UDOP: A Collaborative System for Geospatial Data

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Abstract

The aftermath of Haiti's January 12 earthquake typified disaster relief in that efficiency and situational awareness were reduced by the chaotic, uncoordinated influx of relief and aid. The lack of an environment in which information could be shared was a major component of this chaos. The application of geographic information (GIS) technology was a significant contribution to the relief efforts due to the centrality of location to issues of danger, resources, safety, communications, and so on, and due to the universal understanding of information rendered geospatially using 3D globes.

Concerned that existing solutions were restricting, U.S. Southern Command (SOUTHCOM) engaged Thermopylae to build a user-friendly GIS tool to reach a wide user base, fuse data from disparate sources, and immerse users in relevant content. The resulting SOUTHCOM 3D User-Defined Operational Picture (UDOP) united over 2,000 users to create, add, edit, update, and share data aggregated through GIS tools, existing databases, mobile applications and other resources, geospatially.

The UDOP was built on the enterprise geospatial framework, iSpatial™, which interacts with the Google Earth Plug-in™ browser application programming interface and provided SOUTHCOM's Joint Intelligence and Operations Center with interactive applications and an open platform for the integration of dynamic data for timely and publicly-accessible solutions. The application of the UDOP to relief efforts in Haiti optimized the gathering and management of data from government, military, non-government agency, and first responder resources, which consequently improved relief efforts simply by inviting a large user community to share data on an intuitive common platform. The experience in and lessons learned from Haiti promise great strides into the future of the geospatial technology.

Keywords: GIS, SDI, Google Earth, iSpatial, Haiti relief efforts, USSOUTHCOM, mobile applications, iPhone®, Android™.

1. INTRODUCTION

The User-Defined Operational Picture (UDOP) was Thermopylae's answer to impediments encountered during spatial data-sharing directly following the Haiti earthquake. In order to meet the needs of organizations providing relief to Haiti, it was essential that the UDOP geographic information system (GIS) be tailored to the area and crisis, uniting a growing collection of relief workers and providing data to everyone. As users contributed content, the capability evolved and ultimately replaced many preexisting tools used for strategic and local-level data management. In conjunction with the Google Earth™ browser plug-in, the UDOP provides a 3D Web portal where users can conveniently create and share spatial information freely. As a result, a massive compilation of volunteered information was exposed and fused into a single, publicly-accessible location. To ensure this access, the UDOP Web servers and storage leveraged a combination of resources from a secure cloud on the World Wide Web and government-owned physical hardware.

Figure 1 - SOUTHCOM Relief Operations (Shelley)

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2. SOUTHCOM

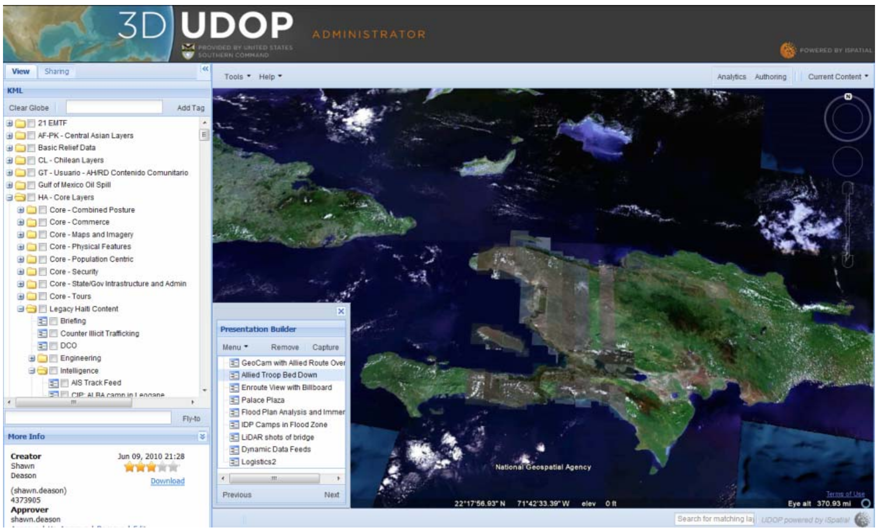
A regional military headquarters, SOUTHCOM is also heavily staffed and affiliated with civilian US government organizations that conduct humanitarian operations. SOUTHCOM supported the military Joint Task Force (JTF) members forward deployed with policy, intelligence, and other support, but also manages issues that transcend localized missions like Operation Unified Response. Prior to this disaster, SOUTHCOM was already focused on humanitarian operations throughout the Caribbean, Central, and South America, but the scope of the damage in Haiti far exceeded anything with which they had previously dealt. The 10,000 deploy troop JTF they oversaw was ultimately charged with providing logistics in support of the U.S. Agency for International Development (USAID) and the Department of State (DoS), but effective collaboration had to include participating governmental, non-governmental, and international organizations to be optimal.

The UDOP was built on requirements of the SOUTHCOM J2 (Intelligence) Knowledge Management Office and Joint Intelligence Operations Center (JIOC) which provide solutions for SOUTHCOM's headquarters and regional operations. Driving their agenda was the fact that pertinent information would be plentiful and unclassified given the important role of a large international community. With these circumstances, complications in language, time, preparation, and the scarcity of a central controlling body would have to be addressed in any IT solution. SOUTHCOM leaders had information from its individual directorates, but a comprehensive perspective of all other activity in Haiti did not exist. Information was fragmented, diverse, and often contained in articulate forms, held separately and locally by the many individuals who compose society (Sobel and Leeson. 2007). Two fundamental objectives were 1) to fuse the efforts of the relief community by collecting data from diverse and scattered entities; and 2) to present it as a single, interactive picture to all users and to their command center the. Aggregating and displays all data in one place was a natural solution.

In evaluating their GIS requirements SOUTHCOM took into account previous investments the US DoD and DoS had made in Google Earth geospatial solutions. They measured their requirements against the U.S. Department of Homeland Security's (DHS) similar project Virtual USA, which was in its nascent phases. The open standard of the Google Earth browser application programming interface (API), associated data ingestion, and development APIs with the iSpatial™ framework allow untapped levels of integration.

With the browser-based Google Earth plug-in and the iSpatial framework, SOUTHCOM and the relief community attained a robust, highly-accessible solution for exposing and sharing data everywhere. The Web-based toolsets provided by iSpatial provide users options as they integrate the tools they need, allowing each to customize its view of the mission while sharing the underlying data. The UDOP architecture was designed to benefit all involved parties, as a virtual world is built out with key data, contributing to the development of a spatially enabled society.

Figure 2 - SOUTHCOM 3D UDOP Interface (Eckersley)

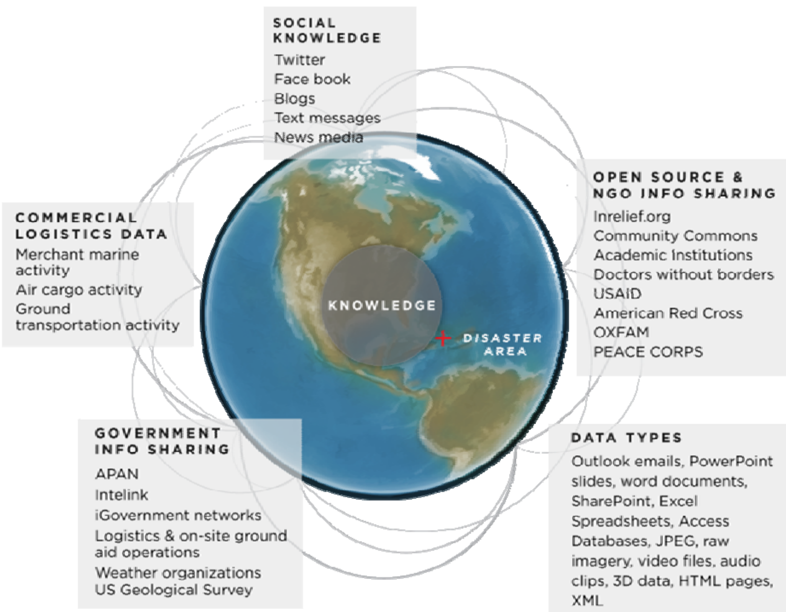


3. OVERVIEW OF PROBLEM SET

According to some accounts, the chaos in Haiti following the earthquake left 220,000 dead and the dire shortage of food, water, medical care and supplies for the approximate 300,000 injured and over 1 million displaced people. The initial crisis response by military components, federal agencies, state/local emergency response personnel, non-governmental relief organizations, and commercial industry members from across the globe rushed thousands of people and massive quantities of supplies to the already densely populated area surrounding the capital, Port-au-Prince. The international response was overwhelming, but data to enhance communication and coordinating logistics was in critical need of improvement. Breakdowns resulted in delays in the transport and delivery of much needed aid. Many of the participatory organizations possessed pertinent data and their own management practices, but the lack of a central environment and medium for collaboration hindered efficient execution of relief efforts.

To date, the most widely-available legacy data is from UN deployments documenting the location of various elements of infrastructure. However, this limited resource is pre-quake and comes from a single, central, thus limited place. It does not account for entities such as informal gathering areas, influence bases, and communication patterns essential to aiding the populace. Engaging the populace presented a challenge. Unlike most information available during crises, that pertinent to the Haiti disaster is unclassified, meaning the international community could and did play a much larger role. While this opened the door to more information exchange, complications of time, preparation, the scarcity of a central controlling body, and language arose. The non-standardization of nomenclature proved an issue for the collaboration of data. English, French, and Caribbean languages like Creole are all commonly used locally, so a single location could conceivably, and often did, have three separate names. As more and more ad hoc tent cities, aid stations, and distribution points were set up, multilingual nature of Haiti presented a challenge to the compilation of data that the 3D Viewer resolved by rapidly identifying duplicate entities using the universal language of geolocation.

Figure 3 - Wide Range of Collaboration (Eckersley)



4. DETAILS OF TECHNOLOGY SOLUTIONS IMPLEMENTED

The limited timeframe drove the need for a robust, scalable and feature-rich solution. These core user requirements included the ability to create globes containing diverse data within a Web-based application that allowed users to upload, dynamically author, and link to content, in addition to collaborate, share and manage data. A platform with a familiar look and feel would reduce training time and accelerate user adoption; Acknowledging this, SOUTHCOM selected the Google Earth Enterprise (GEE) product for its familiarity, and for its ability to collect and streamline a vast amount of spatial formats of imagery, terrain, and vector data in a simple and highly-usable visualization system. Additionally, the Google Earth browser plug-in provided experiences in an entirely browser-based environment, greatly increasing user access to the tools.

Building these applications from the ground up would have been a time-consuming process requiring special skill sets. SOUTHCOM needed a tool that provided as much of the desired customizable, rapidly-implementable functionality as possible; for this reason, the iSpatial Enterprise Visualization Service was the natural choice for the core of the UDOP development process, providing the ability to develop Web applications rapidly on GEE and the Google Earth API plug-in. It is a rich platform comprised of both front-end libraries which augment and extend the Google Earth API and back-end services, which provide analytics and access to data, as well as support the creation of new data. These Web services assisted with quickly developing geospatial analytic capabilities, while simultaneously integrating multiple, disparate data sources. iSpatial provides the value of pre-built components and application functionality that could be quickly customized to specific requirements. The net result is a higher-quality product in a shorter time period. iSpatial is developed in coordination with the latest Google Earth API functionality, ensuring that both products are fully synchronized. Using this approach SOUTHCOM reduced their software development time by an order of magnitude, delivering the Web-based UDOP in days versus months.

Base Globe Production

While content generated by users layered the UDOP, their base was a special, customized globe on iSpatial technology, served as the foundation of the UDOP software. SOUTHCOM was able to take raw spatial products and fuse them into a self-managed Google Earth globe. They could control their own fixed geospatial data instead of having it managed by Google. As new geospatial products such as imagery, vectors layers, terrain, and Open Street Map (OSM) became available, they could be added as optional layers, but to create new versions of their own globe with updated base imagery was critical to reducing confusion.

Haiti presented a major challenge in terms of imagery acquisition. There was a pressing need for post-quake imagery, but unclassified content was extremely limited for the first few days following the disaster. A few organizations began providing imagery at no cost to those performing relief work. A major contributor to SOUTHCOM's initial globe was GeoEye, an organization that provided publicly accessible satellite imagery data. National Oceanic and Atmospheric Administration (NOAA) also provided aerial imagery. During the seven days following the earthquake, SOUTHCOM officials were put into direct contact with the Federal Emergency Management Agency (FEMA) National Response Coordination Center which notified SOUTHCOM of all known scheduled imagery collection dates from all the major providers and projected dates for release, which proved to be invaluable to the planning.

The heavy influx of imagery challenged SOUTHCOM's imagery analysts, who inspected all incoming data, removed data that contained substantial cloud cover, corrupted images, inferior resolution, or other elements rendering it unusable. Newer, more relevant data replaced older data on the globe which was then pushed onto a live production server accessible to all of the UDOP users. To make rapid updates, developers used a Google Earth Fusion Grid comprised of seven dedicated high performance servers. Additionally, over 15 terabytes of storage space was available via a storage area network (SAN) used to store raw imagery resources and the final globe product.

Adherence to the KML/KMZ format throughout the UDOP was a logical choice as it was the only robust, textual extensible markup language (XML)-based, open standard format within the geospatial realm. Ultimately, a user could open any text editor and extract the geodetic data from a KML file; the same cannot be said for various other files such as a shape file or National Imagery Transmission Format (NITF) file. A clearly-defined requirement for an inclusive environment ruled out proprietary formats. They would have been more difficult to manage, and the resulting data would have been challenging to synthesize with other spatial data files among the user base. Finally, more tools were readily available for displaying and manipulating KML/KMZ files than existing tools for other geospatial formats. The decision to standardize via using the KML/KMZ format ultimately proved to be beneficial, as information could be easily shared throughout the disaster response community.

5. FEATURES, SOLUTIONS, AND APPLICATIONS IMPLEMENTED

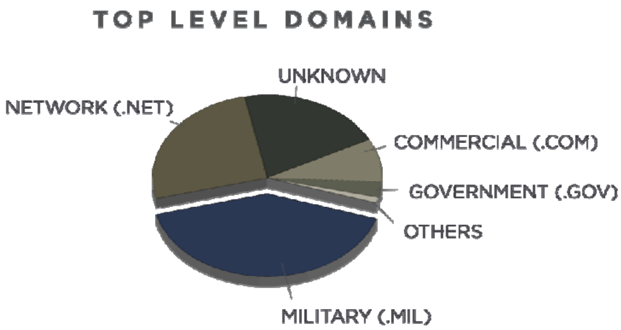
Creating and Sharing Content

The SOUTHCOM 3D UDOP was initially an extension of SOUTHCOM's preexisting and non-geospatial collaboration portal, All Partner Access Network (APAN). APAN's image, document and comment sharing were crucial to information management within SOUTHCOM's Humanitarian Assistance/Disaster Relief (HA/DR) network, which included non-military participants. Although the APAN was widely used, users made more time for the UDOP when it was accessible on the Web outside of the UNCLASSIFIED military network, and eventually became a permanent fixture in the SOUTHCOM Crisis Action Center (CAC).

The UDOP Haiti project addressed the challenge of creating one common picture of spatially-relevant data applicable to Haiti after the earthquake. The initial operating capability had three core features to support data collaboration. The first feature allowed users to import any KML/KMZ file and load it to the UDOP view. The second allowed users to link to a URL and send dynamic updates to other spatial files and render them in the UDOP. The third, which was imperative to promoting an environment of sharing, was a spatial content export tool, which allowed users to use the UDOP as a "marketplace" of spatial data, even if users didn't ultimately use the tool for fusing the information into a single picture. This ensured that the UDOP served a dual purpose as both a repository within which content could be created or viewed and as an index of available content, which was critical to its widespread use as an environment for data sharing. The ability to link spatial data layers from sources outside of the UDOP gave users the ability to define a custom view through their browser. As the volume of data increased, two additional tools, one allowing for the creation of lines, polygons, and points, and also a common labeling and icon scheme, rendered the content more easily comprehensible. Moreover, all new content automatically recorded the users name, contact info, and date of creation, in order to provide lineage and pedigree data for future viewers.

Another obstacle taken on was the limited access to high-speed communications, as many users interacting with the UDOP were on the ground in Haiti, where infrastructure was unreliable at best, prior to the disaster. Regarding poor infrastructure, most of the globe has played only a minor role, if any at all. If GIS is to be a truly global initiative and confer its benefits to all global citizens then a way must be found to bring these nations on board. (Holland, et al., 1999) On the Google Earth browser plug-in, users were able to cache and view imagery, content layers, and other data without having to coordinate communications with the server. The commonality in data production, achieved by providing a basic guideline via the Web-based content production tools, allowed different users to understand content instantly, regardless of the authorship of the layer.

Figure 4 - UDOP User Data (Eckersley)



The fact that independent users were conducting damage assessments of key facilities was invaluable to the UDOP collaborative effort, as it contributed to the creation of 3D models in Google Sketch-Up, terrain features, and LiDAR data. In turn, an inclusive environment for spatial collaboration was extremely valuable to all users, as the 3D functionality, the up-to-date imagery, and a host of functions allowed the users to define their view and create, and instantly update it. The collection of these functions and abilities within a single place not only drove users to the UDOP, but also increased the time users spent interacting with the site. Once the content creation tools were integrated and the overall volume of information in the UDOP increased, Thermopylae noticed major spikes in the time each user spent in their session; within one week of the earthquake, the average time a user spent interacting with the data was between two and three hours per session. This was up from little to no time spent interacting in a spatial collaborative environment.

Mobile Apps were some of the most effective methods for building knowledge within the system and collected data directly from those individuals in the field during the crisis. To this end, SOUTHCOM officials were able to take advantage of smart phone (i.e. iPhone® or Android™) technology and integrate customized software on various mobile platforms that complemented UDOP. Allowing relief workers to share and post data about their immediate surroundings in real-time. Integration of mobile applications leveraged the comprehensive 2-D version of Google Maps™ for mobile phones. This included uploading geo-located text and descriptions, as well as photographs taken using the mobile application through in-house developed Disaster Relief and also using GeoCam developed by NASA and Google. The UDOP also leveraged existing crowd source tools include Ushahidi based services that generated layers from geolocated SMS messages sponsored by local telecoms immediately after the earthquake.

Figure 5 - GEOCAM App in UDOP (Eckersley)

SOUTHCOM developers deployed Android GI mobile phones in Haiti, loaded with a custom mobile application that allowed users to be “collectors.” The phones were able to embed 3.2 megapixel photographs with a pinpoint-specific location and the camera's heading at the time of the picture. With this capability combined with Web connectivity and server space, military personnel in Haiti had the ability to provide all UDOP users with sharp, geospecific imagery that updated to a dynamic UDOP layer in near-real time. On the UDOP, the image appears as an upright window with a zoom capability. Thus, phone carriers could effectively build a room where the walls make up a 360-degree view.

These applications provided quick and easy access to critical knowledge on an as-needed basis, such as locating the nearest medical facility or relief camp. An important additional feature of the application was an offline mode that allowed users to store data on their mobile device locally before finding a data point, such as a Wi-Fi® hotspot or a working cell phone tower. Once data was able to be sent and received, the mobile application prompted the user to submit the locally-stored data. The "Disaster Relief" application was created initially using the iPhone software development kit (SDK). The application was made freely available within Apple®'s "App Store" and allowed ad hoc distribution. The application was also ported to Android and other popular mobile platforms.

By combining these resources, SOUTHCOM leaders were able to build a full-featured solution, supporting the sharing of information among relief supporters and coordinators, as well as enabling direct interaction with those on the ground in Haiti. If information is power, it must be placed in the hands of all participants so they can work together in myriad ways to solve the problems of crisis and improve lives (Onsrud 2003).

Figure 6 - iPhone UDOP App (Eckersley)

The **Presentation Builder** is the UDOP's answer to PowerPoint, but is a briefing tool with notable advantages. Presentations are sequences of content and view captures that can be easily rearranged, updated, or interacted with on the fly. They can be built rapidly manipulating the entire catalog of content contributed by the user community instead of from creating content scratch. Furthermore, Presentations update automatically as the UDOP's content is updated by data custodians and users click through different personalized views. The daily standup briefs at SOUTHCOM are now conducted with the Presentation Builder, putting audiences immediately in touch with their community's content.

iHarvest immerses each user in the UDOP's content and user community by profiling the layers and areas searched. As that profile is built over time, the user will be prompted with new and existing content similar to previous searches and users with similar profiles will be informed of each other's presence. No longer do UDOP users operate in a vacuum. iHarvest also allows users to exchange or update profiles which facilitates familiarization of a new area or mission. Turnovers can begin long before a relief worker ever enters a disaster area as situational awareness spreads.

Collaboration was further improved by promoting interaction and the exchange of opinions regarding geospatial data. The **Sharing** function allows users to share their screen with others, even those without logons, so the user community can show each other content which is a step up from ordinary discussion. With each layer shown is **Scoring**, shown in stars, that is aggregated from the entire user community's feedback.

6. CONTENT MANAGEMENT

According to Manual Castells, “The most critical distinction in organizational logic is not stability, but inclusion and exclusion” (Castells 1999). In relation to the UDOP, this meant that aggregating data from varied sources was central to accommodating as much of the relief community as possible, but it also presented challenges. Even early on data was bountiful, but managing it proved to be a significant test.

Organization

The initial organizational strategy was based on the first users who populated and verified much of the initial content at SOUTHCOM. Spatial layers were organized under ten headers, such as "Operations" and "Logistics", which reflected U.S. Military Joint organization. As content and the user community grew a more intuitive strategy became necessary. Centrally managing layers became unwieldy and nonscalable as administrators were reluctant to dispose of other's data when misplaced or disorganized. Another disadvantage was that central management implicitly made SOUTHCOM responsible for the accuracy and timeliness of each layer. Watch standers and content managers at SOUTHCOM were not onsite in Haiti, so once they took control of specific layers, they soon became unsure of whether or not information was still relevant, or moreover if it was even accurate in the first place. Short of calling each aid station, there is no way to confirm the relevance or accuracy, so the onus must remain with the custodians of each layer who may reveal information.

To make the UDOP as open and inclusive as possible to the international community, its sponsors sought input from the global geospatial community referencing Spatial Data Infrastructure (SDI) Cookbook documentation and subject matter expertise from the Geospatial Data Infrastructure Association (GSDI). A team of GIS and SDI experts structured data around a disaster relief ontology. The resulting organization structure was well received by the user community and has built in flexibility for future relief efforts.

Moving towards dynamic layers was more scalable portraying content as controlled by its custodians. It is better to trust the original source of the information rather than a regurgitation. Data custodians are empowered with the ability to expose or conceal all parts of their data discovery. Centrally managing content was easier to standardize, but problems from KML file names, to icon colors, to the format of embedded data and was update schedules weighed on administrators. The solution was to clarify which icons and standards were approved by embedding a transparent legend, instructions in the user manual, and icons themselves which were both useable in the UDOP and exportable to Google Earth where some content was built.

Content Fidelity and Validation

A recurring issue focused on the validity of data. The SOUTHCOM J2/J3Deputy Director for Knowledge Management assessed that while individuals could update data to a collaborative site, for the data to be orderly when publicly viewed, it needed to be vetted and approved by a content management group. Occasions where the UDOP was filled with "bad data," illustrated the need for checks. Centrally managing content was performed by Miami-based SOUTHCOM personnel, but this practice proved to be grossly inefficient, due the number of people and hours need to be dedicated to uploading static data layers that was already managed elsewhere.

In version 1.0 of the SOUTHCOM UDOP, there were only two types of users: general and administrator. Any user could add content to the site; administrators also had the ability to approve the content for public view. Content managers soon found themselves with too much data to manage. Early program administrators were able to delegate administrator rights to others, which led to large numbers of questionable layers being approved, and others being unnecessarily deleted. Once a layer was uploaded, there was no mechanism to check its accuracy and it was difficult to tell when certain layers of data were collected, and whether or not they were outdated—or even accurate—without embedded information.

This issue was addressed by creating approvers with narrow purviews. Distribution of responsibilities created order by preventing users from altering content outside their folder, but it was important not to suffocate users by limiting their access to information. Content management benefited from more defined user privileges as loose structures were tightened to make the volume and quality of inputs more manageable by administrators.

User Defined

As users created content, they could use icons from either Military Standard 2525 or internationally-recognized basic relief symbols. The foundation for the international symbols used for the UDOP was based on a collaborative effort by the American Institute for Graphic Arts (AIGA) and the U.S. Department of Transportation.

To further define the structure, a series of voting mechanisms, both manual and automatic to develop baseline metrics, were instituted. The combination of international "crowd input" through voting and SDI expertise is combined on a quarterly basis to update the content management strategy for the UDOP. The voting mechanisms provide capability way for knowledge managers to understand which layers have more or less value and relevance.

Figure 7 - Fusion of Layers (Eckersley)

Duplication of Info

Data was bountiful , but managing it proved to be a significant challenge with the duplication of information. This occurred when content was completely identical, and also when they represent the same thing, but differ in format, name, language or appearance. If two organizations' territory overlapped and kept records on the same aid station, there would be two icons representing the same thing. The icons may have different names, manage separate information, or make updates at different intervals, but such is likely with the patchwork nature of urgent relief efforts. The SOUTHCOM UDOP is building features to resolve and account for the duplication of information by automating communication forums for the custodians with or collocated data. Matching layer custodians and encouraging their collaboration by prompting them with a comment window or other functions will promote merging or removal as means to address icon redundancy and duplication.

The UDOP effort stressed the integration of *different* file formats and this compilation becomes uniquely valuable when formatting data originally unintended to be viewable geospatially. The UDOP can place the fruits of many collectors' labors in one interface, in a context that everyone can understand: geographic space.

7. BEST PRACTICES AND NOTEABLE EXPERIENCES

Training

According to proponents of the open-access of geographic information, distance learning has increased accessibility and contribution in education, paralleling collaboration in the information age (van Loenen 2004); this philosophy was adopted for the development of the UDOP.

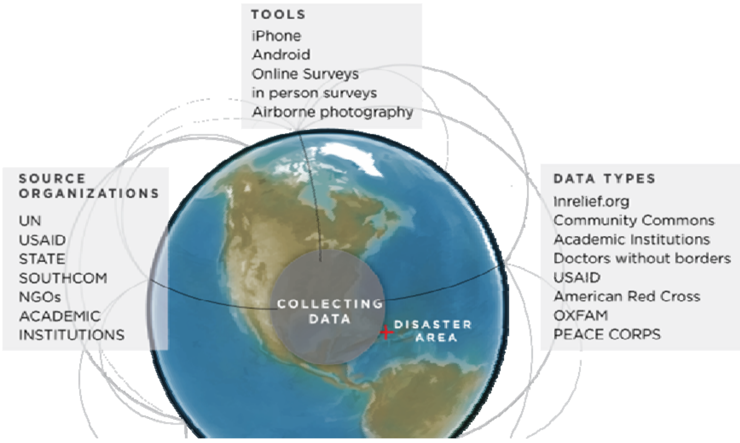
Training was provided in a variety of formats to include as many learning styles and operating resources as possible as it was anticipated that time and/or bandwidth would be limited. A user manual familiarized users with the UDOP capabilities and explained how the program fit into SOUTHCOM's mission. This succinct document informed users, well before they received an account or downloaded the Google Earth plug-in. Training video podcasts were also created to provide step-by-step lessons for all functions. Demonstrations of the range of content promoted the creation of more content, while also highlighting the contributions of others. The cumulative diversity and density of data that could be layered was testament to the need for agility and innovation in content management. Although the technical team was only exposed to approximately 10-15 percent of the user base on the Web site, they were able to capture the prioritized needs from that group, and then expand upon the capabilities the entire user community needed. Furthermore, when brief training videos were viewable directly from the UDOP splash page, requests for support dropped by 70 percent. Using a common tool such as the Google Earth browser plug-in with the iSpatial framework, relief workers could use the UDOP with little-to-no training. Users could build video fly-through presentations with data that was live, up-to-date and interactive, so when it was presented a user could stop and drill down into a greater level of detail for facilities, mobile units, and landmarks as well as basic reporting and imagery. This supported an extremely adaptive environment for the intelligence personnel supporting the relief effort.

Figure 8 - Training CNIGS on UDOP (Holliday)

Hands-on training was provided to those most in need as well. Thermopylae's program liaison travelled to Haiti to train their geospatial agency Centre National de l'Information Géo Spatiale (CNIGS), a small group of intensely committed professionals, in the UDOP and how it could be useful for use by their domestic services. Infrastructural problems were an obvious limitation, but senior officials in the Civil Protection Agency saw the value in a tool that could be used by most people with minimal training and handled the inputs of a large user community. In rebuilding their country, they had the foresight to want to rebuild their institutions so that they could a common place to view information and a way of reaching the population.

While conducting training at SOUTHCOM and beyond, all training materials produced were available to the entire user population, with the prospect of delegating content management to best-suited the individuals. Intuitive and easily-used training products garnered enough interest in the UDOP so custodians of each data set were willing to share their closely-managed data with SOUTHCOM.

Figure 9 - Supported Data, Tools, and Sources (Eckersley)



8. CONCLUSION

How the UDOP filled the need for collaborative geospatial data coordination in disaster relief is undeniably one of the most notable features. Thousands of users from partner nations, non-government organizations, and local and state first responders had one central location to access and share relevant intelligence. From geo-tagged snapshots of gang areas and flood plains on smart phones, to the creation of adaptive spot-reporting layers, the UDOP flexed to meet a variety of needs for relief workers in Haiti and was referenced in Chile, Guatemala, and the Gulf of Mexico oil spill this year as well. The future promises to bring new challenges as the limits of how much information can be fused into one Google Earth browser plug-in. The door is open to a variety of potential capabilities, and it will be exciting to see further experiments with matching the right functionality to a spatial data representation.

In the UDOP project with SOUTHCOM officials, much of the innovation was driven to make the tools immediately needed by the relief coordinators. Due to the urgent need for a timely response, SOUTHCOM officials broke from the norm and embraced an inclusive, collaborative environment. The UDOP for Haiti demonstrated that if users are intellectually involved in improving the technical capability, they have a greater interest in the application. Also, having a responsive design team that can integrate capabilities in a matter of days, versus weeks, was imperative to retain user buy-in. The humanitarian community benefits from this rapid spiraling method of development as tools are tailored to their biggest challenges. As the technical capabilities for sharing data increase over time, new ideas will be formed from users as they reset their understanding of what the high-water mark is for inclusive sharing of spatial data.

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