Research and Experimentation for Local & International Emergency First-Responders

RELIEF 11-01

Report on the RELIEF 11-01
Experiments at Camp Roberts

*Humanitarian Technologies for
Domestic and International HADR Operations*

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In Partnership with the

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RELIEF 11-01

# Background

From 8-12 November, RELIEF convened its sixth session of field experiments for humanitarian information management and crisis mapping at Camp Roberts in Paso Robles, CA. The RELIEF experiments occurred within a partnership of the National Defense University’s Center for Technology and National Security Policy and the Naval Postgraduate School.

Problem domain: RELIEF 11-01 focused on problems stemming from operations in Haiti, the US Gulf Oil Spill, and Afghanistan/Pakistan. It attempted to solve three problems common to both domestic and international response operations:

1. *How to integrate imagery collected and/or processed by multiple communities*. During each operation in 2010, both commercial and government satellites collected imagery, making much of the data available under open licenses for use by multiple stakeholders, including state and local agencies, academic institutions, and non-governmental organizations (NGOs) and private volunteer organizations (PVOs) such as OpenStreetMap and Crisis Mappers. However, there existed no single place to index these various data sets, let alone store the processed imagery in formats that enabled any stakeholder to quickly mashup and analyze data as multiple layers.
2. *How to make citizen-generated map data available for editing and/or correction by federal officials and UN field staff*. In Haiti, OpenStreetMap created the best map of the post-disaster situation, tracing roads and building footprints for most of the country in a matter of days. This dataset quickly became the standard used across the operation. However, traditional GIS tools (such as ESRI ArcGIS) could not read or write in the data format of OpenStreetMap, making it difficult to reconcile changes made in one platform with edits made in another.
3. *How to reduce the delay between data collection and its integration into the information systems being used to make decisions*. While data collection and assessment teams collected reams of paper forms, this data often sat in piles for long periods before being entered into data systems used for decision making. This problem was particularly an issue with georeferenced data collected about the locations of critical infrastructure, including hospitals, schools, and cholera treatment clinics in Haiti. It is also an issue for citizen-generated data that requires translation.

Approach. Unlike the hackathons and code sprints which have become common among other crisis organizations (like Crisis Camps and the Random Hacks of Kindness) which generally invite technologists to invent new software platforms to solve a range of problems), the experiments at RELIEF extend existing applications. The intent is to gather the inventors of the open source software commonly used by responders and the large organizations that deploy to humanitarian emergencies. In this case, RELIEF convened a panel of top humanitarian technologists from industry and the open-source domain. This team included the following software developers:

* **George Chamales**, system administrator for Ushahidi’s Crowdmap and core collaborator on other Ushahidi tools.
* **Aaron Straup Cope** of Stamen Design, core developer of the geospatial capabilities in Flickr and inventor of Dotspotting and Prettymaps.
* **Thomas Emge**, member of Jack Dangermond’s ESRI Rapid Prototype Team and author of the ESRI OpenStreetMap plugin.
* **Trevor Ellerman**, member of the Afghanistan Synergy Strike Force team and system administrator for both Burning Man and the University of Arizona School of Engineering.
* **Schuyler Erle**, noted neogeographer and author of *Mapping Hacks* (O’Reilly).
* **Michael Migurski**, CTO of Stamen Design and inventor of Walking Papers.
* **Rob Munro**, computational linguist at Stanford University and author of the tools that automatically translated Kreyol to English for Ushahidi in Haiti.
* **Sergio Rodriguez,** support contractor with SAIC on the DARPA Tactical Ground Reporting System (TIGR) deployed in Iraq and Afghanistan.

The RELIEF team also convened SMEs who focused on the social and policy problems around the use of open-source software in the field, including including:

* **Thea Clay** of MapQuest and community ambassador for OpenStreetMap;
* **John Crowley**, experimentation lead and crisis mapping coordinator at both the Harvard Humanitarian Initiative and National Defense University Center for Technology and National Security Policy.
* **Bill Hyjek**, Vice President of G&H International and support contractor for the Virtual USA project.
* **Christine Lee**, Program Manger at DHS S&T; and
* **Jon Nytrom** of ESRI, manager for FEMA accounts;
* **Jon Perez,** Booz Allen support contractor who manages SOUTHCOM’s JCTD programs, including DARPA TIGR and Transnational Information Sharing Consortium (TISC).

Over the course of four days, the team engaged in a collaborative mashups and extensions of several pieces of code: OpenAerialMap, OpenStreetMap, Walking Papers, Dotspotting, ESRI ArcGIS OpenStreetMap plugin, as well as work in computational linguistics and gluecode for improved deployments of GeoChat in Afghanistan. The accomplishments appear below for each initiative under each of the three problems outlined above.

# Problem 1: Shared Imagery Platform with OpenAerialMap

## OpenAerialMap

### Problem Statement:

In disaster response, there is a critical need for a platform where all involved organizations can exchange imagery—particularly the satellite and aerial imagery that is made available by commercial providers and governments to non-governmental organizations (NGOs), UN agencies, and state and municipal governments.

During the Haiti response, organizations made over 9TB of imagery available for processing, as well as several additional terabytes of LiDAR data collected by the World Bank. In the after action review of this imagery, the communities consistently brought up five requirements for future operstions:

1. **Format**: The imagery needs to be available in both raw format as well as processed format, so that geospatial analysts can access the original data and exchange derived works, such as tiles made in a specific projection. It will be expected that application developers will download the imagery they need to local (redundant) storage for use by their applications.
2. **Media**: Raw and processed imagery needs to be accessible via public Internet. It must also be available via media that can be carried into low-bandwidth environments, including external hard drives and USB memory sticks.
3. **Index/Catalogue**: Users need to be made aware of potential imagery choices for a given area of interest (AOI), so that user scan select which imagery best meets their needs.
4. **Standards**: Imagery needs to be available in a common, standardized format that conforms to OSGeo standards.
5. **Reliability**: Imagery needs to be available from a distributed network of servers that duplicate content and enable continuous access even when main nodes are down.

The team at RELIEF 11-01 addressed these challenges by continuing the resurrection of OpenAerialMap, a project that intends to create the raster equivalent to OpenStreetMap: to act as “a steward for the discovery and use of open aerial imagery.” The idea of an OpenAerialMap (OAM) has been tried several times before; each iteration failed because it tightly coupled the components of indexing, storing, and serving imagery into a single application—a design that saddled the storage, processor, and bandwidth costs upon a single entity, usually a university department. The work at RELIEF 11-01 is the fourth iteration—an attempt that marks a radical departure from the earlier designs towards a modular approach, where each of the three functions of indexing, storing, and accessing imagery can occur on a distributed set of servers hosted at multiple institutions. In this sense, OAM is not acting as the storage host; it is the *index* to available imagery, both from existing third-party sources (e.g., the U.S. Government) as well as imagery that has been optimized for use in OAM (so-called OAM Optimized Imagery or OAM-OI).

The RELIEF experiments have hosted several of the design discussions for OAM, including meetings to reconstitute the project in November 2009 and May 2010. During the RELIEF 11-01 experiments, Schuyler Erle from the core OAM development team joined Mike Migurski and Aaron Cope from Stamen Design to complete the first end-to-end imagery process for OAM Mk IV, based on code that Schuyler built on the (herculean) work of Christopher Schmidt. This work essentially meant that more than a year of negotiation and architecture from RELIEF 09-04 through 10-04 has paid off: the OAM project in its new design has completed a viable proof of concept.

### Work Completed

Schuyler Erle led the work on OAM. He began the experiment with an explanation of the core architecture of OAM. The finished diagram from this white-boarding session follows in Figure 1. The architecture of OAM is divided into three parts:

1. **Index Servers**, which point at both OAM Optimized Imagery that is available in the Storage Servers and through any Access Tools, as well as third-party imagery, which could be available in other projections and formats (such as U.S. Government imagery). It is in essence a catalogue of available imagery.
2. **Storage Servers**, which host OAM Optimized Imagery in the following consistent format:

	* A Geographic TIFF
	* Projected in EPSG:4326
	* With internal tiling at 512px x 512px
	* Has overviews to provide easy access to lower levels of detail without reading the entire image.
	* Uses YCbCr JPEG compression at quality setting 75
3. **Access Tools**, which consist of both tile servers as well as web mapping services (WMS) that can be pulled into traditional GIS tools. The tiles can be made available for many applications, including OpenStreetMap, which will use them for tracing roads and critical infrastructure during disaster response operations.

#### Index Server and Storage

Schuyler Erle extended work by Chris Schmidt on the index server and storage server formats, building both servers on osgeo.org. He extended functionality of prototype code to allow for automated ingestion of NAIP imagery of the US into an OAM index and automated processing of NAIP raw imagery into OAM Optimized Imagery format. The first imagery was from Joshua Tree National Park.

#### Access Tools: TileStash

Mike Migurski and Aaron Cope partnered with Schuyler Erle to build the first Access Tools for OAM, integrating Schuyler’s NAIP imagery from the first OAM storage server into an automated process to tile the imagery for use in TileStash (a development project built by Mike and Aaron). This TileStash served tiles of Joshua Tree National Park into PolyMaps via a web service late on Thursday night (day 3 of experiments).

### Remaining Challenges:

#### Storage Nodes and Tile Servers

To store pre- and post-disaster imagery of major catastrophes, OAM will require a distributed network of storage servers, which are capable of handling large data sets and which provide redundant, reliable storage for disaster imagery. Haiti generated approximately 100TB of geospatial data alone. OAM is seeking at least 250 TB of storage as an initial node, with hopes to expand to other storage sites worldwide (one in Europe, one in Asia, etc). These nodes might be hosted on university networks, as well as military servers for imagery which might require licensing and access rights.

#### Alpha Code

Licensing and access permissions to imagery will be part of the design of the metadata for OAM, but will require additional coding to integrate permissions into the core infrastructure.

# Problem #2: Citizen Generated Map Data

## ESRI OpenStreetMap Plugin

### Background

In Haiti, OpenStreetMap became the *de facto* map for response operations. This geospatial wiki (with over 150,000 contributors) enabled 640 mappers to trace satellite and aerial imagery of Haiti and mark roads and critical infrastructure (1.4 million nodes) for most of the country in *under two weeks* (see Kate Chapman’s blog post on this feat at <http://www.maploser.com/2010/09/06/openstreetmap-in-the-first-month-after-the-haiti-quake/>).

Within weeks of landing on the ground, the GIS units of many of the responding UN agencies and major NGOs switched from their own digital maps of Haiti to OpenStreetMap. The switch was not so much about the technology as about the comprehensive, updated data that the OpenStreetMap community was creating, and the opportunity to enable Haitians to contribute to (and eventually steward) the mapping data that was being uploaded to OpenStreetMap every hour of every day.

### Problem Statement

As vital as OpenStreetMap had become to operations, the technology is a set of web services, not a GIS platform which can perform analysis on issues like flooding risks, routing maps (walking distance times), and comparison of potential development plans on the human and physical environments; for these tasks, one requires a GIS application like ESRI’s ArcGIS client. However, there exists no means for users of ArcGIS to read and write data to/from OpenStreetMap. The team at RELIEF 11-01 attempted to continue work from RELIEF 11-03 to address this problem.

In RELIEF 10-03, an ESRI team worked with Kate Chapman of the Humanitarian OpenStreetMap Team to devise a mapping between the hierarchical feature taxonomies in ESRI with the bottom-up, wiki-style tagging system of OpenStreetMap. In RELIEF 11-01, Thomas Emge of ESRI addressed a second problem with the OSM<->ESRI read/write process: each has different methods for handling polygons.

### Work Completed

(*quoted from ESRI*): “As a participant in the November 2010 Camp Roberts RELIEF effort Esri examined the existing ArcGIS Editor for OpenStreetMap and validated the plug-in for the ArcGIS desktop platform with respect to other initiatives in the OpenStreetMap community. At its current 1.0 release, the editor allows the user to download, to edit and to digitize OpenStreetMap data. The user can then synchronize the local changes back to the OpenStreetMap server. At the 1.0 release the focus was to lay the foundation to allow for a lossless exchange of data into and out of ArcGIS environment and the data exchange started with simple (single part) map features. At Camp Roberts ESRI built a prototype of allowing the user to download complex (multi-part) features into the ESRI native editing environment. This prototype effort will be continued to support complex features throughout the editing process as well as the synchronization back to the OpenStreetMap server. As the code changes for downloading, editing, and uploading the data are completed the new functionality (incl. source code) will be made available as the 1.1 release at [http://esriosmeditor.codeplex.com](http://esriosmeditor.codeplex.com/).”

### Remaining Challenges

The ESRI code will open OpenStreetMap to a wide range of analysts, including many of the DoD’s GIS teams. That said, there may be issues stemming from the interaction of the communities, particularly if GIS analysts look to “clean up” cartography built in the wiki without regard for the understanding of place that has emerged from bottom-up tagging systems (and an understanding that the OpenStreetMappers who made the original annotations often live in the place being mapped and are closer to ground truth).

## Walking Papers

### Problem Statement:

Digital maps require a computer and power. When they cannot be used in an offline format, they also require a network connection with adequate bandwidth, which can be costly during disasters (especially over satellite connections). For these and other reasons, paper is still a preferred medium for maps. It is durable; it enables its users to write on it; it is very high resolution in comparison to screens; and it is easy to share via photocopy or simple sneakernet exchanges.

That said, paper maps can easily become outdated, especially in the rapidly changing dynamics of a disaster response operation. Roads reopen, field hospitals emerge, as large new settlements of internally displaced persons (IDPs) get built with their own networks of roads and infrastructure.

Mike Migurski of Stamen Design had the idea of combining the immediacy of editable digital maps with the strengths of paper, creating a tool called Walking Papers. The idea is relative simple: to enable a user to print out any grid square from OpenStreetMap (a wiki for maps) via PDF, and to imbue that PDF with geo-data that enables the user to write on the paper and scan those annotations back into an OpenStreetMap editor, where the handwritten notes can be traced back into the digital map.

Walking Papers has undergone several iterations at RELIEF over the past 15 months. The first version enabled Walking Papers to use satellite imagery as a base layer, overlaid with road data (like a hybrid satellite/street view). To support urban search and rescue and election monitoring, it also added the ability to overlay the map with various grids, including MGRS. The second version added the ability to print large atlases—essentially allowing a user to print more than one grid square at a time. This capability emerged from field requests in Port au Prince, where Walking Papers has become the primary method for printing data from OpenStreetMap (which is the de facto digital map of Haiti for most UN agencies). The third version of Walking Papers added the ability to use GeoTIFFs as a base layer, a feature that enabled users to generate their own imagery (like balloon or aerial imagery) and use that imagery as a basemap for tracing, decreasing the wait for satellite imagery to filter down to the field and tying Walkng Papers to UAV operations.

The fourth version—built at RELIEF 11-01—tried to tackle both the digital divide and literacy barriers in Haiti. During each of six missions in 2010, the Humanitarian OpenStreetMap (HOT) team has used Walking Papers as a tool to train Haitian citizens how to map their own environment. These paper maps enable trained citizens to annotate points of interest on either streetmap views of their area or satellite photography. As such, these annotations generally require literacy: the users of the tool must know how to write. The annotated papers also require someone to read the annotations and trace them into a digital map by hand, which can be very time consuming. During the cholera outbreak, HOT found that valuable information about the locations of potential cholera treatment centers was sitting in stacks of paper, waiting to be traced, wasting days of time. HOT asked for a tool to decrease the time between data collection and its availability to analysts and decision makers. Similarly, domestic first responders also asked for tools to decrease the time that paper-based information sits on a table in an EOC. Mike Migurski set out to find a solution to this problem at RELIEF 11-01.

### Work Completed

Mike used a simple concept from primary school as his metaphor: the application of small stickers to paper maps to mark points of interest. Stickers do not require literacy, so long as someone knows that a red cross means a hospital, and a blue diamond means a police station. Stickers also can be automatically recognized by a scanning routine, and their locations on the Walking Paper converted by computer into GPS coordinates and entered directly into OpenStreetMap, without any more human intervention than is required to manage the flow of paper through a flatbed scanner. In this conceptual example, the sticker with a red cross represents a hospital. **[images are available in a more detailed report – please contact Star-TIDES staff for more details]**

This paper would be scanned into the map and the hospital location would be automatically added to OpenStreetMap. This is best shown at a higher zoom level, taking the sticker from the westmost hospital on the above map and showing it as a OpenStreetMap POT of type.

### Remaining Challenges

Walking Papers with stickers can speed up data entry and bridge both the digital and literacy divides. However, the work at RELIEF 11-01 focused on the technical implementation of this functionality, which now requires user testing.

The sticker concept also requires one or more symbologies, so that POI stickers Walking Papers can be customized for use in domestic and international response operations. The current implementation is very flexible: an arbitrary sticker can be assigned to any POI type (at CP Roberts, the team used different smiley faces, as this was the only type of sticker available at the Paso Robles office supply store). That said, for immediately deployment, responders will not have time to assign stickers to symbols and match those symbols to POI types in OpenStreetMap. This work will need to be completed before deployment of the new tools to a response operation.

# Problem #3: Crowdsourced Data Management

## DARPA/SOUTHCOM Tactical Ground Reporting System (TIGR)

### Problem Statement

The DARPA Tactical Ground Reporting (TIGR) System has been used by over 30,000 personnel in Iraq and Afghanistan to track and share patrol-level observations for several years. When the project came up for transition, SOUTHCOM took on the task of investigating the application of the technology to HADR operations in its AoR. The experiments at RELIEF 11-01 offered a one-day window to test the system and get feedback from humanitarian technologists.

### Work Completed

Sergio Rodriguez from SAIC and Jon Perez from Booz Allen Hamilton demonstrated the TIGR tool, showing how its map-based interface gives near real-time access to reports submitted by other users of the system as well as georeferenced items in XMl feeds from UAVs. The overall assessment of the system was positive: it showed a capability that is two generations beyond the All Partners Access Network—an old-style web portal built under the TISC JCTD with limited usefulness to NGOs and UN agencies that are now using web services to exchange data. In contrast, DARPA TIGR offers NGOs and UN agencies the opportunity to share selected XML-feeds with US military units and to integrate that situational awareness directly into patrol-level activities. This technology should be explored further to see if it can be made fully compatible with the information needs of HADR mission partners.

### Remaining Challenges

The TIGR system will need some additional development to transition it from combat support to HADR support. These include 1) support for crowdsourcing data, 2) support for multiple basemaps and baseline data maps, and 3) read-write capabilities for routing within OpenStreetMap:

#### 1. Crowdsourcing Support

TIGR already enables users to view georeferenced reports and to subscribe to all reports made within an AOI. However, given the volume of crowdsourcing reports that flowed through Haiti’s 4636 shortcode (over 90K), use of TIGR for viewing crowd-generated data will require strong filters at every level of use, from patrol to policy makers. It may be necessary to develop a middle layer that offer analysis tools (like those offered by Ushahidi’s SwiftRiver and InTEDD’s Riff/Evolve).

#### 2. Support for Multiple Basemaps and Baseline Data

Disasters change both physical and human landscapes. Knowing what and who was in a place before the shock is critical to an effective response mission. TIGR will need to support visualization of multiple base maps, so that pre- and post-event imagery is available for comparison. It will also need to support visualization of layers that show baseline data for demographics about specific AOIs (like villages with a history of religious violence, which would be critical know if the overall humanitarian emergency was triggered by ethnic violence and the religious violence needs to be addressed with different TTPs, as is the case in areas of West Africa). It is unknown if the system supports this type of data exchange on the classified level.

#### 3. Read-Write Capabilities for Routing

The system is an good patrol-level tool for tracking road condition data and routing issues. However, it is not equipped to exchange shape files or to read/write to OpenStreetMap’s native data format. This functionality should be explored, especially for situations like Haiti, where routing issues changed with building collapses.

## Synergy Strike Force: Crowdsourcing Support Tools for Afghanistan

### Problem Statement

RELIEF has supported Synergy Stike Force’s (SSF)crowdsourcing activities in Afghanistan since August 2009, when the RELIEF team built an election monitoring system for eastern Afghanistan. After a year of operation, the SMS gateways have revealed several opportunities for improvement. One of these is the design of using the FrontlineSMS software via a USB SMS gateway connected to a netbook. Each of these elements—FrontlineSMS, the USB SMS gateway, and the attached netbook—have proven difficult to configure and maintain remotely. The SSF team sent its system administrator, Trevor Ellerman, to RELIEF 11-01 to explore different tools.

### Work Completed

Trevor consulted with several crowdsourcing experts on site and remotely on iSMS, which is a stand-alone SMS gateway with a simple web interface. Trevor wrote a Java library to interface with the iSMS gateway, as well as an application that uses this Java library to retrieve messages from the iSMS and stores them in a MySQL database. He also wrote a quick PHP script that serves the data up via XML.

### Remaining Challenges

The iSMS gateway offers another version that supports up to 8 SIM cards, so that SSF could support up to 8 SMS gateways in one unit. SSF will explore this capability at a later time.

## Automated Translation for Crowdsourced Data

### Problem Statement

In Haiti, responders faced the challenge of quickly translating tens of thousands of SMS messages and social media posts (Twitter and Facebook) from Kreyol and French into English. This process was done by humans through a Mechanical-Turk-like microtasking processing, first over Skype and then under contract with the microtasking social venture, Crowdflower. Computational linguist Rob Munro was the primary organizer of this workflow. In his after-action thinking, he saw an opportunity to allow computational linguistics to speed up the translator’s work using automated translation tools for crowdsourced data.

### Work Completed

Rob built a machine-translation plugin for Ushahidi that connects to the Google and Bing APIs and automatically translates all incoming messages into the language(s) of the user's choice. The week after RELIEF 11-01, this tool was deployed for evaluation as part of a UN OCHA earthquake simulation in Colombia, adding English translations to Spanish text messages. The tool sped up the workflow of the (human) translators and broadened our effective workforce by allowing English-only speakers to immediately identify potential urgent/actionable messages.

### Remaining Challenges

The application of computational linguistics to crowdsourcing is an area that should be explored at scale at a future RELIEF experiment, with preference for applying the tool to a low-density language with written scripts that use non-Roman glyphs.

# Policy Discussions

## OpenStreetMap

The RELIEF experiments enabled members from OpenStreetMap and Walking Papers to talk with representatives from ESRI and CalFire. The ESRI conversations were instrumental in the work on the ESRI OSM read/write plugin, and to discussing how OSM and ESRI will work in the future.

Members of the OSM team also had the opportunity to discuss the use of crowdsourced mapping data with CalFire responders. The conversations reaffirmed known challenges in security and verifiability of information:

1. *How to ensure that the data that citizens generate is accurate, actionable, and not malicious or deceptive*. The OpenStreetMap tools do not yet have methods to mark certain edits as suspicious and to limit what responders in BRTs can see to those data which are verified.
2. *How to create a bounded crowd*, where the individuals who submit data are known to the response community and the platform is in some way under the information assurance regimes of state or federal agencies. This problem has already been tackled in the IC, where DIA is running its own instance of OpenStreetMap on JWICS. It has not been tackled in the domestic emergency responder community yet.
3. *How to integrate mobile data visualization with push mechanisms* to enable responders to subscribe to anything happening in a given zone or bounding box, including all social media posts, crisis management system alerts, CAP alerts, and new imagery.

## RELIEF Experimentation

Christine Lee (Project Manager at DHS S&T Directorate) and Bill Hyjek (VP, G&H International and support contractor to DHS on Virtual USA) joined the RELIEF team for the duration of the experiments. The team had several in-depth conversations and brainstorming sessions to look at how to improve future RELIEF experiments and to align the parallel goals of serving responders in the domestic and international HADR/SSTR space.

### Structure for the Experiments

For five cycles, the RELIEF experiments have occurred under a loose partnership between NPS and NDU. This structure has produced a range of fielded technologies for next to no cost (cost for each cycle has averaged less than $7,000.00). However, many of the costs for participation have been externalized on cash-strapped private volunteer organizations and non-profits, who must pay for their staff’s travel to California from multiple countries. Government contracting rules make compensation for international travel difficult, and the experiments may need to slow its tempo to allow for a more reasonable burn rate for participants. Non-profits cannot afford to participate every quarter under this regimen.

The team at RELIEF 11-01 explored potential ways to change this situation. To enable government agencies and foundations to fund additional work at RELIEF, the team explored non-profit and for-profit corporate structures that would allow for government contracting under SBIR and BAA contracts, and for grants made by foundations such Knight and Sloan. No conclusions were reached other than the need to discuss the issues with DHS, NPS, and NDU. The team will continue to explore the strengths and weakness of remaining as a loose research program versus obtaining a corporate status.