textsuperscript{8}, and similar materials will be created for POSM. Source code can also be found on the American Red Cross’ Github\textsuperscript{9} page. In addition, Missing Maps partner organizations have published materials to support individuals interested in hosting a mapathon\textsuperscript{10}, and the team regularly provides support to individuals who contact them with questions.

Missing Maps’ field mapping methods and tools can be leveraged by the humanitarian/development community for a variety of situations. For example, an organization could use OpenMapKit specifically to create a basemap of the area in which it is working, to monitor the state of water points and sanitation facilities, to assess damaged buildings and roads after a natural disaster, to create a database of school locations and addresses, etc. POSM can be used by small mapping teams to map large areas with variable connectivity; it can bridge connected and disconnected environments and provide an offline backup for intermittent Internet connectivity.

\textit{Challenges and research directions}

By engaging remote mappers and local volunteers to map eight million people in just over a year, the Missing Maps project and its partner organizations have made significant contributions to tools and methods for mapping vulnerable communities. Based on its experiences, the American Red Cross has highlighted certain challenges and areas for future growth.

For remote mapping, an important challenge is developing new ways to keep volunteers engaged between disasters. High numbers of volunteers express interest in remote tracing after a major disaster. However, remotely training a large pool of extremely diverse volunteers requires time, proper tools, and coordination. A disaster setting is not the ideal time to start the process. Instead, it is imperative to have a large body of well-coordinated volunteers that are ready to assist when a disaster occurs. The American Red Cross is actively developing digital tools and ways to gamify remote mapping, but the humanitarian community could benefit from additional insight and tools for engaging remote volunteers.

For field mapping, sustainability and long-term engagement are areas for additional growth – especially for organizations working internationally. There have been highly successful initiatives undertaken by HOT in Indonesia and by the World Bank/KLL in Kathmandu, and the American Red Cross recently launched its mapping hub in Guéckédou, Guinea. Again, this area could benefit from additional insight into ways to effectively engage with local communities, promote local interest and ownership over data collection, and support a community of mappers who are trained and motivated to continue mapping activities independently. Rural areas may present a particular challenge; previous tech hubs and mapping initiatives have been based out of urban centers like Nairobi, Kathmandu, and Jakarta, which benefit from more developed infrastructure, the presence of university students, and a more technically-skilled volunteer base.

As the Missing Maps project moves forward, the American Red Cross and its partner organizations will continue to evaluate their methods and tools for mapping, evolving new tools and engagement strategies to address the challenges experienced along the way. By mapping vulnerable communities, humanitarians are better able to share better analysis of hazards, mitigations, and response capacity in communities, enabling stronger disaster response efforts and program planning in the future.

\textsuperscript{3} Available at: http://www.openstreetmap.org/edit?editor=id
\textsuperscript{4} For more information: http://wiki.openstreetmap.org/wiki/JOSM
\textsuperscript{5} For more information: https://opendatakit.org
\textsuperscript{6} For more information: http://fieldpapers.org
\textsuperscript{7} For more information: http://github.com/americanredcross/posm
\textsuperscript{8} For more information: http://openmapkit.org
\textsuperscript{9} https://github.com/AmericanRedCross
\textsuperscript{10} For more information: http://www.missingmaps.org/mapathons
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