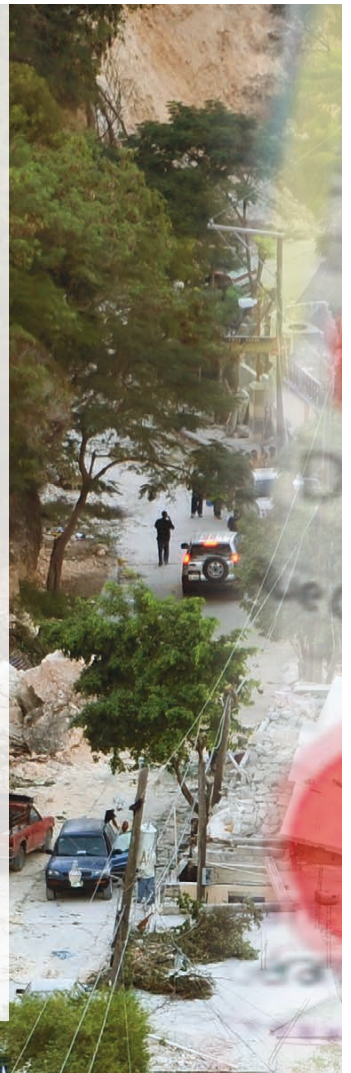




AT 4:30 P.M. ON JAN. 12, 2010, the island of Hispaniola twitched and jerked, as if the earth were shivering. In Port-au-Prince, Haiti, on the island's western half, it was 82 degrees—hardly hypothermal. As the shaking persisted, it became clear—Mother Nature wasn't cold—she was having a seizure. Although the 7.0-magnitude earthquake lasted just 45 seconds, it killed more than 220,000 people, injured more than 300,000, and left upward of 1.5 million homeless. >>

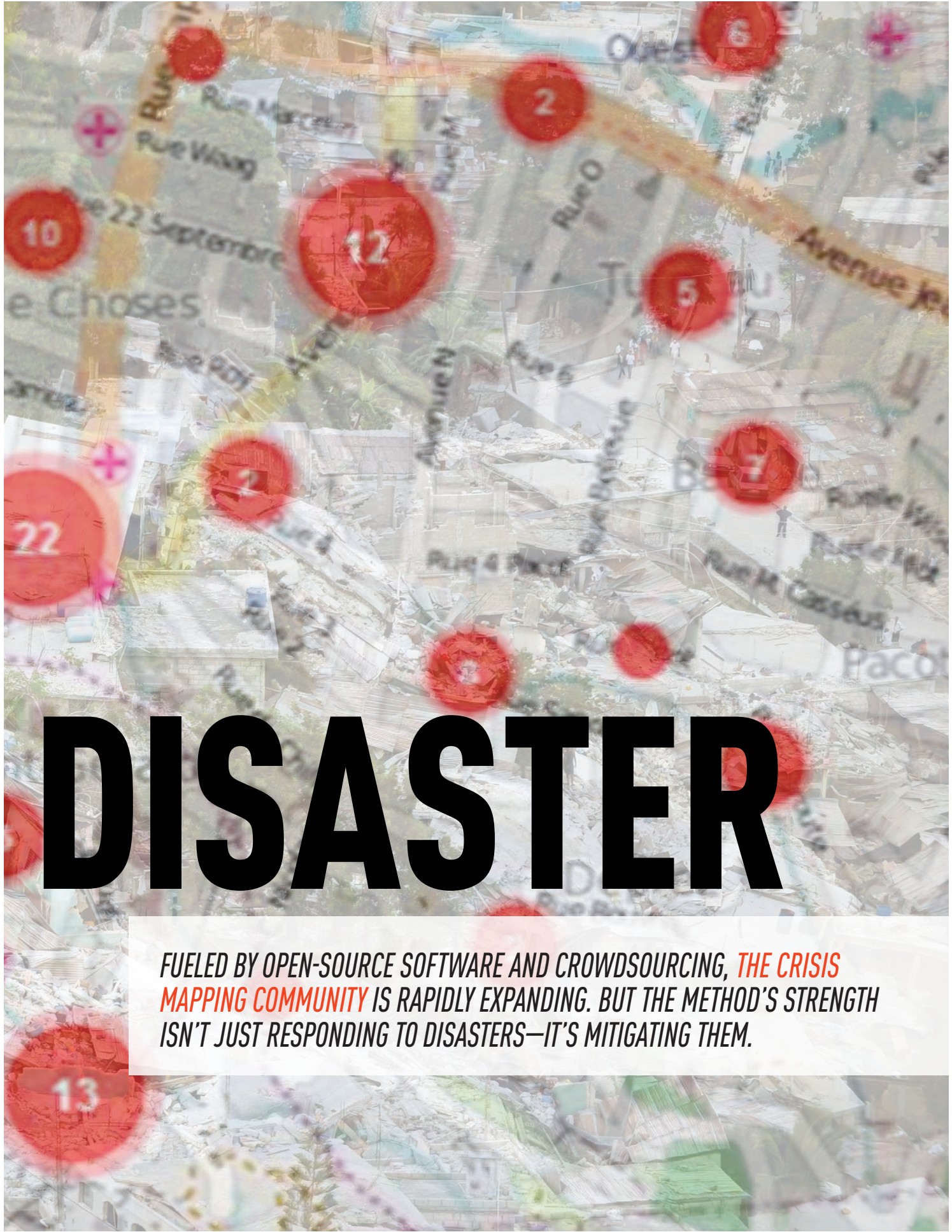


DEFEATING

BY MATT ALDERTON



THE USHAHIDI Haiti Crisis Map (right) visualized more than 2,000 individual reports in the aftermath of the 2010 earthquake.



DISASTER

*FUELED BY OPEN-SOURCE SOFTWARE AND CROWDSOURCING, **THE CRISIS MAPPING COMMUNITY** IS RAPIDLY EXPANDING. BUT THE METHOD'S STRENGTH ISN'T JUST RESPONDING TO DISASTERS—IT'S MITIGATING THEM.*

The quake and its aftershocks destroyed an estimated 60 percent of the buildings in Port-au-Prince alone and caused up to \$14 billion in damage. According to the Haitian government, the quake damaged or destroyed more than 313,000 homes, at least 30,000 commercial buildings, more than 1,300 schools, 13 out of 15 government buildings, and more than 50 hospitals, not to mention more than 43 miles of primary roads.

Amid so much rubble, relief efforts seemed impossible. Still, humanitarian organizations descended on Haiti with food, water, and supplies. All they needed was someone to tell them where their help was needed, and how to get it there.

Dr. Patrick Meier did exactly that. Now director of social innovation at the Qatar Computing Research Institute, he was then a graduate student at Tufts

more than 100 people to map reports from social networks, mainstream media, and a dedicated SMS hotline his group established to accept text messages from Haitians in need. In total, the Ushahidi Haiti Crisis Map visualized more than 2,000 individual reports.

Mapping these incidents wasn't easy without a reliable map on which to do so. Most of Meier's volunteers used Google Maps, but Google had only mapped a modicum of the country. To fill the gaps, OpenStreetMap (OSM)—the geospatial equivalent of Wikipedia—activated its international network of volunteer mappers. Using high-resolution commercial satellite imagery made public by providers such as DigitalGlobe, OSM crowdsourced the most detailed map to date of Haiti's infrastructure.

"Ultimately, you had about 640 mappers that made 1.4 million edits to the map of Haiti in about 25 days. That's the equivalent of a cartographic year of work for one person," explained John Crowley, a consultant with the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR), as well as a research fellow at the Harvard Humanitarian Initiative. "Not by any stretch of the imagination was the data perfect. But it was the best available map, and it was free and open to everyone, which really catalyzed the use of [crowdsourcing] for disaster response."

Since the Haiti earthquake, the crisis-mapping community has experienced exponential growth and continues to evolve with new tools, technologies, and capabilities. While questions remain about the quality and reliability of crowdsourced data, crisis mappers' ability to mobilize quickly and en masse makes them an undeniable force in the wake of a disaster.

FROM CHAOS TO COLLABORATION

A combination of forces made Haiti a seminal event for crisis mapping. One was the scale of the disaster. Another was the budding proliferation of mobile and social technology. Finally, there was the maturation of a global crisis-mapping community, which originated with the emergence of open mapping platforms such as OSM and Ushahidi—which

launched in 2004 and 2007, respectively—and culminated with the first annual International Conference on Crisis Mapping (ICCM) in Cleveland in October 2009, just three months before the Haitian temblor.

"At the very first [ICCM] a whole group of people came together to form a collective understanding around the question, 'What is crisis mapping?'" recalled Crowley. "Then Haiti happened. So there was a gradual convergence of streams, a few key events, and then a major disaster ... where crisis mappers had the chance to apply the lessons we'd learned from all the work we'd been doing."

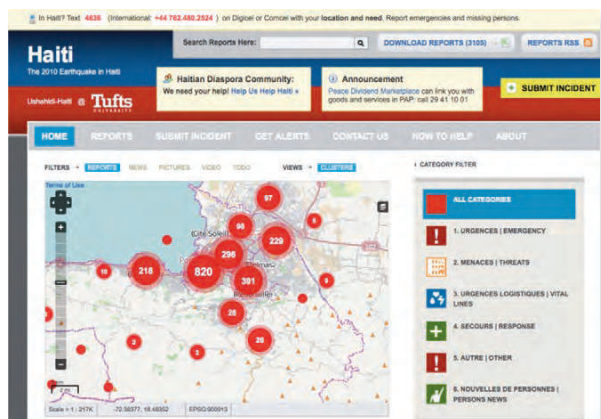
In the earthquake's immediate aftermath, an OSM offshoot called the Humanitarian OpenStreetMap Team was established to facilitate collaboration between OSM and humanitarian responders. In 2012, the Digital Humanitarian Network (DHNetwork) was born, serving as a clearinghouse connecting humanitarian responders with various crisis-mapping networks as needed. These organizations and others have given formal structure to an inherently unstructured community, which in turn has helped crisis mappers demonstrate their value during numerous disasters since Haiti, including the worst floods in the history of Pakistan in 2010, the Japanese earthquake and tsunami in 2011, Hurricane Sandy in 2012, and Typhoon Haiyan in 2013.

THE CASE FOR OPEN DATA

Crisis mapping yields numerous benefits during states of emergency.

"With the volunteer geospatial community, you've got a thousand, a million, or in some cases a billion human sensors who can rapidly collect information that might otherwise be very expensive and time-consuming for a government to collect," said Dr. Alanna Simpson, a senior disaster risk management specialist at GFDRR.

For humanitarian groups and disaster victims, the more obvious benefit is situational awareness. "Especially during a big, sudden event like an earthquake or tornado, the first 72 hours is when we need the most information. But it's also when we have the least," said Dr. Jen Ziemke, associate professor of international



STUNNED BY THE EARTHQUAKE, [MEIER] BEGAN MAPPING TWEETS BROADCAST BY HAITIANS IN THE AFTERMATH, HOPING TO HELP RESCUERS AND AID WORKERS LOCATE THEM. HIS CHOSEN TOOL WAS USHAHIDI—SWAHILI FOR “WITNESS”—A FREE, OPEN-SOURCE PLATFORM CREATED IN 2007.

University in Boston. Stunned by the earthquake, he began mapping tweets broadcast by Haitians in the aftermath, hoping to help rescuers and aid workers locate them. His chosen tool was Ushahidi—Swahili for “witness”—a free, open-source platform created in 2007 to map election abuses in Kenya. Within a week, Meier had recruited and trained



DISASTER MANAGERS from the Honduran Permanent Contingency Commission, as well as representatives from the Honduran Red Cross, firefighters, military, police, and other organizations, use GeoSHAPE during a demonstration in June 2014.

DoD IN THE MIX

The Defense Department is also experimenting with crisis mapping. In June, the U.S. Army Engineer Research and Development Center (ERDC) completed its Rapid Open Geospatial User-Driven Enterprise [ROGUE] program, a two-year Joint Capability Technology Demonstration to test the utility of open-source software for humanitarian and disaster relief efforts in Latin America. ROGUE's combatant command sponsor, U.S. Southern Command (SOUTHCOM), hopes to use the program's byproduct—a data collection and sharing platform called GeoSHAPE—to facilitate crowdsourcing of geo-tagged data in disconnected environments. Using GeoSHAPE, first responders can document their route to disaster victims. For example if a road is blocked, they can record it on the GeoSHAPE map, locate an alternative route, and share the information with other responders.

"This tool allows us to put the concept of crowdsourcing in the government's hands," said Juan Hurtado, SOUTHCOM's science advisor and chief of its science, technology, and experimentation division. "We can remotely tag and track data, such as the state of roads, buildings, and bridges, and synchronize it on available maps to see on a near-real-time basis how the crisis is changing and how we can make better decisions that improve our response."

SOUTHCOM is also exploring how to transcend tools to foster open data.

"So far, nobody has been able to figure out how to achieve unity of effort when there's no unity of command—that's our biggest challenge," said Ricardo Arias, an operational manager with SOUTHCOM's science, technology, and experimentation division. "Many people look at information sharing as the way forward, but information sharing isn't a technology; it's a behavior. There will never be one solution that everybody adopts, so data needs to be able to flow freely across platforms."

relations at John Carroll University and co-founder with Meier of Crisis Mappers Net. "What neighborhoods are destroyed? What roads are flooded? Where are there shelters, and hospitals, and food distribution points? If you're trying to save lives, deliver supplies, or access services, you can leverage crowdsourced reports to give you real-time information."

Crisis mapping also holds triage benefits such as verification and tipping and queuing, which help first responders distribute resources quickly and effectively.

"You can use the crowd to sift through overwhelming amounts of data to help you find that one piece of gold information that might save a life," Ziemke added.

The key to realizing crisis mapping's benefits is open-source software, according to Simpson. "Open-source software lowers the barriers to entry for a lot of people," she said, adding that GFDRR has leveraged open-source software since 2010, when it began to support the open platform GeoNode, which serves as a content management system for geospatial applications. "As a result, small investments go a lot further; it's amazing the innovations that come out of open source."

FEDS JOIN THE CROWD

Although crisis mapping's benefits are numerous, so are its challenges. Because of its siloed nature, the federal government used to pose a hurdle for the community by hindering the data-sharing principles on which crisis mapping relies. Today, however, federal agencies are actively searching for solutions to crisis mapping's biggest challenges in a larger effort to empower and exploit crisis mappers' capabilities.

"While the two communities live in slightly different worlds, the government and crisis mappers have learned to like each other and are increasingly building bridges to figure out how to work together," said Dr. Christopher Tucker, chairman and CEO of the MapStory Foundation, whose open-source platform is used by the humanitarian community to map human geography.

Events leading up to October 2012's Hurricane Sandy illustrate perfectly how feds and crisis mappers are learning to collaborate during disasters.



ADDITIONAL RESOURCES

Visit trajectormagazine.com or download the *trajectory* tablet app to watch videos and read reports on crisis mapping.

IMPORTANT EVENTS IN CRISIS-MAPPING HISTORY

2004

Steve Coast establishes OpenStreetMap to create crowdsourced maps of the United Kingdom, where the government was criticized for creating maps but not publicly sharing them. The OpenStreetMap Foundation is established two years later to expand Coast's efforts worldwide.

2007

The open-source mapping platform Ushahidi—Swahili for “witness”—is created to map eyewitness reports of violence in Kenya in the aftermath of a disputed presidential election.

2009

The Naval Postgraduate School commences its Research and Experimentation for Local & International Emergency & First Responders (RELIEF) series of crisis-mapping experiments at Camp Roberts in California.

2009

Jen Ziemke and Patrick Meier co-found the International Network of Crisis Mappers to organize a community of crisis mappers capable of developing and sharing best practices. They hold the first annual International Conference on Crisis Mapping in Cleveland in October 2009.

2010

Volunteer crisis mappers from around the globe employ Ushahidi and OpenStreetMap to create the most detailed roadmap ever of Haiti in the aftermath of the Haiti earthquake, demonstrating for the first time the contributions that crowdmapping and open-source software can make in the wake of a disaster.

2011

Following a string of 300 tornado touchdowns in the southern United States, the Federal Emergency Management Agency (FEMA) realizes the power of crowdsourcing and commissions its own crowdmapping tool, MapMill, which is deployed in October 2012 to assist with relief efforts in the wake of Hurricane Sandy.

A PRELIMINARY DAMAGE ASSESSMENT mobile app built on Spatial Network's Fulcrum platform shows color-coded collections from the main airfield of Camp Roberts during an experiment with FEMA and Tomnod (now part of DigitalGlobe) to verify crowdsourced data from imagery in real time.

In 2011, a supercell thunderstorm system ambled through the southeastern United States. Afterward, the Civil Air Patrol took thousands of photographs and ascertained there had been approximately 300 tornado touchdowns from Texas to New York.

“Unfortunately, FEMA [the Federal Emergency Management Agency] didn't know there were 300 tornado touchdowns until day five,” recalled Crowley, who subsequently assisted with efforts to evolve FEMA's crisis-mapping capabilities.

“FEMA's new [geographic information officer] didn't want that to ever happen again, so he asked, ‘How can we process these photographs more quickly?’ The answer was we had to change the way the Civil Air Patrol collected the photographs, and we had to build a crowd-sourcing tool.”

The tool, called MapMill, was tested after Hurricane Irene in August 2011. Lessons learned were applied when Hurricane Sandy hit, with FEMA leveraging more than 6,000 volunteers to analyze more than 35,000 geo-tagged aerial images.

“Very, very quickly they were able to get a damage-assessment map showing what areas Sandy impacted the worst, and what areas it impacted the least,” Ziemke said.

MapMill was developed at Camp Roberts, a California National Guard post where researchers from the Naval Postgraduate School have collaborated with industry since 2009 on a series of humanitarian experiments known as the Research and Experimentation for Local & International Emergency & First Responders (RELIEF) program. Now in its fifth year, RELIEF experiments have yielded technology to help feds and crisis mappers alike overcome obstacles. One of the most recent experiments focused on mobile data collection in disconnected environments.

“We can use applications like Pushpin—which is basically like Foursquare for OSM—to collect location-based information during a crisis, but without communication on the ground there's no way to get information from the field to [the open-source community],” said Anthony Quartararo, CEO of Spatial Networks, which designed Pushpin.

To help solve this problem Spatial Networks created Fulcrum, a mobile app field-tested by FEMA at Camp Roberts for its ability to collect location data in low- or no-connectivity environments, then upload it to a central data center once Internet access becomes available.

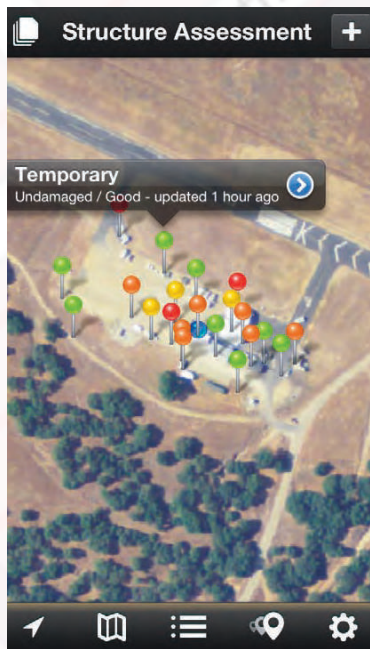
The U.S. State Department is likewise focused on information sharing.

In 2013, its Humanitarian Information Unit (HIU) launched “Imagery to the Crowd,” which leverages the National Geospatial-Intelligence Agency's (NGA) NextView contract to provide high-resolution commercial satellite imagery to crisis mappers.

“Volunteers will do work if there is a compelling reason and they have access to commercial satellite imagery in an easy-to-use manner. That means you've got to figure out how to put the imagery on the web and turn it into web services that are prepared and ready to use,” explained Josh Campbell, a former GIS architect and geographer with the State Department who recently became vice president of product management at Boundless. “With Imagery to the Crowd, we [process and share] imagery the U.S. government purchases ... and serve it out to volunteers ... In that way, we've tried to utilize imagery as a catalyst: If there's imagery, will they come map it?”

In more than 15 instances to date, this strategy has been effective, according to Campbell, who cites Typhoon Haiyan as a watershed example.

“Haiyan hit on Friday night local D.C. time,” he recalled. “[NGA] worked all day Saturday and Sunday to do an initial damage assessment. They got the first clean commercial shots of [hardest hit] Tacloban on Sunday, and by Monday [HIU] had them downloaded for processing. By Tuesday night we had the first Imagery to the Crowd scenes



SCREEN IMAGE COURTESY OF SPATIAL NETWORKS

2013

The U.S. State Department's Humanitarian Information Unit (HIU) launches Imagery to the Crowd to provide high-resolution commercial satellite imagery to crisis mappers. In 2014, HIU follows Imagery to the Crowd with MapGive, a program to educate and involve the global community in mapping.

2013

Crisis mappers mobilize before and after Typhoon Haiyan in the Philippines. Their speed, collaboration, and effectiveness stand in stark contrast to Haiti, illustrating immense progress for crisis mapping in only three years.

of post-event Tacloban up and available for the crowd to map, which they did in about 36 hours, tagging in Tacloban alone approximately 30,000 buildings as damaged or destroyed. It was pretty amazing."

Equally as amazing as what happened after the storm was what happened before.

"Prior to the storm even hitting, the American Red Cross mobilized the Humanitarian OpenStreetMap Team, which activated volunteers to create baseline data," said Albert Gembara, technology integration officer for the Office of U.S. Foreign Disaster Assistance (OFDA) within the U.S. Agency for International Development (USAID). "Those volunteers rapidly mapped buildings, roads, bridges, and terrain features so practitioners on the ground could compare and contrast the before and after picture. That pre-disaster infrastructure data was essential for improving situational awareness on the ground."

A PROVERBIAL CRYSTAL BALL

Although the nature of the crises was different—one was extemporaneous, the other expected—the contrast between Haiti and Haiyan foretells the future of crisis mapping: Yesterday, crisis mappers responded to disasters; tomorrow, they'll anticipate them.

In fact, they already are, according to Simpson, whose GFDRR team specializes in disaster risk modeling and open data for resilience. "Disaster risk

modeling has been around for a long time," she said. "It's like a proverbial crystal ball that tells you what could happen if Kathmandu had a large earthquake—which is generally considered overdue—or if a tsunami hit a particular community."

Adds Tucker, "A disaster may occur, but it doesn't necessarily need to turn into a crisis. Understanding what the landscape of natural hazards is, and how those overlay with the human landscape and the built environment, allows you to calculate risk and think about what investments you can make in infrastructure or capacity building to reduce the likelihood of a crisis."

Although infrastructure investments are critical for long-term risk mitigation, capacity development is an important first step.

"A lot of times, disaster-affected communities lack the capacity to understand how to work with the data that [crisis mapping] creates," Gembara said. "The technology and methodology is moving at a great pace, but helping vulnerable communities understand the information they're receiving is something we're trying to build capabilities around."

USAID's GeoCenter regularly partners with universities to host "mapathons." In November 2013, a three-hour mapathon at George Washington University attracted more than 90 geography students who used OSM to map infrastructure in earthquake-prone Kathmandu, Nepal. By the end of the evening, the areas they'd been asked to map were virtually complete, which will help humanitarian organizations plan ahead of a potential crisis.

USAID is working to expand this program internationally in places like Bangladesh, where local students will be trained to map their own cities. Doing so is a first step toward supporting OFDA's capacity building goals, according to GeoCenter senior analyst Chad Blevins. "The best practice is to have locals create their own data because they can add attributions to buildings they know, designating them as schools, hospitals, markets, and whatnot," he said.

The State Department's HIU is similarly engaged in capacity building. Following its success with Imagery to the Crowd, it unveiled a new initiative

called MapGive in March. Leveraging the State Department's social media followers, MapGive aims to build an army of "digital humanitarians" by educating global citizens on the importance of mapping, teaching them to contribute to the OSM community, then deploying them during volunteer mapping projects.

"To my knowledge, this is the first time there has been a formal process to connect the government and the grassroots," Crowley said.

By producing not only more maps, but also more unity of effort, such connections will hopefully lead to more resilience.

It's happened before. Consider the history of urban fires, such as the massive blaze that destroyed much of Chicago in 1871. As a result of joint efforts by governments and citizens to

GEORGE WASHINGTON UNIVERSITY

geography students in November 2013 helped USAID and the World Bank map Kathmandu by tracing satellite imagery using online tools for the Open Cities project.



develop smart land use plans, strong building codes, solid insurance policies, and effective fire prevention education, cities no longer burn to the ground.

"We solved this problem because our collective will was strong enough," Simpson said. "I'm fairly optimistic that one day we'll consign disasters to history much in the same way we have urban fires." ■

PHOTO COURTESY OF CHAD BLEVINS/USAID