Proceedings of the 9th U.S. National and 10th Canadian Conference on Earthquake Engineering
Compte Rendu de la 9ième Conférence Nationale Américaine et
10ième Conférence Canadienne de Génie Parasismique
July 25-29, 2010, Toronto, Ontario, Canada • Paper No 1811

USING TECHNOLOGY TO INFLUENCE INDIVIDUAL, SOCIAL, ORGANIZATIONAL, AND COMMUNITY BEHAVIOR BEFORE AND AFTER AN EARTHQUAKE EVENT

Charles K. Huyck* Walter Svekla*

ABSTRACT

With the advent of Web 2.0 and online mapping technologies, emergency managers, responders, and the public at large has grown increasingly comfortable with a “map centric” view of the world. Stunning, atlas-quality maps integrating a variety of remotely sensed images from satellites, nadir aerial photography, oblique aerial photography, and even insitu photography of much of the earth’s surface is now available to all internet users. Advanced users have the capability to upload custom digital photos or even 3D buildings that are subsequently shared with the world at large. Combined with mobile platforms and the rise of Internet-based social networking, there is an almost off-the-shelf capability for governments to harness both spatial technology as well as spatial information and data for emergency response. With the barriers for entry low for institutions, experts, professionals and now laypeople, there have been few formal efforts aimed at assessing such applications in the context of life and death earthquake events. The media at large, who are experts in neither earthquake science, geographic information science, nor public safety, aggressively implements these technologies without the knowledge required to assess details such as suitable presentation or important context. This paper examines some technologies that are available and suggests ways to hasten adoption. A question and answer format is adopted, with the questions provided by the session moderator.

1. What technologies show the greatest promise for significantly improving pre-earthquake event mitigation, and/or post-earthquake event response and recovery?

Pre event mitigation and post-event response will be advanced over the next several years not by new technologies, but by better methods of integrating and disseminating various information from existing sources. Certainly, satellite imagery and satellite-based SAR will continue to play a key role in assessing post-event damage throughout the world. As more countries launch microsats and offer commercial services to fund these efforts, the price per pixel should drop substantially. GPS units are common place, as is digital video and digital photography. GIS and remote sensing departments are also common, mapping both pre-event hazards and post-event damage. Individually, each of these areas will continue to make incremental advances, but the major advance it be integrating all these technologies into a common platform. Although satellite imagery and aerial photograph sources have come a long way in terms of ease of ordering product, eventually, these products will have to be ordered in such a way that they are instantly pushed to end users through a WMS or similar technology. The pricing mechanism for distribution throughout an agency needs to be scalable, with little barriers to entry and minimal

* ImageCat, Inc., 400 Oceangate Ste., 1050 Long Beach, CA 90802

negotiation. For emergency purposes, there needs to be some method of temporarily setting pricing aside, so that the data can be used by all for the common good and paid for later. Although satellite companies are happy to work with governments through the national charter and perhaps see an altruistic role in disaster response, quite an effort must be undertaken to acquire, process, and serve data into a Google Maps or Microsoft Bing framework. This is even more difficult with SAR data, or if the imagery is acquired from a source other than the primary high resolution satellite companies.

GPS units are everywhere, from dedicated handheld devices to integration into even the most basic of mobile smart phone. While Next Generation GPS data accuracy will only increase, the current level of GPS-derived data accuracy is more than enough for emergency response purposes. The advance in GPS will be integration into various data formats in a manner that makes Geo-tagging data ubiquitous and automatic. For example, although many go through the effort required to geotag photos and these are often being served through Google maps, Flickr, and other services, it still takes a special camera and a little domain expertise. This process will be simplified, and geotagging digital photos and even video will become common place. Although all phones have some degree of locational awareness, utilizing this feature in conjunction with the photo capture feature is not common, which is likely to change.

Table 1: Data feeds from public and private sources.

Source	Description	Potential Use
Mobile Phones and wireless internet devices	Voice, SMS text messages, photos, video, and location.	Monitoring traffic flow, situational awareness, damage assessment.
Closed-circuit television (CCTV)	Video stream for security and crowd control.	Monitoring traffic flow, situational awareness, damage assessment, Public safety
Internet	Webcams, blogs, chats, emails.	Situational awareness at the local level.
Radio-frequency identification (RFID)	Product Inventories	Emergency resource allocation.

Handheld platforms are enabling the emergence of the world's most sophisticated data processing engine: people. Historically, people have not made good sensors in large-scale disasters, as phone lines are typically overloaded and prioritization of response based on firsthand accounts is highly problematic. However, with digital cameras and GPS-enabled cell phones, geotagged photos are easy to distribute. This data can be interpreted by experts and translated into actionable information. ImageCat has deployed the "Virtual Disaster Viewer" (http://www.virtualdisasterviewer.com/), a system for georeferenced video and GPS enabled video for two international earthquakes: the L'Aquila earthquake in Italy, and the Sichuan earthquake in China. Figure 1 illustrates how analyzing field data within Bing maps reveals not only the spatial distribution of damage, but important information for response- such as how certain buildings looked before they fell down Additional multi-modal data streams can be mined, or fed directly into similar online applications. Table 1 examines some of these potential sources.

Figure 1. VDV is a social networking platform for disaster research. Users upload photos and experts interpret them in the context of spatial data. In this image, the Pictometry data in Bing provides users with information that this collapsed building in La' Aquila had a "soft story", or parking under the structure. This would be difficult to determine from the damage data alone.

Expanding online applications such as VDV to harness users as sensors can capture damage missed by CAT models, and can be used to inform search and rescue efforts and mobilize resources. Real-time information on disasters through such social networks as Twitter, Facebook, YouTube provide more immediate awareness of the event. However because they are not integrated into a coordinated 911 system they leave government and society in an often untenable situation—government cannot respond to emergencies based on ad hoc information. Government needs centralized data and processes in order to dispatch emergency response services, resources, and funds. If these resources can be utilized effectively, it is likely that we will see dissemination of imagery and video of disaster conditions pouring in from all angles. Centralized repositories for these data that serve them onto Microsoft Bing or Google Maps style interfaces can potentially inform managers, responders, the media, insurers, investors, and public as to the spatial extent and magnitude of a disaster. It is easy to envision the advantages of such a system where photos from all users populate online maps in a manner that allows experts to classify damage in such a way that responders can prioritize efforts. With such a system, it becomes much less likely that there will be less of a chance that responders will expend undue resources for minor events, and pockets of damage will be less likely to go without help. This was illustrated recently when the professional wrestler Nuufolau Joel Seanoa, also known as "Samoa Joe," used his Twitter feed to post alerts after the recent tsunami in Samoa. Although these "Tweets" were by a known entity, and there currently is no organized way to classify and utilize this type of information on a mass scale. However, this simple example illustrates how social networking platforms hold promise.

The USGS, along with student researchers, is harnessing the Twitter social networking platform to gather earthquake event information. The Twitter Earth Detector, or TED, combs through tweets immediately following an earthquake event. The USGS system identifies earthquake related messages and aggregates statistics based on location, time, and quantity. The tweets themselves may contain firsthand experiential accounts, damage reports, and even links to uploaded on-site photographs. Additional analysis along the lines of message coding and filtering as well as the spatial and temporal aspects of Twitter messages can help characterize not only the event itself but also provide insight into human perception, behavior and response. USGS acknowledges that such technology may outperform official publication of scientific and authoritative information and public safety alerts in terms of delivery speed and access to final end users. In addition, hardcore as well as casual adopters of such technology are quickly empowered to publish and receive various information and data. In this case of the Twitter application, the entire platform and the ability to conduct essentially-real-time searches of tweet content and its time of posting approximates a kind of public and transparent 911 service. This is an optimistic development, but more needs to be done to assure user observations are harnessed directly for actionable information. The Chino Hills earthquake of 2007, a minor event, illustrates the potential of collecting data directly from the public. In excess of 40,000 surveys were submitted to the USGS through their online portal. Although clearly beyond the charge of the USGS, a system that expanded an online platform to except a wider array of data is likely to emerge for response purposes.

An additional technology will include accessing post-event data from portable devices, primarily cell phones. These applications are currently in their infancy, but with Google and potentially Microsoft entering the mobile phone market, context depended advertising is likely to follow- with the context largely driven by the user's location. Once this platform is built, it is likely to be opened up for developers to create a portable virtual world. "Augmented reality" is a term used to describe these virtual worlds where in-situ information is served through a GIS database. These will be attached to spatially aware search engines, and eventually be used to lure shoppers to a given location.

CAT modeling and exposure management, along with the government equivalents, loss estimation and hazard mitigation, are for the most part viewed as domain expert utilities. Indeed, it is easy to misinterpret these results with dire financial impacts. The impact of misunderstanding risk is typically much less than the impact of being unaware of risk, however. Additionally, these tools require a large variety of expertise- from structural engineering and computer science to finance and GIS. Understanding how these pieces fit together to run a model requires an expertise all of its own, which may not reside with those who could best use the results of a modeling platform.

In essence, much as the GIS analyst has historically been a bottleneck for maps at the enterprise level, the CAT modeler is the bottleneck for modeling or exposure management. Google maps and similar applications have largely turned GIS analysts into data facilitators- moving data from one source to another, assuring that its interpretation and content is correct, or performing custom analysis. As CAT models and exposure management tools begin to jump online, we are likely to see CAT modelers themselves adopting the role of facilitators, enabling a much wider base of users.

Although these users may be less sophisticated, they may be in a better position to make decisions about mitigation or bring about the political changes necessary to build resilient communities. As with the previous technologies, much is to be gained from integration with other platforms. Particularly if a social networking platform guided by experts can be combined with loss estimation tools. A loss estimation tool, if implemented in a cloud computing environment or with optimized algorithms, will produce estimates for a given real world scenario long before data is available from the field. This data can be used to inform the first wave of response. Additionally, as loss estimates are by nature prone to uncertainty, user-based field data can be used to interpolate data such as ground motion or wind speeds between sensors, essentially updating results as more data become available. Exposure management and hazard mitigation tools should be built upon the same platforms so that users become familiar with the tools used in disaster situations. Inlet, shown in Figure 2, is a real time loss estimation tool for earthquakes in California which simplifies the loss estimation process to reach a wider range of end users. If a single platform is used for assessing risk, estimating impacts, and collating field data, the system will also receive the attention and IT maintenance required to be fully functional when a disaster occurs.

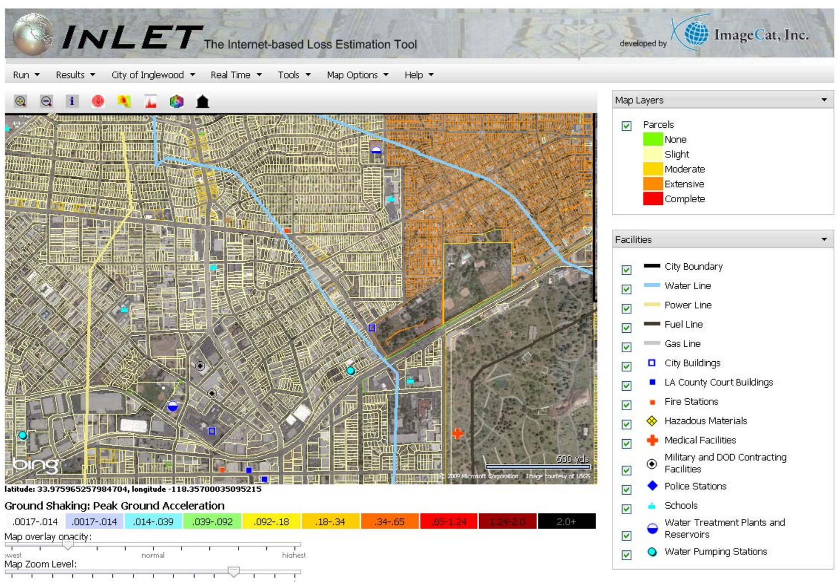

Figure 2. Inlet is a real-time earthquake loss estimation tool for the State of California. In an actual event, USGS Shakecast data is used to predict damage to buildings in less than a minute. This map displays Inglewood building damage at the parcel level for The Great California ShakeOut planning scenario.

2. What are the biggest problems or impediments that must be overcome to effectively implement these technologies?

There are several barriers to the full realization of an integrated loss estimation, mitigation and response tool combined with an information portal. Primarily, components to such a system are being developed currently at many different locations, with little coordination between developers or institutions. Ideally, efforts would be coordinated between parties in a manner that allowed for an extensible architecture for all. Secondly, although many of the players in this space have proven to be "good corporate citizens," they need to be compensated for their efforts. This includes satellite imagery companies, as well as the developers of various software and modeling components- such as geocoders, street databases, the Bing or Google mapping environment, and so forth. Developing a scheme to fairly compensate these systems for risk assessment is difficult. Research efforts have proven promising, but in order to ramp up to full production, money will have to flow. Much of these services, when combined, will run into cannibalization issues. For example, if a satellite imagery provider sells data to Google, and Google makes this data available to the City of Los Angeles through their licensing agreement, this is likely to dissuade the City of Los Angeles from buying its own imagery. With Web Services becoming a prevailing method of delivering GIS data and services, cannibalization can make pricing exceedingly difficult.

Governments have not always been at the forefront of implementing these technologies, perhaps because the technology itself evolves so quickly. Often, a concerned citizen or media outlet has stepped up and attempted to fill the gap after a disaster, which can lead to erroneous results. Effective implementation of these technologies will require both leadership and an extensible architecture in a manner that encourages all stake holders to contribute, but allows domain experts to guide implementation. This is significantly more difficult than the technical challenges.

3. What are the social, cultural, political, and environmental consequences of using these technologies?

The benefits of such a system in terms of better community planning, better assessment of risk, outreach, and so forth are fairly obvious. Additionally, if implemented correctly, such a system could clearly save lives. However, it is likely that such a system would be built on top of a WMS serving aerial and satellite data- such as Google Maps or Microsoft Bing. These technologies concentrate heavily on urban areas within first world countries. Additionally, much of the features discussed rely on inventory databases or technical infrastructure that is not available throughout the world. This is unfortunate, since those who can benefit most from such a system are least in a position to use it. For those seeking to build a global system, this disparity amplifies the need to address inventory development on a worldwide scale. The modeling adage GIGO (Garbage-in, garbage out), applies.

Apart from social equity issues, there are serious privacy and security issues built into the use of spatial information on the web. After September 11th, much of the nation’s GIS data tracking vulnerable infrastructure was pulled from the public domain. In time, much of it trickled back without the attributes needed to characterize vulnerability. Analyzing data on the web actually can potentially side step security and some cannibalization data by providing aggregate assessments of underlying databases without allowing the user to map the vulnerable infrastructure. This is less than ideal, but perhaps warranted under certain conditions. Privacy concerns may be more legitimate, particularly when data accuracy is at stake. A simple example is “Meagan’s law” in California, where sex offenders must register, and users can map their locations down to the street level. However, these databases may not be correct or entirely up to date. Similar problems arise when news organizations start digitizing crime locations, but may not have precise information. Even when data is accurate, questions of privacy remain. Google Streetview, in particular, has faced several lawsuits for integrating ground level photograph into its maps provided on a regional basis. In addition, Google receives daily requests from governments requesting removal of certain features from the map database, and frequently relents. It is easy to recognize that these data sets can be used to plan criminal activities, as well as justifiable activities, and societies may take very different approaches to allowing access to additional information on top of these resources. In the United States, access to many data sources are protected by law, but as these data become easier to use, this may change. In California, for example, it is illegal to provide the address of an elected government official online, prompting some counties to remove their assessor parcel databases form public access.

4. How can we work together in a global sense to accelerate the implementation of these technologies? What role should be played by corporations, government agencies, NGO's, and others in the adoption and implementation of these technologies?

Developing a system for all to contribute, private companies to receive reasonable profits, and IP to be protected is a daunting effort and will likely evolve when the need becomes quite obvious. In the meantime, working with others to produce partial solutions can serve as demonstrations for integrating various elements of the technology. For some technologies, there has been significant funding from the private sector, but presumably the underlying agenda is to build a marketplace from which to profit. Governments have been very slow to fund developments in this area, and this will likely have to change if significant progress is to be made. Emergency responders are in new territory with advanced technologies that allow very rapid response, live tracking, or even prediction of events. Emergency managers need clear legal and legislative support to empower decisions to pursue or reject advanced technologies. Without this support, it is very difficult for emergency managers to integrate advanced technologies with confidence. More effort should be expended harnessing research into applications that can be widely used. The community would benefit substantially from a method of linking models together, although in practice this will be quite difficult to achieve.

5. What research areas or topics deserve further study? Who should do the research? How should it be funded?

There are many areas of research that are compelling. Technology is evolving rapidly and best practices have a short window of opportunity to arise before the next innovation occurs. In the past, emerging GIS software created opportunities for specialists outside the field of geography to develop spatial approaches in their particular fields of application, often without attention to critical issues of geographic modeling, analysis, and transformation. Geographic information scientists turned their attention to issues of measurement, representation, data accuracy, visualizing uncertainty, and model validity in the past, all brought about by changes in technology. These new frontiers of handheld data collection devices, wireless networks, and Internet-based platforms deserve this same attention by geographic information scientists and disaster professionals. Research concerning the scope and limits of technology and its application, advanced metadata standards, and society and technology are all worthy of investigation.

Open internet mapping applications such as Bing Maps and Google Maps greatly simplify the process of disseminating real-time information gleaned from a variety of websites. The Southern

California fires of 2007 revealed a very high level of sophistication of the media in geocoding burnt structures and displaying them with online maps. But given the limited spatial accuracy and conservative approach of delineating burn areas, maps depicted many more burnt structures than detailed surveys could confirm. Given the amount of data verification and interpretation required to correctly use data from disasters, the emergency response community needs to establish the best way to use these data sets so that they are not misinterpreted.

This requires not only building the IT infrastructure to process real-time data, but funding development in areas such as transportation, where the optimal use may not be clear. Although there are many opportunities for research, the emergency response community at the federal and international level is best suited for defining the direction of these technologies. Other agencies, such as NSF, NOAA, and USGS should play a clear, supporting role. The challenge to developing a system will be expansibility, so that the academic and private communities can contribute.

Conclusion

Online modeling tools, combined with post-event data have the power to turn anyone into a risk analyst. In much the same way that Google Earth turns laypeople into image analysts, online CAT modeling tools and real-time data will drastically increase the number of planners, engineers, emergency responders, and citizens with the ability to assess risk. Worldwide, populations are booming in megacities with substandard infrastructure and building practices that are vulnerable to natural disasters, but despite this escalating risk, compelling disaster mitigation options such as an Indian Ocean tsunami early warning system or strengthening of the levees around New Orleans are neglected until it is too late. Mitigation strategies and recommendations sit on bookshelves, while the public feels largely powerless. Online risk models promise not only to expand the capabilities of planners and responders, if implemented correctly they can empower citizens to understand risk and face the political challenges necessary to build safer communities.