Crisis Mapping and Crowdsourcing in Complex Emergencies

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Summary

Crisis mappers secure satellite imagery, photos, video, event data, incident data, and other documentary evidence to create an operational picture of a disaster in order to facilitate improved humanitarian response and assistance in a crisis.

The era of human-powered crisis mapping between 2009 and 2014 was a bootstrapped effort very much a function of the peculiar state of technological development at the time—available but not yet formalized, streamlined, and automated. Humans filled the gap until machine assistance could catch up. These efforts, often mundane (e.g., cut and paste over and over for hours), were more reflective of the state of technology at the time than anything else.

Another precondition that enabled the field to grow is the often taken-for-granted public good provided by the GPS satellites maintained by the U.S. Air Force. Without this service, the project at the time would not have emerged where and when it did.

The future will be shaped as a result of improvements in automated forms of data collection; improved machine learning techniques to help filter, identify, visualize, and analyze the data; and the proliferation of low-cost drones and other forms of sensors, to name a few.

Keywords

crisis mappers crisis mapping crowdsourcing disaster response ICCM crisis analysis

In this article, the authors provide a brief overview of crisis mapping, charting it from its inception through its evolution. Incredible technological change rapidly emerged in such a short amount of time and just a few years ago—crisis mapping evolved in a manner coincident with these technological advances. The authors then highlight the security and political implications of this work. To conclude, the authors imagine how a variety of emerging trends will converge to shape the future of these efforts.

Taxonomy of Crisis Mapping

Despite the wide variety of different users, apps, platforms, and deployments that are referred to as “crisis mapping,” some core elements of crisis mapping can be

identified. Crisis mapping delivers to end-users in a complex emergency a picture of the operational environment meant to improve disaster and humanitarian response. Crisis Mapping is a project that consists of a sequence of steps: Sourcing, Filtering, Visualization, Analysis, and Operations. The Crisis Map is created from data and information gathered from the crowd, the press, imagery, and a wide variety of other sources. Crisis Maps are the result of a crowdsourced effort to gather, filter, visualize, and analyze data on a map.

Sourcing and Filtering

Sourcing consists of a crowd of volunteers leveraging the crowd as the source for most relevant, timely, and actionable data and information in an ongoing emergency. Thus conceived, crowdsourcing refers to both a primary source of data (human sensors) as well as a method embedded within Crisis Mapping (Avvenuti, Cimino, Cresci, Marchetti, & Tesconi, 2016; Bott, Gigler, & Young, 2014).

The crowd is always there and can help provide a real-time picture of the operational environment with the use of news feeds, blogs, tweets, pictures and video, and social media platforms, in addition to fresh satellite imagery (Elliott, 2019; Gao, Barbier, & Goolsby, 2011; Hanchard, 2012; Hunt & Specht, 2019; Levental, 2012; Liu, 2019).

After the earthquake that ravaged Haiti in early 2010, for example, the remote crowd around the world relied on the local community in Port au Prince to feed the remote volunteer translators and geolocators the relevant information.
Volunteers from around the world sitting remotely on their desktops, tablets, and smartphones, combed through updated web feeds from YouTube, Twitter, Facebook, blogs and the press for additional information in order to enhance situational awareness on the map. It is important to remember that the final product is in fact the result of an arduous, at times mundane, and often traumatic effort undertaken by volunteers.

Of course, information comes in thousands of different languages, raising the issue of automated translation and using computer assistance to help comb through and tag the millions of tweets, terabytes of data, and thousands of texts coming from any monitored feed. The field of natural language processing (NLP) and the growth of machine learning offers automated assistance to this enormous effort.

Filtering is about turning information into data points. Too much information has no decision-relevance and handicaps responders and analysts. However, the crowd itself can be utilized to act as a filter to turn information into verified and relevant information. The crowd can also help correct rumors on social media in real time, detect reporting biases, and process, tag, and identify imagery. Crowd filters act as an excellent first pass over the data, freeing up time so experts can cope with the most interesting pictures, tweets, or reports. However, in the era of fake news, disinformation campaigns, and deep fakes, problems of verification are actually increasing with time, such that photographic or even audio tapes are no longer completely credible.

Visualization and Analysis

How do stories, events, and SOS texts appear on the map? The process is one of creating reports, either manually, or, increasingly, with the assistance of automated tools, to help with place-name recognition, geotagging, and assigning a category for each event. First, developers or volunteers, depending on the platform, create a specialized instance of the crowdsourced crisis map, complete with categories specific to the context and relevant geospatial extent, in order to generate specialized multidimensional visualizations of the data for each deployment. A detailed discussion of the wide variety of methods for geospatial data visualization and analysis remains beyond the scope of this article, but they include, for example, point pattern analysis, spatial regression, and enhanced data perceptualization.

Operations

Once sourcing, filtering, visualization, and analysis are complete, a crisis map becomes operational as an interactive platform for information dissemination and decision support. Affected populations and responders on the ground use these maps to better identify response needs. All of these shape files and layers can be used to create baselines for comparison with subsequent crisis maps and in order to assess impact and assist recovery efforts.

How do we understand the historical evolution of Crisis Mapping through the lens of social science in general and Political Science in particular? We see it as largely coincident with the state of technology at the critical time of its evolution.

Making Sense of the Evolution of Crisis Mapping Through the Lens of Political Science

Modern maps provide users with a common language that imparts a form of legibility and cartographic certainty that helps them navigate the terrain. Maps enable humans to grasp their relationship to space and to do so irrespective of origin, language, or location. For example, travelers can look at the topographic map of a mountain range and understand the route to the summit in terms of conceptually uniform latitudes, longitudes, and topographic features, and do so regardless of the particular language they might use to understand their world. Because of latitudes, longitudes, maps, and navigation, humans can navigate across an unfamiliar city with a smart phone, in search of a friend, and not get lost.

However, in the immediate aftermath of a sudden-onset acute crisis, such as a flood, pogrom, or earthquake, a map loses its legibility because crises fundamentally alter relationships to space and other people. The information challenge in a disaster thus results from an incongruity between what is represented on the old map between the new, altered reality on the ground. Crisis mapping emerged in the attempt to help first responders overcome this information challenge.

Information is in critical undersupply in the early stages of a disaster. Properly verified and collated, disparate facts, figures, images, and stories from the crowd become decision-relevant information. Whether it is first responders attending to those in need, law enforcement attempting to restore order, or soldiers pursuing an objective, all face the same information challenge.

Once the monopolized prerogative of the state, mapmaking has slowly democratized over time, which bears directly on the rise of crisis mapping. Maps, as well as the human understanding of one's place within the spaces defined by them, always evolve. This evolution is tied to precisely how technologies evolve and societies change; and, critically, they are reflective of how political power is organized in a location at the time. Modern states impose "legibility"[1] on physical and social space through activities like census taking and recording property rights through cadastral mapping, and by delineating roads and other infrastructure. As such, maps help states impose order, control people, and accumulate territorial wealth (Scott, 1999).

Historically, because mapmaking was a prohibitively expensive venture, only states could marshal the resources required for the project. Private entities had limited incentive to undertake a task that promised little in terms of commercial return. Because states enjoyed a monopoly on mapmaking, the road maps, plat maps, infrastructure maps, and cadastral surveys they created functioned as public goods provided by the state.

The state no longer enjoys a monopoly on mapmaking, as maps are generated by private entities for commercial use, deployed by civil society organizations as a public good, and created by individuals who populate maps with their own information. Yet maps built in 2019 generally still rely on the initial cartographic foundations originally delineated by the state.

Within this broader socio-historical context, crisis mapping is a community-led process of generating new and detailed maps of legibility to track complex crises. This field of practice emerged at the confluence of three pillars: a positive externality that evolved out of a global public good provided for free in the form of a GPS navigation system, technological advances that made it possible for a global digital community to emerge; and the emergence of technologically enabled digital volunteers the world over.

The proliferation of web-enabled, handheld devices and open mapping platforms and apps sparked the rise of digital volunteerism. That dynamic has been well documented elsewhere (Alderton, 2014; Heinzelman & Waters, 2010; Meier, 2012, 2015; Turner, 2006; Vinck, 2013; Ziemke, 2012). However, the essential role of GPS systems as an indispensable prerequisite condition has so far not been recognized.

The 2nd Space Operations Squadron, 50th Space Wing, of the U.S. Air Force provides and maintains a constellation of GPS satellites that are available to any individual, or public, commercial, or military entity in possession of a GPS receiver that can obtain an unobstructed line of sight to four or more GPS satellites orbiting the earth at any given time.[2] This public service transformed both the private and public sectors.[3] It is also the case that without this global public good provided by the U.S. government, crisis mapping would not exist.

At first, GPS technology was primarily used by advanced industries (e.g., the trucking and shipping industry) that required enhanced transportation and logistics planning or by adventurers with expensive receivers. Later, cellular phone companies and the computer industry integrated their standards into the GPS architecture for advanced location accuracy. Smartphone technology obviated the handicap of maintaining an unobstructed line of site to satellites through the use of telephonic systems by bouncing signals off transmission towers. IP addresses could utilize the telephonic system with GPS services as the (free) cartographic foundation, or they could make use of the Russian Global Navigation Satellite System (GLONASS) that became operational in 1995. The EU's Galileo complete system of satellites came online in 2020, with China and other great powers also in development of their own systems (Crichton & Tabatabai, 2018).

Location-based services became so easily accessible for the average person that it became part of a taken-for-granted aspect of modern life in 2020. This had an effect on the way people view their relationships with the maps in their pocket. One needs only access the map on the phone in their pocket to find the precise time, navigate the terrain, or find one's location. However, at the same time, many became aware of a great shortcoming—they found that many areas of the developing world—their neighborhoods—were either not fully mapped or absent from the maps.

Political prerogatives, security concerns, and the path dependency of the poverty trap played a role in generating this shortcoming. Wealthier countries have better maps (at least in well-to-do, urban areas); as countries develop, the complex societies that emerge spawn social regulations that lead to even richer mappings of the environment, and states need accurate maps in order to implement their public policies. By contrast, poorer countries face a divergence in their mapping capabilities—typically the focus is on delineating wealthy, urban areas, and often at the expense of both densely populated neighborhoods and isolated or rural areas.

In addition, underdeveloped areas on maps typically reflect disparate realities on the ground, especially in countries where regions are treated differently with respect to development. At the subnational level, certain areas in weak or underdeveloped states face deteriorating or non-existent roads and bridges and even less critical infrastructure, rendering these areas disconnected from the center of power. In some instances, this was not a mistake, but a political calculation meant to divert resources away from rivals while also enabling the state to distribute wealth and the best infrastructure to populations who form the basis of their political support.[4]

It is important to note that rural areas in highly developed countries may have mapping deficits. This was the case, for example, in Sweden in 2014 during a period of large wildfires, where outside rescue services had difficulties in navigating unevenly mapped country and fire roads that came up blank or wrong on Google maps (Bynander, 2019).

Other examples from around 2010 (marking the early years of crisis mapping) that illustrated the disparity in the quality of available maps were numerous, from the shanty towns in the outskirts of Nairobi, to Mumbai, to whole cities and islands in the Philippines and entire sections of Port-au-Prince in Haiti that did not appear on any formal maps.

Yet the confluence of several factors helped create new maps of these areas, and for the first time. The rise and proliferation of smartphones and portable electronic devices equipped with mapmaking software and/or low-cost and accessible Web-based tools meant that individuals and communities could begin to generate maps of their immediate vicinity. That is, citizens could begin to detail the formerly blank space in terms of their own understanding of what existed on the ground, and "the state," the age-old watchman of mapmaking—began to lose its monopolized prerogative altogether.[5] No longer reliant on waypoints for direction, or, even worse, literally counting off the number of steps to the next location, not only did citizens begin to map these "blank" areas on the map, but they could also use maps to document the state's shortcomings. The ability to place information on maps led to a cultural shift—digital maps seemed to encourage a whole new form of storytelling and truth telling: stories of states engaged in "land grabbing" for oil, of impassable roads and broken infrastructure, and even of the lack of security on city streets. Citizens were marking exactly where and when they were asked to pay a bribe, documenting resource disparities, and using maps to lay claim to their property rights as well, as the case of Cadasta demonstrates.

What technologies facilitated the rise of these new storytelling dynamics?
In 2004, OpenStreetMap (OSM) burst onto the scene, ushering in an era dominated by the democratization of mapmaking. OSM was a citizen's mapping effort, deploying crowdsourcing and micro-tasking to generate the world's first "wiki map." Volunteers used fresh imagery as transparencies on which they traced roads, structures, and available resources on blank sections of existing maps, relying on others for error correction and continual improvements of the map. The creation of Google Maps followed in 2005, and soon many had some version of a digital map accessible via their cell phone or laptop.

A new era in geography was taking hold, democratizing mapmaking. No longer the exclusive use of state surveyors or militaries, these tools offered individuals the chance to contribute to maps that defined their human geography and relationship with the wider world, and on their own terms. However, no application or platform yet existed that enabled geolocated stories to be posted as visual points on a map. This changed in 2008 in the face of an acute information challenge and a political crisis in Kenya.

Ushahidi and the Rise of the Crisis-Mapping Community

In 2008, in the wake of crisis-induced political violence in Kenya, Ushahidi ("to witness" in Swahili) was developed as a first-of-its-kind "crisis-mapping" platform in order to identify, help mitigate, and prevent electoral violence during the election.[6] Ushahidi is a company that offers a free and open-source platform that deploys crowdsourcing to create a map of crisis information that is then visualized on the Ushahidi Crisis Map (Werby & Meier, 2010).

Though originally tasked to monitor election-related violence, the platform has since been repurposed thousands of times as deployments to help track damage after

earthquakes, tornados, and firestorms; identify resources available to communities after a disaster (e.g., identify food bank, health service, and shelter locations); or call attention to social problems (e.g., HarassMap in Egypt); and much more.

Ushahidi was first out of the gate with an interactive, online mapping platform to enable the collection of critical, crowdsourced event data to facilitate disaster response. At around the same time, also in Kenya, initiatives such as Map Kibera (est. 2009) and Spatial Collective (est. 2012) began to map the many areas left unmapped. The emergence of iHub in Nairobi in 2010 further cemented the city on the cutting edge of technological innovation, leading many to consider the city the birthplace of crisis mapping.

At around the same time, there were disparate groups of "crisis mappers" all around the world, working across a variety of different complex emergencies and in the humanitarian space. Crisis mappers are a global epistemic community of extraordinary diversity, working in various capacities across the world, who leverage mobile & web-based applications, participatory maps & crowdsourced event data, aerial & satellite imagery, geospatial platforms, advanced visualization, live simulation, and computational & statistical models to power effective rapid response (and generate early warning systems) for complex humanitarian emergencies.(CrisisMappers, n.d.)

In 2009, the International Conference of Crisis Mappers (ICCM) convened this epistemic community for the first time. The ICCM was deliberately designed by its creators not to be an organization or an institution, but only a forum to facilitate collaboration focused on cultivating best or at least better practices and ideas. Precisely because technology democratized mapmaking, by definition, each map, or professional working in this space, or volunteer has a variety of different goals, aims, strengths, interests, and backgrounds, and has worked in varied political contexts facing very different security concerns. Consequently, the ICCM brought together "an international community of experts, practitioners, policymakers, technologists, researchers, journalists, scholars, hackers and skilled volunteers engaged at the intersection of humanitarian crises, new technology, crowd-sourcing, and crisis mapping."

Immediately following the inaugural ICCM conference in 2009, crisis mappers as a community were thrust into the crux of a complex crisis and came of age in the wake of the Haitian earthquake in January 2010. The response to that crisis fundamentally shaped the community and its subsequent evolutionary trajectory in substantial ways.[7]

The 2010 Haiti Earthquake and International Crisis Mapping

In the early hours of January 12, 2010, an earthquake that registered 7 on the moment magnitude scale (MMS) occurred 20 kilometers west of Port-au-Prince, Haiti, devastating much of the capital. With the death toll rising to over a hundred thousand,[8] international response teams, ranging from UN agencies (with the Office for Coordination of Humanitarian Affairs [OCHA] in the lead), to local and international nongovernmental organizations (NGOs), to the U.S. military, responded in force.

On the ground, everyone faced a complex emergency made that much worse by the underdeveloped nature of Haiti. Complex emergencies kill people, but poor governance, corruption, and weakened capacity usually shape the follow-on effects of a disaster in the days, weeks, and months after and can lead to even more casualties.

Developed countries with building codes, established protocols for risk mitigation, and emergency preparedness training are better situated to respond to complex emergencies than weak states with limited institutional capacity. Yet, first responders in Haiti faced a complex emergency of monumental proportions compounded by the fact that Haiti consistently ranked at the bottom of all development indices.

Disaster responders attended to two eventualities simultaneously: while they engaged in immediate rescue efforts and provided first aid, they also simultaneously prepared for the day after, which would inevitably lead to more casualties and dislocation if basic sustenance needs were not quickly met—water, food, shelter, hygiene, and security.

The first step of most any response is to obtain decision-relevant information: Who is in need? What is the nature of their need? Where are they located? What is the condition of the terrain in the immediate area and the best way to reach the area?[9] In the first few hours and days after a sudden, unexpected event occurs, this information is in critically short supply. It is in these moments that harnessing accurate information to capture the evolving nature of emergency needs becomes the animating concern; this information can help save lives.

Though all crisis situations are unique in some ways, a few underlying necessary conditions made the digital crisis response in Haiti unique. Despite the nature of the disaster, the communications infrastructure was not completely disabled, enabling people on the ground to report their needs and concerns via text in near real-time and share on social media, which was then picked up by the press. As a result, people across the world tracked the disaster and international response by following news and engaging in conversations on multiple news and social media platforms.

Concerned people understood the challenge faced by the Haitian people and responders and realized that they could volunteer through remote, digital deployment to help overcome the information challenge. Their efforts generated a global digital community of concerned citizens willing to help. The community followed local conversations, translated and recorded distress calls, and isolated two challenges that they could help overcome: the first was finding accurate geo-referenced information that correlated with the distress texts coming from the established helpline: 4636. The second was to generate a near real-time map that kept evolving in order to capture the reality on the ground and in a way that would do most to assist first responders with their information challenge. Because of privacy concerns, the local cell provider, Digicell, was not releasing the GPS coordinates of the cell tower origins of the 4636 messages. Digital volunteers stepped into the void by micro-tasking their collaborative efforts. The crowd diligently combed existing maps to find the location of the emergency with the use of landmarks and terrain features, marking the information by hand on the map, tagging the event with as much information as they could gather on the nature of the emergency and need in question.

Finally, crisis mappers faced another problem that was also bedeviling emergency responders on the ground. Most of western Port-au-Prince was never mapped by the government. Available maps at the time consisted of main terrain features and avenues of approach but were neither detailed enough to capture the precise locations of those in need, nor did they serve as an accurate guide for first responders who quickly tried to navigate to the geotagged location.

Humanitarian OpenStreetMap (HOT-OSM) came to the rescue. Remote volunteers connected digitally via their laptops to use fresh imagery to update the map with critical information. These efforts rapidly generated a crowdsourced road map that facilitated first responders' efforts on the ground. This brief animation[10] shows how the edits in HOT-OSM helped populate and improve the map over time. First responders downloaded the most updated OSM roadmap on their GPS units for frontline disaster response efforts.

Figure 1. OpenStreetMap map of Port-au-Prince before the earthquake.

Credit: Boccardo and Pasquali (2012).

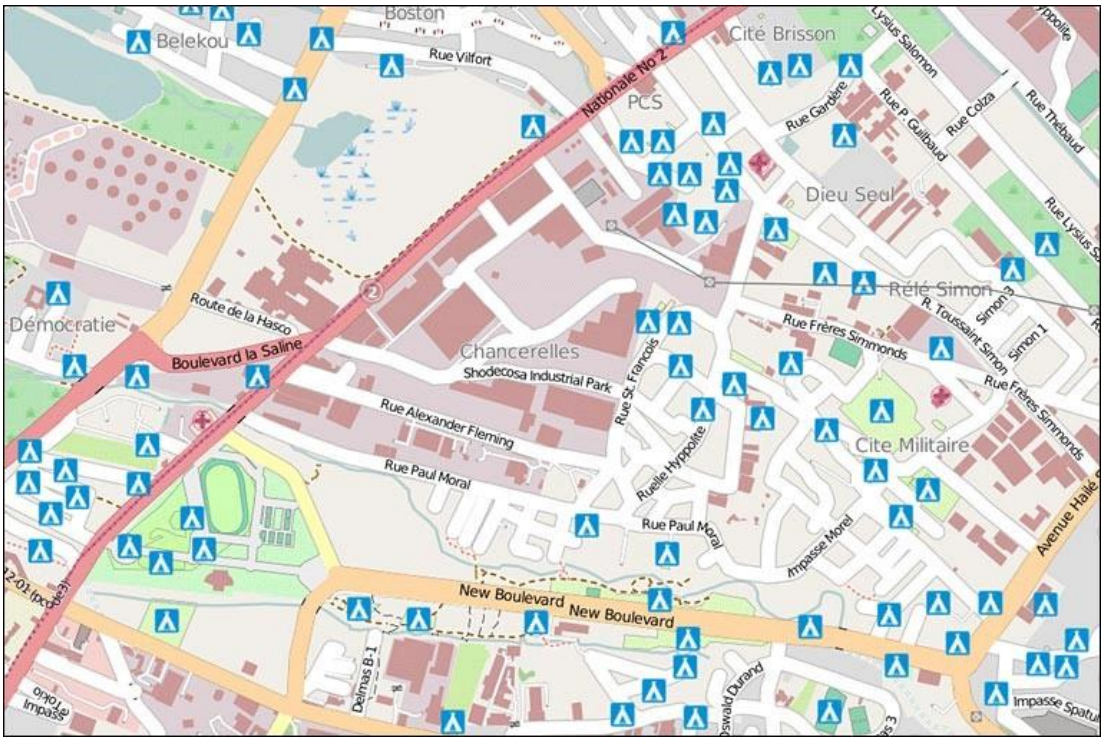

Figure 2. OpenStreetMap Map of Port-au-Prince one week later.

Credit: Boccardo and Pasquali (2012).

The OpenStreetMap contribution (see Figure 1 and Figure 2) is just one part of a broader story of a collective remote digital response to the Haiti earthquake. The collective effort loosely came to be known as Mission 4636,[11] so called because that was the help number established for Haitians on the ground requesting assistance who were able to text this number for free to report their needs. Information that came through this line was translated through a global micro-tasking service called CrowdFlower. Volunteers from the diaspora in cities around the world would digitally report during their lunch break or stay up all evening to offer on-the-fly Creole–English translation. Once translated, the English messages would bounce to volunteers, many of whom were originally located in the basement of a building at Tufts University. Students and other volunteers began manually tagging and geolocating events onto an Ushahidi instance specially created for the Haiti case, resulting in the live and continually updated crisis map. Each point on the map points to an incident report complete with geotagged information and categorized by need: food and water needs, trapped persons, security alerts, and urgent messages related to public health, to name a few.

What began among graduate students and friends at Tufts University quickly scaled to a global effort through friends' networks, radio and television press coverage of their remarkable work, and word of mouth. Soon people the world over were responding in shifts, taking advantage of the fact that a volunteer in London would be awake different hours, typically, than someone in Boston or Los Angeles, all providing countless free hours as a labor of love and out of a genuine concern for affected persons in the disaster zone.

This was truly a global response. To name everyone involved across a loose "network of networks" would be impossible. Individuals, innovators, and volunteers invented, bootstrapped, and accelerated the ability of the crowd to help provide lifesaving assistance during this emergency. They shared imagery and coordinated satellite tasking. They helped one another with coding tasks and managing multiple databases.

The outcome of this collective effort was the world's first crowdsourced crisis map—a map created by volunteers around the world, working around the clock on their laptops from home, digitally deployed to assist a complex emergency. The crisis map was recognized as providing the best situational awareness available to the humanitarian community on the ground at the time, according to then-director Craig Fugate at the Federal Emergency Management Agency (FEMA).

Despite some early successes, the community began to wonder if the Haiti case might be unique. Would such an effort be possible in contexts where the infrastructure was even more damaged and where communication networks were down? Fortunately, many innovative projects initiated around this time focused on helping offline users access the Web in underpowered and disconnected environments.

Crisis Mapping in Offline and Underpowered Environments

It is important to note that crowdsourced crisis mapping is possible, even when communications infrastructure has been destroyed. Many crowdsourced mapping and data collection environments have consciously built their platforms for these contingencies. To take just a few examples of many, in 2006 in rural northern Uganda, BOSCO (Battery Operated Systems for Community Outreach) emerged to provide "innovative ICT solutions using a collaborative, web-based approach to foster social and economic development in peace building" despite the context of violence and war plaguing northern Uganda at the time.[12] Another example of innovation for offline environments is KoBoToolBox, where users create forms that resemble Google Forms for carrying out surveys, for example. No Internet is needed, yet thousands of forms will automatically be saved and uploaded as if one were directly connected, as one of the authors experienced directly by creating a health survey in rural Honduras in an environment completely off grid, using paper maps and KoBoToolBox-generated survey forms. Once connectivity is restored or one travels to an area with connectivity, the forms are automatically saved to the online environment. Another example of work in this area is the Nairobi-based initiative BRCK, established in 2013, which helps people in disconnected markets link to the Web by offering a rugged Internet that promises access to the Internet in a manner that is "simple and reliable wherever you are."

States have also supported efforts to get communities connected during a disaster, or find offline solutions, recognizing that the real first responders are often the neighbors that step in even before first responders arrive. Thus, enabling citizen access to geospatially relevant local information can enhance community resilience. For example, supported by the Joint Interagency Field Experimentation (JIFX) at Camp Roberts in Paso Robles, California, the Naval Postgraduate School has hosted the community in operational field environments that facilitated further developments by

creating the time and space for intensive collaboration to overcome challenging conditions. The NPS annual event run by civilians sought to enable civilians and nonprofits to create their own tools and provided a place for them to field-test them in remote environments and interact with others doing similar work, most of whom were working in civilian space. Without this service, many projects would not be the same. An example of innovation in offline humanitarian mapping is HOT-OSM's Field Papers (called Walking Papers at the time), where those working off the grid are able to download a paper map for damage assessment, print it, and use paper and pen edits to mark changes. The edited paper maps can then be scanned later back into the digital OSM once accessibility is restored or on returning from the disaster zone. Together with several other innovations in this area, crisis mapping is rendered increasingly possible even in the most austere environments.

Evolution of Crisis Mapping: Critical Scaling, Growth, and Deploying Best Practices

Following the Haiti experience, the international crisis-mapping community faced a specific puzzle: is this a one-off moment, or could the best practices of this experience be formalized? The crisis-mapping community helped integrate the experience in Haiti by both routinizing the best practices and formalizing channels of communication. It also raised follow-on puzzles that led the community to explore areas of further innovation.

Following the Haiti response, the community had a chance to reflect on lessons learned during the second ICCM conference in 2010. The Standby Task Force (SBTF) emerged as a response to the concerns raised from the formal first-responder community to address the issue of whether these contributors could be relied on to participate in future events.

The volunteers of SBTF constitute a network of highly skilled remote assistants around the world "on standby," ready to engage in various tasking teams according to skill and interest, working in shifts to analyze and comb through social media feeds, create and geolocate incident reports, verify and analyze data, and perform a variety of technical and task-oriented support. The SBTF pre-positions trained volunteers that are ready to assist the next disaster to help coordinate remote assistance and operational response for future disasters. But this is not the only innovation.
A "whole of community" approach helps solve various aspects of the volunteer management problem in different ways. For example, the Humanitarian OpenStreetMap (HOT-OSM) team responded to the charge of "how to manage the swarm of volunteers" so as to avoid duplication of effort by developing a tasking manager to divide the operational zone of interest into grid squares that volunteers can claim for live mapping work, thus avoiding gridlock from too many people swarming to work on the same section of the map.

Linked to this effort was the ongoing need for platform interoperability, requiring a global effort of tireless individuals working on tasking satellites and other kinds of imagery to negotiate a UN Charter declaration that enables free distribution of this expensive imagery to the informal network of skilled GIS and IT professionals offering their support as individuals and to groups such as Geeks Without

Bounds (est. 2010), GISCorps (est. 2003), Humanity Road (2010), and Map Action (est. in 2002).

By late 2011, the formal disaster response sector engaged a variety of informal networks via the ICCM conference and virtual crisis-mapping community to share their concern about the proliferation of volunteer networks doing this work. They asked, "How does one engage the relevant part of this 'ecosystem' of volunteers given our diverse needs?" Informally, people came to know that some of the groups active in the digital humanitarian space were HOT-OSM, CrowdFlower (now Figure 8), GIS Corps, Standby Task Force, Humanity Road, and Geeks Without Bounds, among others. But how could ad hoc networks, volunteers, and crowds engage with the formal sector? How could informal knowledge learned about "who does what" and whom to contact be routinized?

In response, leaders from both the formal and informal sides met in 2012 to create the Digital Humanitarian Network (DHN). The DHN aims to bring volunteer communities into the same coordination scheme as formally organized institutions.[13] Now, after a disaster strikes, any formal institution can send a single request to activate relevant volunteer and technical communities (V&TCs) that are needed to remotely support the disaster responders on the ground. These V&TCs offer skilled volunteer labor in the service of disaster response efforts. On standby are statisticians, geographers, skilled data analysts, network analysts, coders, and translators, among others.[14] Rather than engage each of these groups individually, after a disaster strikes, any formal institution simply sends only one formal request for activation to the DHN as the single interface with the broader V&TC community, which then activates those portions of the network needed, within 24 hours (see "History & Today," n.d.).

Imagery From Above

Underlying many of these efforts was the persistent need by many actors involved in disaster response to acquire the best or most recent satellite and aerial imagery of affected areas in order to document damage and assess needs from above.

Recall the earlier contention that technological changes that brought down the cost of mapmaking ended up shifting the domain of mapmaking from the sole province of states to a variety of non-state actors and individuals. The same development cycle happened in the domain of "imagery from above," but the dynamic lagged a few years behind. Before 2010, only states or companies had the ability to garner such fresh imagery, as launching and tasking satellites was prohibitively expensive and largely in the purview of the state.

It wasn't until around 2015 or 2016 that users could begin to buy reliable, sophisticated drones equipped with cameras in a way that would transform an individual's ability to access a near real-time view of the earth from above. On the horizon, handheld lidar, CubeSats, and the promise of flying cars and taxis by 2019 or 2020 will continue to transform the crowd's ability to collect "imagery from above" for themselves. Soon, this imagery will be easy for many to obtain.

The story of the mid 2000s and early 2010s was one of innovative individuals and creative crowds bootstrapping their way toward early capacity before it was to become mainstream. One example of citizens gathering their own "imagery from above" during a disaster is a story from 2010, when members of Grassroots Mapping rigged kites and balloons with cameras to document oil spills in the Gulf of Mexico. Another example occurred in 2012, during one of the experiments at Camp Roberts, when HOT/OSM, GISCorps, and Public Lab worked with pilots on Civil Air Patrol planes to acquire photographs of the devastation caused by Hurricane Sandy. The photos the pilots took were distributed via a simple, straightforward app to the crowd (which was asked to assess levels of damage on a given picture as either none, mid-level damage sustained, or truly destroyed). Via triangulation and mobilization of many digital volunteers, a crowdsourced damage assessment map used by first responders to coordinate and prioritize their efforts was rapidly obtained.

The U.S. government actively worked to enable the crisis mappers in a variety of different capacities and through various agencies. For example, also in 2012, the Humanitarian Information Unit at the U.S. State Department created a path-breaking way to deliver high-quality "Imagery to the Crowd" (ItC), via MapGive, to the "trusted network" for free; the beta launch was announced at an Ignite Talk at ICCM 2012 and formally launched in 2014. ItC leveraged the National Geospatial-Intelligence Agency's (NGA) NextView contract in order to "provide high-resolution commercial satellite imagery to Crisis-Mappers" (Alderton, 2014). These are only a few examples of innovative projects and initiatives that emerged at this time. The community's stories stretch easily into the tens of thousands, on both the civilian and military side, and often stand at the juncture between peoples and states, with good people trying to facilitate saving lives in the worst of circumstances.

Open access, open source initiatives help facilitate flying drones for community development (see the Humanitarian UAV network), using the resulting imagery in an open source platform, specially stitched together for three-dimensional space (see especially OpenAerialMap and OpenDroneMap).

Crisis Mapping in 2020

Over time, the crisis-mapping community has come to know itself and learn what happens in digital response in the immediate hours, days, and weeks following a disaster. This collective understanding helps facilitate who does what, where, and when, and what niches are as yet unfilled. For example, starting in 2010, the community came to expect that Google would create a specialized instance of Person Finder for rapid-onset, large-scale disasters, connecting people who are missing with those looking for them. Starting in 2014, Facebook Safety Check began offering a similar service. The community also worked to avoid duplication of effort and promote data sharing with the creation of the common data exchange portal, the Humanitarian Data Exchange (HDX), in 2014. These are just a few examples of the socially constructed communities that resulted from these informal and ad hoc global conversations and collaborations.

More broadly, the community, writ large, began an informal process of integration and consolidation, formalizing ad hoc responses and bringing them into existing formal processes. From proprietary software companies to open-source communities, as well as government agencies, militaries, and NGOs, large and small, many began creating their own platforms and deploying their own instances and apps in support of crisis mapping. These trends helped institutionalize crisis mapping, often by bringing elements in-house. For example, Google created the Google Crisis Map; ESRI began supporting Ushahidi through its ArcGIS integration; the Red Cross opened the Global Disaster Preparedness Center ; and FEMA's National Response Coordination Center (NRCC) mobilized to facilitate a variety of responses to recent natural disasters. Crisis maps also provided support to humanitarian aid efforts following Cyclone Idai in Mozambique in 2019 (Kaplan, 2019) and after Hurricane Harvey in Houston (Sebastian et al., 2017). A repository for data sharing via the National Geospatial Intelligence Agency's Protected Internet Exchange, known as PiX, complements ecosystem efforts (Adams & Studds, 2014).

The crisis-mapping community has routinized its procedures so that they can and do formally engage with traditional actors. Given its diffused nature, the network bridges a variety of traditional, hierarchical national and international actors that respond to complex emergencies with ad hoc volunteer networks.

The Political and Security Implications of Crisis Mapping

There will always be both political and security implications related to crisis mapping, regardless of whether those who deploy or participate in the map realize it or even when they expressly share that their motives are deliberately apolitical (Shanley, Burns, Bastian, & Robson, 2013). We contend that there is no such thing as an apolitical map, nor is there a map free of security implications, but the context matters more than anything else in terms of assessing the relative risk. The authors briefly discuss how each differentially apply to both natural and human-made emergencies, as well as to the individuals involved.

The specific location of a deployment matters. The exact political and economic context within which a crisis map is deployed shapes what outcomes are most likely, and nowhere is this more true than in the sphere of politics and security. Do you want to map? The first question is where, specifically, and what is the nature of the disaster or emergency?

Emergencies that result from natural causes generate direct ramifications for national security, with indirect implications in the political sphere. The security implications primarily relate to the criminal element. Crises alter human geography and, consequently, structures of authority and social order. Absent civic order, the sense of safety and security breaks down on the ground. Opportunistic malicious actors will seek to capitalize on these crises for personal gain. As crisis mappers geolocate the most vulnerable individuals and communities on a map in the wake of a disaster, criminal elements can then use these maps to exploit the most vulnerable. Criminal elements constitute the foremost security concern for contexts such as post-

earthquake Haiti in 2010, the Philippines during Hurricane Yolanda in 2013, or after the 2015 earthquake in Nepal.

Political implications are a second-order effect. The same information contained in a crisis map indirectly becomes a performance assessment tool that grades how effectively the disaster responders are handling their tasks. In the case of third-party interveners, this simply works as a kind of Yelp review for their performance. But in the domestic context, the same information becomes politically salient because the map highlights how different local institutions performed. Because heads of department are mostly political appointees, the map may alter local and national-level political contestations, and thus the map becomes part of the contested space itself. Crisis mapping in the context of civil war or other form of organized violence places the effort at the very heart of political and security issues that animate the crisis. Crisis maps in conflict zones track outcomes of violence in terms of constantly changing human geographies. And maps become part of the nature of contestation itself, because crisis maps help protagonists to the conflict overcome aspects of the information challenge.

From the vantage point of combatants, crisis mappers are providing real-time strategic intelligence that explains changes in the battlespace in near real-time, as the 2011 Libya Crisis Map or any of the Syrian crisis maps. These changes can, in the hands of intelligence analysts, be turned into tactical intelligence with which combatants can decide the best applications of violence for a specific geography. Further, the same platforms that collect crisis information may also become evidence admissible in war-crimes tribunals.

In addition to these macro- and institutional-level security and political implications of a crisis map (as well as the strategic implications), the crowdsourced nature of the micro-tasking itself creates very specific security implications for individuals and liabilities for volunteers exposing themselves to risk (see Robson, 2012). In conflict conditions, some crisis mappers are activists who internalize the risk, (in the case of Syria, some may even have come to accept the possibility of death), but many cannot or will not absorb this kind of risk or even recognize the nature of the risk. Most simply seek to contribute and help, absent a political agenda. However, there is no such thing as an impartial, apolitical information contribution to any deployment, and much less in a conflict zone.

Participants face multiple security concerns, from geolocation and personal privacy to surveillance. Every time information is updated by someone on the ground (e.g., an event is newly geotagged), even if the geotag is scrubbed, the data packet inevitably moves through multiple servers and bounces off multiple telephonic networks. A state with even the most rudimentary surveillance capacities can track the location of not only the event but the person recording it and his or her location. Indeed, most cell phone and Internet service providers that deploy telephonic services in conflict zones usually have tacit agreements with all sides of the war to generally either provide backdoor access and/or user information as a precondition to not attack their infrastructure (or the owners and workers) so that everyone party to the conflict may rely on the telephonic infrastructure.[15] Unwitting civilians in moments of rage or anguish could place themselves at risk of retribution without knowing they are doing so.

There are also unintended security concerns that apply irrespective of the nature of the crisis. Crisis-mapping platforms are always dual use. The same platforms and apps that are used by one individual to inform the changing nature of neighborhood water resources, road construction, and issues with school supplies are then used in a different way as evidence of bureaucratic malfeasance and political malpractices that turn the map into a political instrument. For example, in Khartoum in 2013, protests that began over fuel subsidy decreases turned into anti-government protests. Many protestors had used variations of crisis-mapping apps as a coordination tool. Many of these apps are not designed as subversive instruments, but when individuals in Khartoum used them—under the misinformed illusion that they could maintain their anonymity—state officials, instead of shutting down the apps, allowed their use and turned the very same apps into an instrument of surveillance by a repressive regime.

The same can be said of how non-state actors take advantage of collated real-time information from social media to shape their operations. For example, in early 2013, during the terrorist attack by Al Shabaab on a mall in Nairobi, Kenya, frightened victims were live-tweeting emotional messages, revealing to the perpetrators not only their location but other critical information as the event was in process, directly impacting operations on the ground, and in real-time. More recently, T. McLaughlin (2018) describes an instance where What's App was used in India in such a matter, where fake news on the platform fueled violence. Civilians and their platforms of communication are a critical component of contestation in the battlespace, and their role should not be assumed away.

The Future of Crisis Mapping: States, Markets, and Citizens

Crisis mapping was designed by individuals determined to generate a public good with a focused objective—to help overcome the information challenge in complex emergencies. Yet the data that citizens generate as a byproduct of crisis mapping itself becomes the focus of contestation between citizens, states, and market forces.

Crisis mapping emerged at a time when most of the devices could receive but few transmitted data. By 2015, both voluntary and involuntary data transmission had become so ubiquitous that everything from smart devices, computers, and software applications, to the Internet of Things and automobiles had become a surveillance platform where individual user data, clicks, and likes, are all monetized and where companies retain the data.

The nature of the state itself (democratic, authoritarian, or weak[16]) shapes the way in which private companies choose to engage inside each of these different regime types. In liberal democracies, a handful of private entities shape the nature of interactions between citizens. There, cyberspace has evolved into a stratified market built on deliberate regulatory decisions that have allowed the tech sector to evolve freely. On the other hand, authoritarian states provide a fundamentally contrasting vision to the liberal model. In this case, the state uses virtual space to assert its authority, often in unforeseen ways. China is the poster child of what the state can get away with, without citizen accountability. Most authoritarian states are starting to make the case for advancing a state's sovereign rights over the cybersphere and doing so in a way that is

analogous to the sovereign airspace of countries. Indeed, in authoritarian states with effective state capacity, “cyberspace” has become a veritable surveillance arm of the state.

Why this all matters is because in order to make a profit, multinational companies will increasingly come to adopt different policies, depending on the country in which they operate. Already, some companies have effectively created two operating practices to navigate the political milieu across different contexts. For example, Apple has one policy for pluralist democracies in the West, and another for China and other authoritarian regimes.[17] The authors anticipate that most companies will come to develop divergent practices for operation between and across very different regimes. What this means in practice for the end user is that anyone can have all the apps, smartphones, and smartphone-enabled drones, but they will not be usable in all contexts, which will sometimes be by design and sometimes by edict, and sometimes all the generated data are harnessed and turned into surveillance instruments free of charge.

At first blush, it appears that private companies (at least in liberal democracies and weak states) will be ideally situated to help overcome the information challenge of re-deciphering the altered geography, as they already have a detailed baseline profile of the entire human geography of the area before the crisis.

Yet open source crisis maps, developed by numerous volunteers inspired by genuine concern, can be acquired and made proprietary with minor tweaks.[18] Thus, developing new models of crisis mapping and citizen engagement that protect shared intellectual property is in order as the community considers the future of this field of practice. How would crisis mapping evolve if major companies directly engaged the UN and other humanitarian aid agencies? Crisis mapping will be shaped at the nexus of a series of debates and contestation around the regulation of private data and the intellectual property concerns of private entities, as well as how such regulation copes with security and privacy implications. How the community will navigate between these trends will forge its path into the future.

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Notes

1. See Scott (1999) for a discussion of how these activities contribute to a state's desire to understand and control the space—in other words, to make it legible.

2. "The signals are so accurate, time can be figured to within a millionth of a second, velocity within a fraction of a mile per hour and location to within 100 feet. GPS provides 24-hour navigation services including: Extremely accurate, three-dimensional location information (latitude, longitude and altitude), velocity (speed and direction) and precise time

A worldwide common grid that is easily converted to any local grid

Passive all-weather operations

Continuous real-time information

Support to an unlimited number of users and areas

Support to civilian users at a slightly less accurate level than cryptographically keyed users."

3. Additionally, because the GPS system was built to comply with U.S. regulatory standards, user anonymity is maintained because the users are not expected to transmit data, but only to receive data.

4. For example, the leadership in Kampala, Uganda, spent money to develop the city and the south but deliberately left the north underdeveloped and disconnected from the rest of the country, and did so as a result of a specific domestic political calculus.

5. At least in the Western liberal democracies and weak states under discussion here. The authors exclude the authoritarian states of North Korea, China, and Russia from the discussion.

6. Periods surrounding elections and the announcement of election returns act as potential flashpoints, especially in deeply divided societies that engage in identity-based voting and where minority populations face little chance of being represented in a majoritarian system.

7. The Crisis Mappers Network was launched at the first International Conference of Crisis Mappers (ICCM) in 2009 at John Carroll University in Cleveland, Ohio. Since then, they have convened conferences for the global community in Boston (2010), Geneva (2011), Washington, D.C. (2012), Nairobi (2013), New York (2014), and Manila (2016), with different hosts in each location, including Harvard, Tufts, the Swiss Confederation, the European Union's Joint Research Centre, the World Bank's GFDRR & World Bank Institute, George Washington University, the United Nations Office at Nairobi, UN-Habitat, Spatial Collective, The Humanitarian Design Lab at Parsons The New School of Design, Google Crisis Response, and Map the Philippines.

8. Everyone agrees that the death toll passed 100,000, but after that much debate remains regarding the official death toll. It is suspected that the Haitian government, for instance, vastly inflates the casualty count as a means to obtain additional aid.

9. The security and logistics challenges inherent to any disaster response operation were initially assumed away, yet emergency responders in Haiti immediately following the earthquake faced of all those challenges.

10. Shareable by Creative Commons Attribution, ShareAlike (CC BY-SA 4.0).

11. Project 4636 is an umbrella term representing a collaborative effort of the following volunteers and organizations: HOT/OSM, Crowdflower, Digicell, the U.S. State Department, Ushahidi, nascent Standby Task Force volunteers, Tufts University, the Crisis Mappers Community, and many more.

12. For more examples of innovation in Uganda, see, for example, the broad scope of work encompassing tech innovation, community mapping, enhanced power for offline environments, data analysis, and much more at Gulu University and Makerere University; Mountbatten; the active HOT-OSM community in

Uganda; the detailed American Red Cross—Gulu Fire Risk Map; Fruits of Thought Mapping Day Uganda; and others.

13. “Formal” institutions comprise a diverse set of actors in the field, including UN agencies like the UN-OCHA, UNHCR, and the World Food Program; companies like ESRI, Google Crisis Response, and DigitalGlobe; international NGOs like Save the Children and the International Red Cross and Red Crescent Societies; as well as groups like the Pacific Disaster Center.

14. An example of V&TCs active at this time include CartONG, Connected Development (CODE), Crisis Commons, CrisisMappers, DataKind, DisasterTechLabs, Geeks Without Bounds, GeoThings, GISCorps, Humanity Road, Humanitarian OpenStreetMap (HOT-OSM), Info4Disasters, ICT4PeaceFoundation, MapAction, NetHope, PeaceGeeks, Sahana, Standby Task Force, Statisticians Without Borders, Translators Without Borders, and Ushahidi, among others.

15. Somalia is a classic example of this dynamic.

16. Weak states cannot define the space given their limited sovereign capacities and market power. They will face a choice to either bandwagon with the market as defined by the liberal democratic tradition, or bandwagon with how authoritarian states define the virtual space.

17. Absent the US-EU common front, China will become the dominant power that will shape the virtual space, given its market prominence.

18. For example, in a specific geographic location, all Android users are monitored in real-time by Google; all iOS users, by Apple; and all Microsoft Office users generate constant streams of data that are hoovered in by them at all times—not to mention the myriad smaller entities that sell the data. There is also a market opportunity if these entities chose to generate their own crisis map with the help of the crowd.