West Africa Mapping Project

FINAL REPORT | JAN 2017

American Red Cross

with local partners:

LIBERIAN RED CROSS

CROIX-ROUGE GUINEENNE

SIERRA LEONE RED CROSS SOCIETY

FINAL REPORT
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West Africa Mapping Project

Project overview

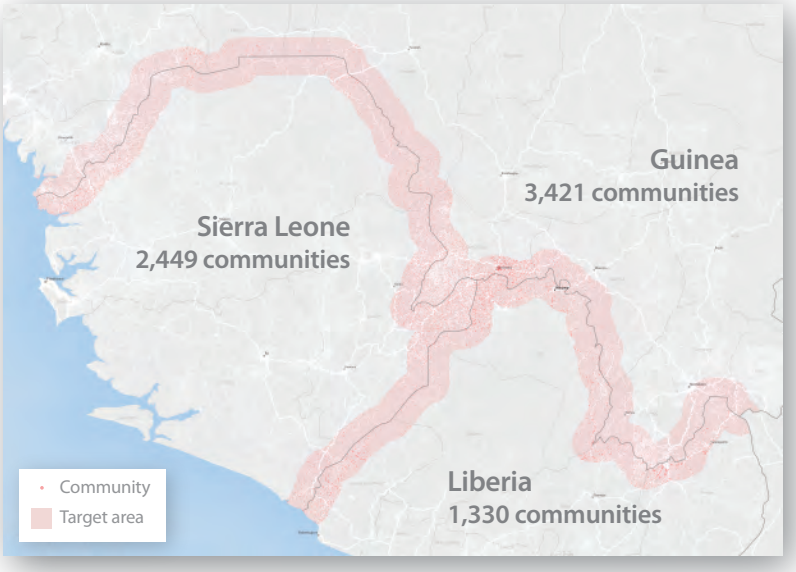
Accurate maps play a critical role in understanding human communities, especially for populations at risk. While much of the world has been mapped to incredible detail, millions of people in developing countries live in communities that do not exist on any maps. This makes it more difficult to reach these communities with assistance during a crisis.

The lack of detailed maps for West Africa posed a problem during the 2014 Ebola crisis; contact tracing was much more difficult without accurate names and locations for all of the villages, particularly in the remote border areas which were the epicenter of the epidemic.

Through a private grant, the American Red Cross set out to expand its Missing Maps project to extensively map all areas within a 15 km distance of the shared borders between Guinea, Liberia, and Sierra Leone. The data were added into OpenStreetMap, a free and editable world map commonly used by humanitarians.

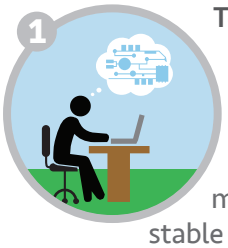
The goal of this work is to create an open and comprehensive dataset of communities for West Africa – and to ensure that decision makers, humanitarian workers, and community stakeholders are better aware of water, sanitation, health, and community resources before and during the next crisis, potentially preventing or slowing the spread of infectious disease during future outbreaks.

The 15 km target area around the three countries' shared borders



Process

The project involved five processes, decsribed below. This report provides an overview of each step and its results.



Tech development

We further developed our mapping tools and created small, offline servers to enable mapping in areas without stable internet connections.

Mapping hub

We created a physical office space to be used as a mapping hub and a venue for community engagement, with local GIS staff and tech equipment.

Rapid assessment

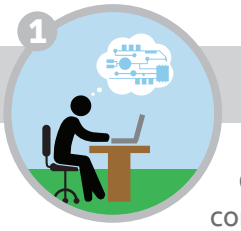
Volunteers on motor-bikes visited every community in the target area to quickly map and survey them.

Detailed mapping

Volunteers returned to the most vulnerable communities to conduct more detailed mapping, using the new and enhanced mapping tools.

Community engagement

Mapping hub staff conducted community engagement in order to build skills and enthusiasm in the area, improving sustainability.



Tech development

Covering an area nearly as large as Switzerland and containing 7,000+ communities, this project required extensive field efforts in a rural region full of challenges: no connectivity, extremely poor roads, lack of electricity, dispersed volunteers, varying languages, pockets of new Ebola cases, etc. With this in mind, we had to adapt our methods and tools to suit these conditions.

The American Red Cross typically uses cloud-based mobile apps for its mapping work. These tools require an internet or cell phone connection to create, modify, or troubleshoot mapping surveys, and to upload data periodically. The West Africa project area was enormous and did not have dependable internet or cell connectivity, so volunteers had to be offline and inaccessible for days or weeks at a time. To bridge this gap, we developed POSM (Portable OpenStreetMap).

POSM is an offline server with a captive WiFi portal that supports all of our field tools: FieldPapers, OpenMapKit, OpenDataKit, OpenDroneMap, and offline editing of OpenStreetMap. This means that a user can pre-download files for an area of interest and then take POSM to the field, where it can be used to create a map-based survey form, push it onto a group of phones, retrieve the resulting data from the phones, and edit these to add them into OpenStreetMap. After the team returns to an area with a reliable internet connection, they resolve any data conflicts and push the data up to OpenStreetMap, where they're available for anyone to download, edit, and use.

Anatomy of a POSM

Hardware: We developed POSM to run on a ~$300 Intel NUC unit, which can be purchased from Amazon or other vendors. We upgraded the wireless card to support more connections.

Software and set-up: The software for the NUC is open source and freely available on the American Red Cross' GitHub account, complete with a guide to the set up process.

Below: American Red Cross GIS staff using a POSM unit (on top of the vehicle) to check on volunteers in Voinjama, Liberia

PORTABLE OPEN STREET MAP

Portable offline servers: use and results

We used 4 POSM units during the mapping in West Africa. POSM was a gamechanger for this project and our work would not have been possible without it. Development was completed on time and we integrated additional features (such as support for drone imagery processing) and used it more extensively than we envisioned; we routinely used POSM to host mapathons of up to 30 people, since WiFi was unreliable.

We took the following steps to ensure that POSM benefits the wider humanitarian and tech community:

- We made the software open source and freely available online, through GitHub: https://github.com/AmericanRedCross/posm
- We documented the hardware we used and the software install process on Github, as well as on blog posts and an academic article. Instructions and posts were written for both technical and non-technical audiences.
- We used social media and mailing lists to announce the project and new developments.
- We presented the technology at several relevant conferences: State of the Map US, State of the Map World, FOSS4G North America, and the Humanitarian OpenStreet-Map Team Summit.
- We conducted small group workshops at the annual Missing Maps member meeting, a Red Cross disaster workshop, and with partners like the World Bank and MSF.
- We are providing support for other groups interested in using POSM; such as the World Bank in Sri Lanka, MapLesotho, King Couny transit in Seattle, and Team48/UNOCHA in the Philippines.
- We are developing a series of video demonstrations and other web materials to reach new audiences and make POSM more approachable for those less familiar with technology.
- We solicit feedback from users to help us continually improve POSM.

Other tech tools

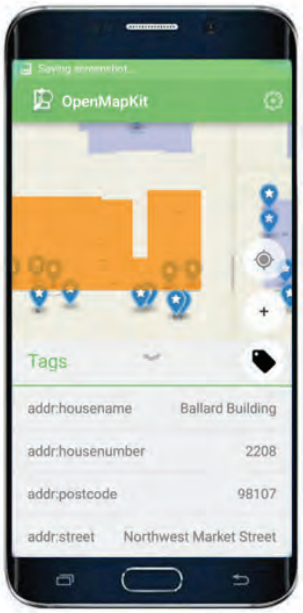
In addition to POSM, we also made improvements to our existing mapping tools as part of this project.

Our preferred mapping tool is an Android app we developed, called OpenMapKit (OMK).

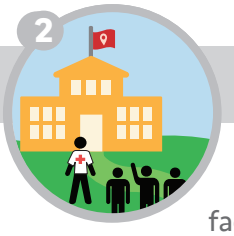
As part of this project, we added features that improve the user experience of OMK and make it faster and easier to collect data.

We also enhanced the backend coding to improve the way that data is stored and to enable OMK to integrate with other mapping tools we use.

Bottom left: OpenMapKit app Bottom right: Volunteers learn to use mobile phones and apps like OMK for data collection



Info: **openmapkit.org**



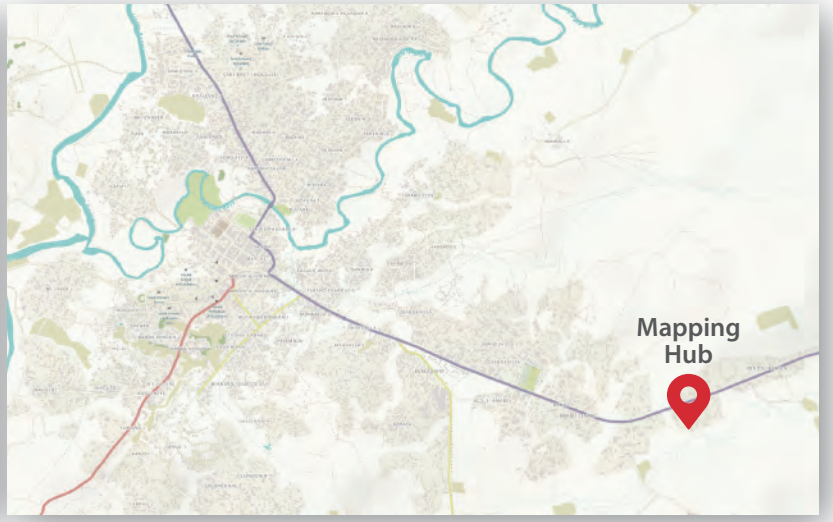
Mapping hub

The mapping hub was originally intended to be located in Voinjama, Liberia. However, external factors beyond our control required that we reconsider the location as we were preparing to launch the mapping project.

We relocated the hub to Guéckédou, Guinea. This move required the team to start from scratch locating a building, hiring local staff, arranging for local bank accounts and financial controls, etc. The launch of the hub and the fieldwork were both delayed as a result. However, the hub was ultimately launched in April 2016.

The mapping hub in Guéckédou, Guinea, shown within the region (bottom left) and at the local scale (bottom right)

Data source: OSM contributors



Data source: OSM contributors

To staff the hub, we hired a GIS supervisor with a strong background in geospatial analytics, leading training sessions, and building communities of OpenStreetMap volunteers in Uganda. We then hired 3 local GIS analysts, as well as an operations coordinator and two finance assistants who provided logistical support to the hub.

We equipped the hub with furniture and equipment for the staff, as well as equipment for conducting fieldwork and leading training sessions in the community. This included: over 100 mobile phones and battery packs, 26 laptop computers, 20 GPS-enabled cameras, POSM units, printers, a generator, and ancillary equipment.

A volunteer in Washington, DC, configures 100 phones to send to the hub

Guinea- and US-based GIS staff arrive at the site of the new hub in Guéckédou

Community training sessions

From its launch in April 2016 to the end of the project, the hub acted as both a base of operations and as a local community training and engagement facility.

Once the local staff had been trained and the fieldwork concluded, the local GIS analysts and the GIS supervisor held weekly skills training sessions at the hub as a means of local outreach and capacity-building. These sessions did not exclusively focus on mapping. Rather, they were tailored to meet the immediate and practical ICT needs of the local population, whilst introducing new technologies and tools. The sessions covered:

- Introduction to computers and basic ICT management skills
- Introduction to word processing and spreadsheets using Microsoft Word and Microsoft Excel
- Introduction to internet and its uses, including how to use a search engine
- Creating and using an email account
- Introduction to mapping with OpenStreetMap using POSM and the internet
- English language classes (Guéckédou is a French-speaking area)

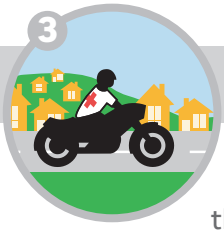
Hub weekly activity summary

17 **Skills sessions**
on computer and language skills

3 **Mapathons**
adding local data to OpenStreetMap

184 **Participants**
over the course of four months

GIS analysts at the hub begin a computer skills training session for the local community



Rapid assessment

Volunteers visited every community in the border, either by motorbike or on foot, to determine the name and exact locations of all communities and to conduct a vulnerability assessment with each community leader. The survey contained 23 questions about population dynamics, water and sanitation facilities, health access, etc. The questions were designed to better inform organizations conducting recovery projects in the area. Additional information about the methodology is documented in this report's annex.

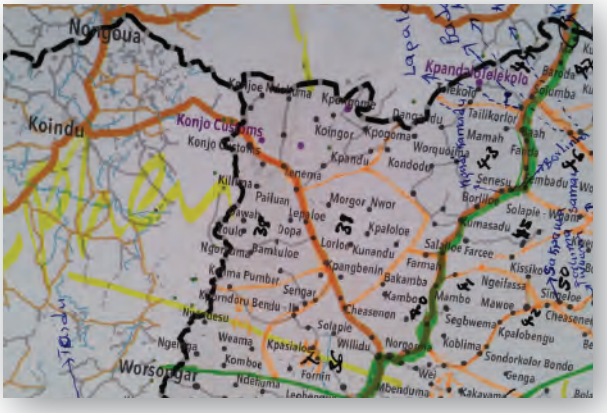
The rapid assessment data collection was conducted on a rolling basis, beginning with Liberia in February 2016, followed by Guinea and Sierra Leone. For each country, we first recruited more experienced volunteers from across the target area and hired them to act as field team leaders. We held a training session with the field team leaders to introduce them to the project and the technology and to solicit their input on the fieldwork and local area. They then spent several weeks visiting communities to spread awareness about the project and to recruit volunteers and motorbike drivers.

Next, volunteer training sessions were held in different regions of each country, beginning in Liberia in March 2016, with GIS staff and field team leaders. Volunteers were trained in Red Cross principles, safety and security, and mapping technologies (including OpenDataKit, OpenMapKit, OsmAnd, and GPS cameras). During the trainings, they completed several hands-on practice sessions and received feedback to improve their performance. We trained twice as many volunteers as needed in each area, then selected the top performers to complete the fieldwork. Once the volunteers were selected, they worked together with GIS staff and field team leaders to plan the schedule for their area.

The rapid assessment data collection lasted roughly 3 weeks in each country. Volunteers visited 7,200 communities during this time. When a volunteer reached each village, he or she would sit with the community leader to complete the survey, which took about 10 minutes, using the OpenDataKit application on his/her mobile phone. If there was a health facility present in the community, the volunteer visited it specifically to conduct a separate survey with the health workers. Follow-up calls and visits were held to check data accuracy and improve its quality, meeting a completed callback rate of 5% of each enumerator's work.

Field team leaders plan the rapid assessment for Lofa County, Liberia

Large paper maps were used to plan the fieldwork and for navigation



A volunteer in Liberia conducts the vulnerabilty survey with a village leader

The target area is extremely remote and many communities were difficult to reach, even by motorbike. Some of the communities could only be reached by foot, and accessibility was even harder during the summer rainy season.

Volunteers and motorbike drivers received a stipend in return for their hard work, as well as expenses for any overnight visits. We sought a gender balance in the volunteers and provided escorts to any female volunteers who were uncomfortable travelling to communities by foot.

After the rapid assessment was complete, GIS staff cleaned the data and analyzed it to determine communities with the highest vulnerability, which informed decisions about where to conduct the detailed mapping.

The results of this fieldwork have been released as open data. Geographic data (e.g. community names and locations) were uploaded to OpenStreetMap and other data were uploaded to Humanitarian Data Exchange (HDX) based on thematic categories: medical facilities, schools, water points, general points of interest, etc.

We also used the rapid assessment information to create and distribute paper-based maps to many of the communities in the target area in order to share the results back with them.

In addition to the survey, the volunteers set their phones to passively collect other information, including cell signal strength and GPS tracks of their travels, which allowed us to gather additional information about the road network and add roughly 500 km of roads into OpenStreetMap, most of which were not visible through satellite imagery and were only detected because of the GPS traces. Cell signal strength data were analyzed, mapped, and uploaded to both HDX and OpenSignal, a website which crowdsources cell signal data on a global scale.

We also used 20 GPS-enabled cameras, attached to volunteers' motorbikes, in order to gather imagery of the area. We uploaded the imagery to Mapillary, a crowdsourced version of Google Street View.

Volunteers navigated extremely difficult terrain to reach the most remote villages

GIS staff meet a volunteer in the field to check in on his progress

Sierra Leone volunteers press on with the mapping, despite very heavy rains

Detailed assessment

Next, local volunteers conducted highly-detailed field mapping for 104 communities. We selected these communities based on a combination of those with high populations and those which ranked highest in the vulnerability index we developed from the rapid assessment data. We also considered geography to ensure that at least one community was selected in each region of a country, and considered major cities just outside the target area. The report annex contains a list of the 104 communities.

Once the target communities were identified, GIS analysts traced buildings and roads from satellite imagery for the selected communities to prepare the areas for detailed mapping and to assist with navigation. To prepare the volunteers, we held a second round of training sessions to introduce this element of the project and to plan the logistics of the mapping.

Using several unique survey forms created for the OpenMapKit application, volunteers returned to each of the 104 communities. They collected information on water sources, schools, medical facilities, and general points of interest likes places of worship, markets, stores, and services. Over the course of several weeks, volunteers combed the target communities to conduct the mapping. This work required 3-4 weeks for each country and took place from May through July 2016, beginning in Liberia and finishing in Sierra Leone. The POSM devices were essential for this work, and enabled us to prepare the volunteers' phones and retrieve data in disconnected areas.

When the mapping was complete, data cleaning and quality control were provided by GIS staff at the hub and from American Red Cross headquarters in the US. The data were then uploaded to OpenStreetMap and HDX, depending on which repository was more appropriate.

In total, over 300 schools, over 400 health facilities, over 3,500 water points, and over 12,000 general points of interest were added to OpenStreetMap. The number of buildings mapped in the region has surpassed 35,000 and a total of nearly 11,000 km of roads have been traced into OpenStreetMap.

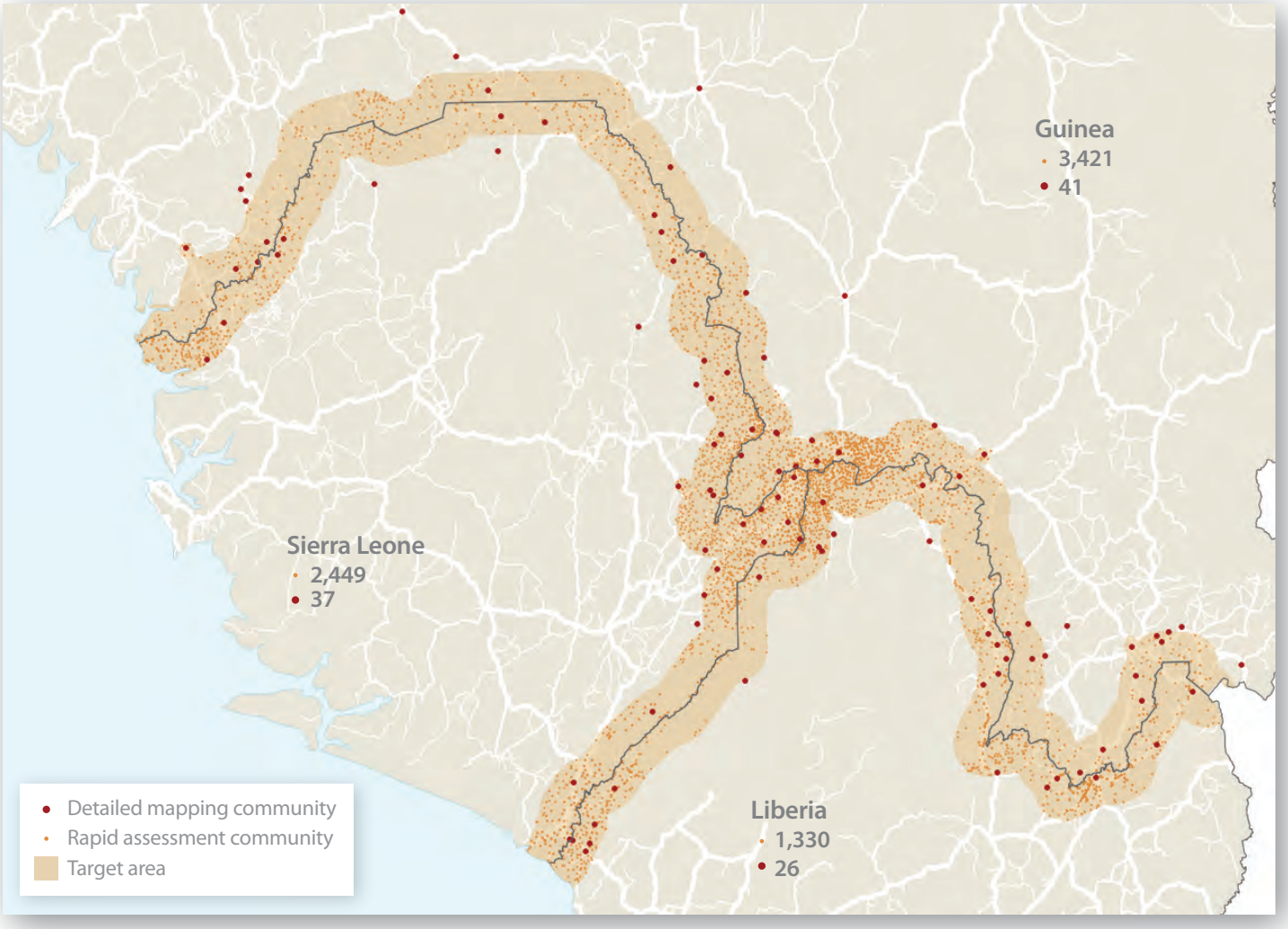
The pages that follow highlight the overall results of the mapping, show the extent of the fieldwork, and present examples of the type of analysis we have conducted on the data.

A volunteer checks the condition of a water pump in Lofa County, Liberia

A volunteer enters a Liberian village to conduct mapping

Overall mapping results

Communities mapped as part of the rapid assessment and the detailed mapping, with key stats for each country



Red Cross volunteers added highly-detailed information to OpenStreetMap:

35,000 buildings

11,000 km of roads and paths

300 health facilities

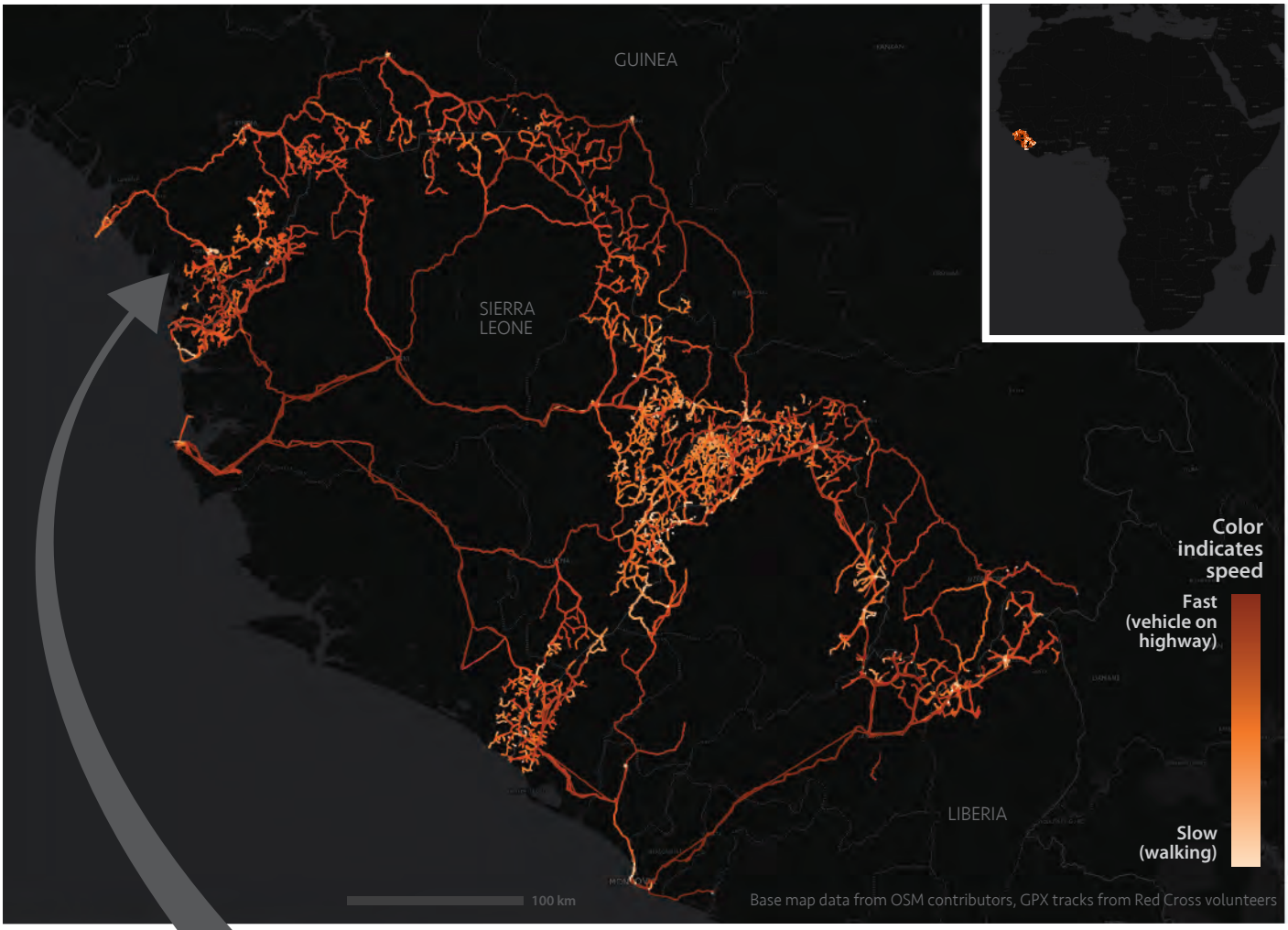
400 education facilities

3,500 water points

12,000 points-of interest

Volunteer coverage across the region

Volunteer GPX tracks visualized in the context of Africa (below, right), the West African region (below, left), and at the detailed scale for an example city (bottom left)



Throughout the project, volunteers recorded their GPS tracks so that we could monitor their progress and identify missing roads to add to the OSM road network. These data illustrate the scale of the fieldwork undertaken for this project. Key stats:

126 volunteers
Number of people who mapped the local area, plus an additional 109 motorbike drivers

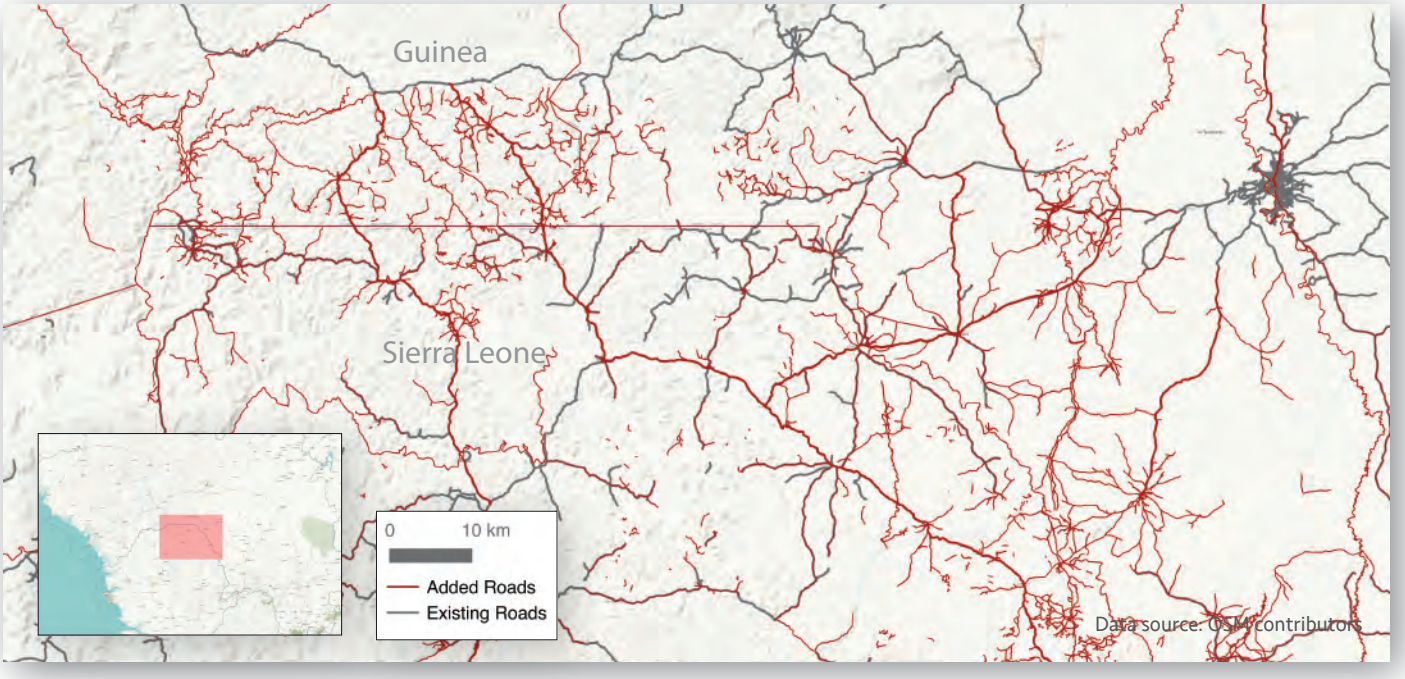
72,000 km
Combined distance traveled by volunteers during fieldwork - equal to travelling around the world 1.8 times

37,000 km²
Area covered by the mapping project. This is roughly the size of Switzerland.

Overall mapping: results at local scale

Before this mapping project, many roads in the target area did not exist in OpenStreetMap or other data sources. Moreover, many communities in the target area either didn't exist on any maps, or were simply names without any further information. The map below shows an excerpt of road data before and after the project.

Excerpt of the border area of Guinea and Sierra Leone in November 2015, before the mapping project, and again in December 2016, after the detailed mapping



The basemap contains a rich set of data about community resources and local amenities. Below is Macenta, Guinea, showing the locations of points of interest that were added to OpenStreetMap during detailed mapping.

Points of interest (POIs) in Macenta, Guinea

Community engagement

Due to the delay in the mapping hub launch and the start of fieldwork, the mapping took longer than expected and carried into the summer. This kept analysts busy in the field doing training, analysis, and quality control monitoring and therefore shortened the amount of time they could spend on community engagement activities. Despite this challenge, the team began conducting weekly skills trainings at the hub in summer 2016, holding 17 of these sessions and 3 mapathons in total.

Outside of the events at the hub in Guéckédou, the staff conducted several GIS trainings and 12 mapathon sessions across the region, in cities like Conakry, Freetown, and Monrovia – areas which had larger numbers of university students and others who would be most likely to take an interest in mapping and continue on their own. The events were held at local Red Cross chapters, at universities, or at tech spaces and similar venues. Approximately 466 people attended these events in total.

The lack of computers and internet access was a major challenge across the region. Many universities we worked with had nonfunctional computer labs; others did not have an available internet connection on the university campus. Most students did not possess personal laptops. These factors made the hub equipment and POSM devices essential to community outreach activities.

During the mapathons, the hub staff presented about the project, OpenStreetMap, and why mapping is important. Staff taught participants how to add data to OpenStreetMap, and spent time doing this with the participants. Local OpenStreetMap chapters were formed in each of the three countries as part of this effort, and they have continued to hold mapping activities since the West Africa project finished. To support them as the project ended, we donated equipment to local Red Cross offices and mapping-specific organizations like GeoSynapse Guinea so that interested community members can continue to map.

Relationships with other organizations

Beyond these local engagement efforts, we met with international and local organizations in each of the three capital cities before launching the project, in order to solicit their feedback and input. We held a workshop with government and institutional stakeholders before the project launch in Liberia and continued to engage with organizations as time permitted. We extended our trainings and mapathons to include staff from agencies such as the Liberia Institute of Statistics and GIS, Statistics Sierra Leone, etc., in order to improve their capacity.

Over the course of the project, we developed relationships with other institutions in order to share our work. This resulted in a close collaborative relationship with the CDC, who provided input on the vulnerability survey metrics and influenced our decision to collect certain data (at their request, we collected information about markets, places of worship, and other features that might draw populations across borders). We participated in bi-weekly calls between our two organizations and with guest speakers, visited their offices to speak more about the project and future opportunities for collaboration, and we are currently working to develop a white paper on data collection and co-authoring a scientific publication analyzing the data from the project.

Regional engagement stats

Mapathons
adding local data to OpenStreetMap

Participants
over the course of several months

OSM chapters
officially launched in the region

Computers
donated at the end of the project

Future directions

As the mapping project wraps up, the American Red Cross is excited to see how the local mapping communities in West Africa will continue their efforts in the three countries.

There are two other avenues we are pursuing to help the project to have a lasting impact: tools and analytics.

Analytics

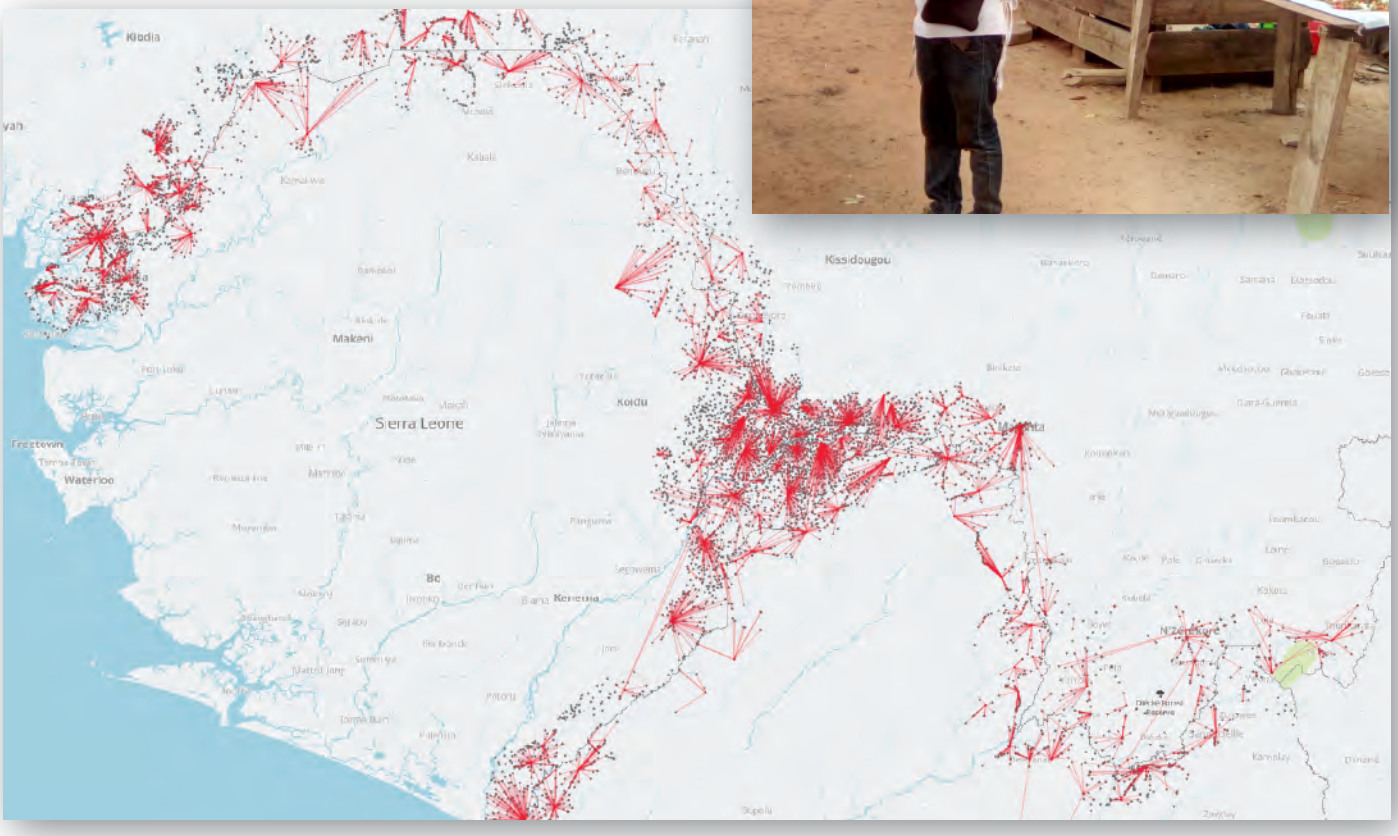
The data collected by volunteers are valuable for basemaps, but also have value for many other uses. Below is an example of analysis performed by the GIS team, which examines linkages between communities and markets. For epidemiologists, markets are an important factor in the spread of disease, since they have such a strong impact on local and regional travel.

One of the survey questions in the rapid assessment asked village leaders which markets they visited on a regular basis. Below is a visualization of the results, showing which communities are linked to one another in this manner (linkages are illustrated by red lines). The data could be further analyzed if needed; volunteers also collected information about which days the markets operated, and what goods were sold there. These data can be combined with population estimates to predict the flow of people on certain days.

The CDC are using these data to create infectious disease prediction and surveillance models to prioritize areas in need of public health capacity building. We are collaborating with the CDC on scientific studies like this one.

We are also collaborating with the World Bank to deploy a web-based accessibility model to examine and analyze the distance and travel time separating populations from services and resources, such as markets.

Below: Market linkages to communities Right: A volunteer collects information about a market

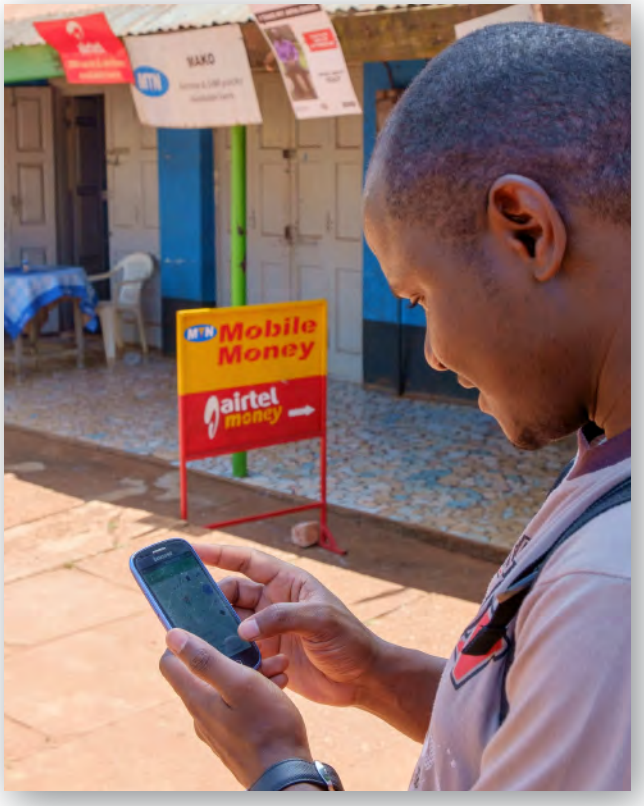


Tools

The technology developed for POSM and OpenMapKit can be applied across sectors in a variety of use cases. Throughout the past year, we collaborated with user groups who are currently using, or planning to use, POSM/OMK for the following:

- **Community mapping projects:** Similar projects in other disconnected areas: Sri Lanka and Comoros (World Bank project)
- **Secure data sharing:** Local intranet for sharing sensitive information among remote, disconnected, or disaster-affected Red Cross centers (IFRC initiative)
- **Education:** Training volunteers with web trainings and course materials currently only available online, and providing other education resources to remote areas (IFRC initiative)
- **Public transit:** Mapping wheelchair-accessible bus stops in Seattle (King County Transit initiative)
- **Financial inclusion:** Mapping financial institutions in Uganda to better serve unbanked people (MapUganda initiative)
- **Environmental applications:** Data storage device that would enable staff to access and modify data about protected areas while conductin site visits in the wildnerness (US Forest Service inquiry)
- **Unmanned aerial systems (UAS):** POSM now has the ability to process drone imagery and turn it into 3D models and imagery for OSM editing, taking the entire mapping process fully offline (Cleveland Metro Parks, Médecins Sans Frontières (MSF), CartONG, private companies)
- **Measles vaccination campaigns:** The phones and POSM devices from this project will be reused in Malawi in spring 2017 to track and map vaccinations to identify clusters of underserved people and advocate for better, targeted public health services (American Red Cross initiative)

A MapUganda volunteer uses OpenMapKit to map mobile money establishments



The American Red Cross will pilot the use of mapping in vaccination campaigns

Summary and closing

Overall, the West Africa mapping project presented a challenging but exciting opportunity to improve open data for Guinea, Liberia, and Sierra Leone.

Despite numerous challenges and a rapid project timeline, the American Red Cross and local Red Cross staff and volunteers successfully met the project goals and targets. The resulting data enables West Africa to be more prepared if Ebola were to recur, and provides organizations and local governments with better access to information to inform their work within the region.

Although the mapping hub closed at the end of the project, we built capacity within local agencies and donated equipment so that skilled and motivated mappers could continue the important work. So far, the OSM communities have continued to hold mapathons and other activities, and we look forward to seeing the communities grow over time.

Beyond the immediate goals of the project, the American Red Cross has also collaborated with other organizations to conduct analytics for data-driven decisionmaking, and to support the applications of POSM/OMK to new sectors and environments, ranging from public transit mapping in Seattle to offline drone imagery processing to intranet services in disaster-affected areas.

We look forward to continuing these efforts and to implementing lessons learned in other contexts, working to make a difference through humanitarian mapping.