Chapter 7
Real-Time National Stability Engineering: Mapping the 2009 Afghan Election

Tom Buckley, Sean Gorman, Laurie Schintler, and Rajendra Kulkarni

7.1 Introduction

The re-building of institutional capacity in post-disaster and post-war zones requires massive engineering efforts. The needs of people on the ground in these situations are often approached from the top-down via emergency groups, NGOs, and governments (Jones, Wilson, & Rathmell, 2005). For actors on the ground, research has shown that such efforts may require ad-hoc capacity to adapt, understand, share, and quickly assess their situational context (NRC, 2007). In the study outlined below, participants were plagued by a variety of barriers ranging from lack of power to lack of trained technical personnel. In a report on improving geospatial support for disaster management the National Research Council identified several critical barriers to successful response to emergencies: a combination of lack of adequately trained staff and technically complicated geospatial software tools, lack of agreement and means for successful data distribution, and data "format[s] which are unrecognizable or unusable [for] responding agencies (NRC, 2007: 157)." A collection of researchers, open source software projects and companies has been developing technology to advance the delivery of geospatial and data sharing capabilities to non-technical users in ad-hoc environments. Recently, a few of these participants coordinated a volunteer effort to test how individual actors might apply such technology in Afghanistan.

Specifically, the team deployed a collection of interoperable technologies in Jalalabad Afghanistan to support data sharing and mapping initiatives for the humanitarian, governmental, and indigenous stake holders in the region. This overview will give some background to the project. First, the paper will briefly review how data has been collected and mapped in Afghanistan for the past 50 years. Second, a review on the project's background will be provided. Third, the paper will review the construction of a coalition of civilian, business, and government technologists including USAID, NGA, NDU, Naval Post Graduate School, UNDP

T. Buckley (✉)
FortiusOne, Inc., Arlington, VA 22201, USA
e-mail: topm@fortiusone.com

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– FortiusOne, Google, OpenStreetMap, Sahana, Stamen, INSTEDD, Development Seed. Lastly, there will be a discussion of specific mapping cases and analyses from the Afghanistan elections.

7.2 Historical Background

Between 1950 and 1960, the U.S. Government and Russia reached an agreement with the government of Afghanistan for creating maps from aerial photographs of the country. Russia photographed the northern quarter of the country, while the U.S. photographed the bottom three-quarters. Both countries produced high quality maps from the imagery, which became the National Atlas for Afghanistan at the time. During the 1980s, after the Russian invasion of Afghanistan the US Department of Defense produced numerous detailed maps as part of their support for anti-Russian insurgents. In one account, paper maps were kept out of Russian hands in the late 70s by an Afghani cook who dropped them off at the U.S. Embassy (Shroder, 2001, 2008).

Mapping in Afghanistan is still undertaken by the U.S., as well as other military forces, the United Nations, and numerous NGOs (Beck, 2003). As was the trend in the 1970s, nations still fight to gain control over information, which they think of as strategic. In 2001, as the U.S. began bombing Afghanistan, the U.S. National Imagery and Mapping Agency bought all rights to imagery of Afghanistan taken by the IKONOS satellite, at the time the satellite with the most detailed imagery (BBC, 2001). This purchase meant not only that the U.S., would have access to all the imagery, but no other country or organization could buy them

Demographics in Afghanistan have been described as "wild guesses and inadequate data (Dupree, 1980)." Throughout the hostilities of the 1980s the Central Statistics Office (CSO) of Afghanistan was largely unable to collect data. In 1992 it effectively shut down. Many of the records that the CSO had collected have been destroyed. Post 2001, the staff of the statistics office has increased tenfold and a housing and population census was implemented in 2003 and 2005. In spite of this, social statistics today are still described as being based on "ad hoc surveys" (CSO Afghanistan, 2007).

7.3 Taj Project Background

For several years, individual volunteers and NGOs have worked to provide infrastructure for the Jalalabad area to promote civil-military information sharing. In trying to achieve this goal, stakeholders have run into a variety of challenges ranging from Internet connectivity to the inability to effectively map the variety of contributed formats. A crucible for testing solutions to these problems evolved at the Taj where stakeholders regularly meet, both formally and informally. The Taj is a guesthouse that was once part of the United Nations compound in Jalalabad, which has the benefit of satellite based Internet connectivity and wifi for visitors.

The social networks created at the Taj have resulted in ad hoc data sharing between the disparate government, humanitarian, construction and NGO groups in the region. The enhancement and promotion of these kinds of information exchanges can be a boon to such groups (Bennett, 1995). This activity was semi-formalized when a hard drive was donated to reside at the Taj to provide a simple repository for shared data. The data-sharing program was started by the Synergy Strike Force (SSF), which was established by Dave Warner of Mindtel. The SSF is a volunteer team that works to support humanitarian relief and stabilization efforts in post conflict environments such as those in Jalalabad, Afghanistan. The program consists of a private volunteer organization comprised of individuals with various technical skills and access to a wide range of social networks.

Much of the data shared at the Taj was geospatial in nature, but mapping it was challenging. Most of the stakeholders in the field did not know GIS, and even if they did, were lacking access to desktop applications. The SSF team found one of the volunteer team's Web based mapping services, GeoCommons, and started using the public Website to map data. The downside to this approach was their satellite up-link powering the Taj's wifi was slow and connectivity could be intermittent or plagued by brown outs.

After learning from the team at the Taj about their use of GeoCommons, the team let them know about appliances that had self-hosted OpenStreetMap and Blue Marble map tiles that could run locally without Internet connectivity. Traditionally, this work has been done via a rack-mounted server, but that solution did not make sense for SSF's purposes. As a result, the team sent a prototype deployment on a Mac-Mini, loaded it with numerous Afghanistan data sets, and donated it to the program.

7.4 Camp Roberts Exercise

Shortly after the discussions with SSF several team members attended CrisisCamp in Washington DC, and met a variety of stakeholders interested in using technology to help with humanitarian relief projects. John Crowley invited several of the team members to participate in a STAR-TIDES sponsored exercise at Camp Roberts to simulate deploying technology for humanitarian relief in harsh climates (no power, no Internet etc.).

SSF member Todd Huffman attended the exercise, and brought along a hardware appliance to test out integration possibilities. In addition to the Afghanistan data the appliance included an Afghanistan specific geocoder for georeferencing data from the field. Once at Camp Roberts, Todd integrated the appliance into a larger workflow of participating technologies. The set up at Camp Roberts included the technologies diagramed in Fig. 7.1.

The basic workflow started with NGA FedExing a brick of Afghanistan imagery to Camp Roberts for the exercise. Next, the data was stripped off the brick and loaded into Google's portable Fusion server. The fusion server then served up tiles to

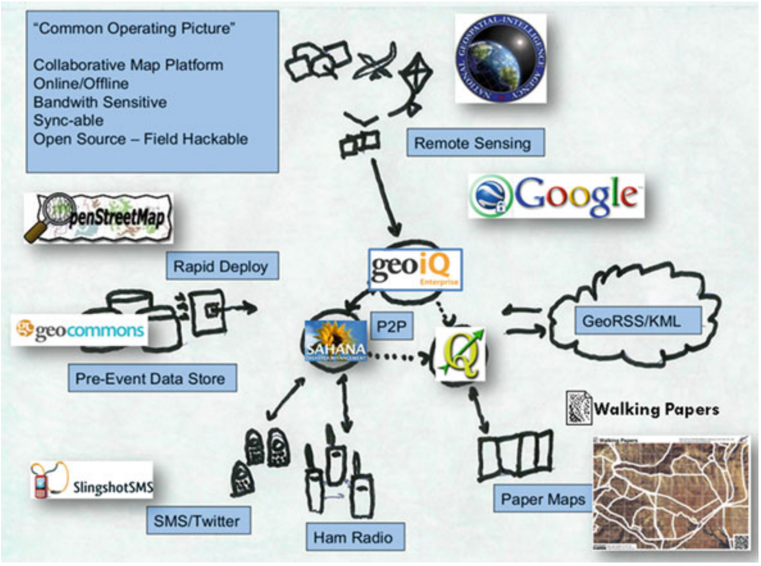

Fig. 7.1 Camp Roberts architecture diagram

the GeoIQ appliance as well as the Sahana and Development Seed mapping applications, which were also being leveraged in the exercise. Field data collected through spreadsheets, SMS, and paper annotations, was then uploaded, geo-referenced, shared, mapped and analyzed in GeoIQ. This allowed data to be easily collected in the field and then overlaid and analyzed on top of NGA imagery by non-technical users. Not only did this allow for more efficient and robust field operations, but also data from the field could now be easily shared back to headquarters. From a potential operational scenario, this could allow NGA to not only send out imagery but also have data easily federated back for further analysis and dissemination.

The testing went exceedingly well and several of the participants became interested in the Afghanistan test deployment that the team was participating with through SFF and Todd Huffman. Google graciously donated a mobile Google Fusion server and configured it to serve tiles to the GeoIQ appliance. In addition, Walking Papers was loaded onto the GeoIQ appliance to work with the OSM tile generator already in place. Walking Papers allows a user to print a map with the NGA satellite imagery and OSM street data, take it into the field, and then make annotations with any kind of writing instrument (pen, pencil, marker). Each map also has a QR code, which allows the data annotated on the image to be easily digitized and brought into OSM as new features. At the simplest level a field operator simply takes pictures of the map, sends it back via email or MMS, and the image can be digitized. When the new digitized data is fed into OSM it can trigger the GeoIQ appliance to render a new tile with the updated data. This is a compelling tool for updating data in a dynamically changing environment. For instance, a bridge is sabotaged and the map can instantly reflect its loss and communicate the fact to a large universe of users as the most current map for the area of operations.

7.5 Field Deployment for the Afghanistan Elections

The first test for the appliance was the Afghanistan elections. Todd and the SSF team had already coordinated with a wide variety of NGO's in Afghanistan to share data throughout the elections. By leveraging the GeoIQ appliance they were able to georeference large amounts of ad hoc data and create a variety of pertinent maps with the information. In addition, all the shared data sets were cataloged in the appliance creating an archive that could be searched by any of the participating groups to find data from the various contributing organizations.

USAID took a lead in sponsoring the pilot for the election and opened up several of their databases to be made available through the appliance. This resulted in hundreds of datasets being available to the team including data from the field and legacy databases providing detailed information on the historic and current state of Afghanistan.

In addition to the data contributed from organizations, the appliance also tapped into the SMS messages being catalogued by Alive in Afghanistan that were being reported by citizens during the election. These included reports of violence and potential voter fraud. This provided a critical real-time perspective from citizenry on the unfolding elections, leveraging the potential of mobile phones to be field-based sensors. Like news sources, live feeds from individuals can result in biased analysis, but steps can be taken to reduce the way that biased data affects analysis (Danzger, 1975). The combined workflow of the Afghanistan deployment can be seen in Fig. 7.2.

The data sharing initiative in Jalalabad resulted in a tremendous amount of data being contributed and shared with the various participating stakeholders. Over a terabyte of data was collected from a multitude of government agencies, NGO's and humanitarian volunteers. The process of engaging with various stakeholders in Afghanistan provided three key lessons that helped successfully enable effective data sharing in the field:

(1) *Create immediate value for anyone contributing data*: when users contribute data they should get an immediate return on that investment. In the case of the Afghan pilot that meant getting to see contributed data on a map of high-resolution satellite imagery as soon as a contributor uploaded it. The imagery for Afghanistan was made available by NGA, then tiled and served up on the Google Fusion Server.
(2) *Make contributor's data available back to them with improvements*: any data that goes in should be available to download back out again. Further, the data should come back better than when it went in. In the Afghan pilot this meant if a participant shared data as a spreadsheet format into the platform they could get

Fig. 7.2 Afghan elections architecture diagram

the data back out in a variety of other useful formats – KML, shapefile, Atom, JSON, spatialite.

(3) *Share derivative works back with the data sharing community*: urge users who create derivative works, with shared data, to contribute their data products back to the group. In the case of the Afghan pilot researchers were taking the detailed data from the field and feeding it into their sophisticated models and simulations. Researchers would then upload the results into the appliance to share the derivative works back with the data sharing community. This meant that agencies and individuals that shared data again got a better product back by contributing. The researchers get better data to feed their models, and a virtuous self-perpetuating feedback loop is created that sustains increasing data sharing.

While a wide variety of data was collected and mapped throughout the pilot one of the main focuses was providing data transparency and analysis of the August 20, 2009 Afghanistan presidential election. One of the persistent realities of daily life in Afghanistan is violence and visualizing the location and concentration of violence through maps provides a personalization that highlights the depth of problem. Specifically the team was interested in mapping violence during the election, so its impact on voter turnout could be assessed. Figure 7.3 provides a small slice in time for violence between August 11 and August 26, 2009.

The map highlights an interesting spatial pattern illustrating violence in both urban areas like Kandahar, Kabul, and Jalalabad as well less populated

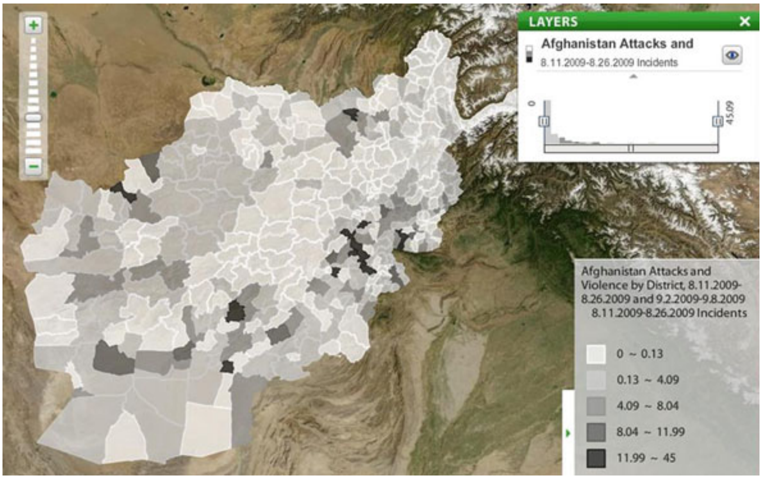

Fig. 7.3 Afghanistan attacks by district, September 2–8, 2009

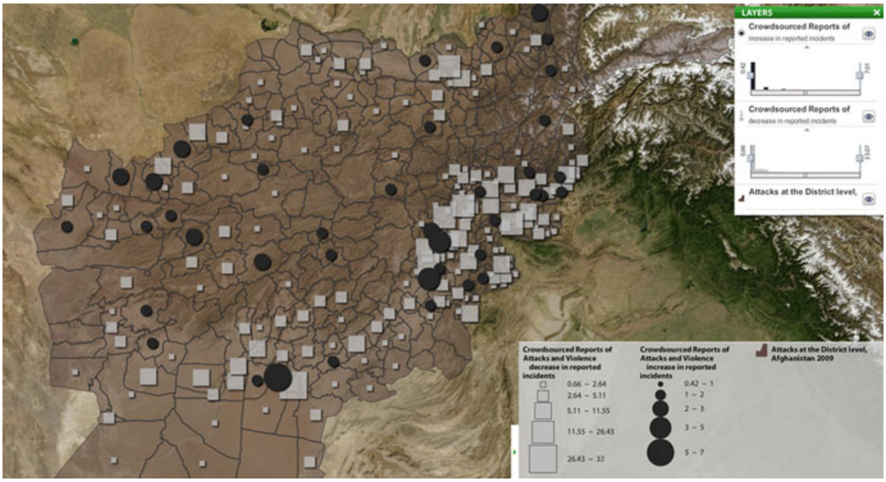

Fig. 7.4 Change in violence by district, August 11–September 9, 2009

mountainous regions. The violence appears to be coalescing largely in the Southern regions of Afghanistan with pockets of violence in the Northwest region of the country. While there are patterns over time, violence in the country is transient and insurgent activity can increase and decrease dynamically based on a variety of factors. Figure 7.4 illustrates how violence changed between August 11 and September 9, 2009 allowing us to view the pattern of violence before and after the elections.

The areas in orange have experienced an increase in violence since the election and the areas in blue have decreased in violence. This exposes interesting patterns in places like Kandahar where violence is spilling over from recently secured areas to geographically tangential locations. Overall there does not appear to be a systematic spatial pattern to where violence is increasing and decreasing, but should be examined in a more rigorous manner in the future. Hopefully the apparent lack of systematic violence means that any single political or tribal was not targeted to prevent their turnout. Again this is an assertion that needs to be examined more rigorously.

The presence of insurgent violence driven by tribal warlords, the Taliban and Al-Qaeda threatened holding safe and fair elections in Afghanistan. The US government, NGO's and the Afghanistan government all put precautions in place to enable an effective election process, but there were still wide spread reports of election violence and fraud (Constable, 2009). One of the main objectives of the pilot in Jalalabad was to provide transparency around the elections through citizen access to data on results fraud and Election Day violence. The last two maps provided a high level perspective of where violence may have influenced voter turnout. The following maps provide multiple perspectives on Election Day fraud issues from different stakeholders. Figure 7.5 illustrates where official fraud complaints where made about the election, aggregated by province.

The second map illustrated Election Day complaints and incidents reported through Alive in Afghanistan's mobile phone based SMS service. The service was set up to allow Afghan citizens to report election related violence and fraud through anonymized text messages from their mobile phones. This effort was set up outside of the government of Afghanistan and United States concerns by "Alive in Afghanistan"; a group of volunteers working on providing a voice to Afghan citizens. Their volunteers utilized a mobile phone based violence monitoring platform

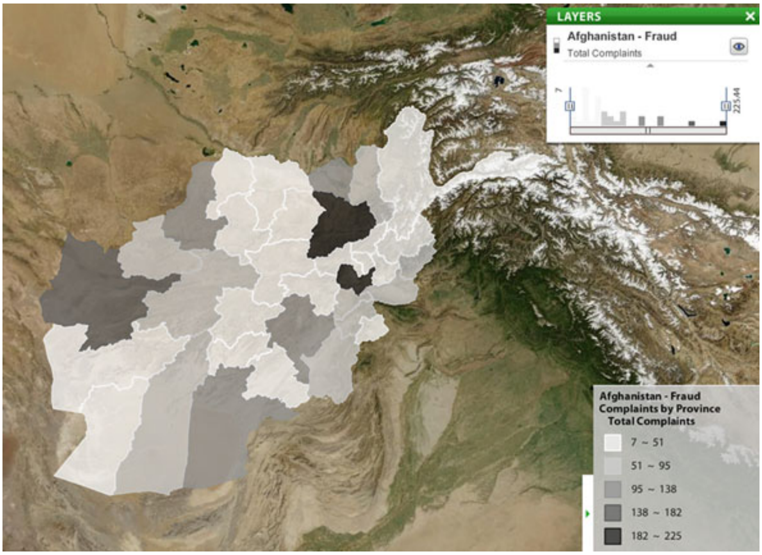

Fig. 7.5 Total fraud complaints by province for the 2009 Afghanistan presidential election

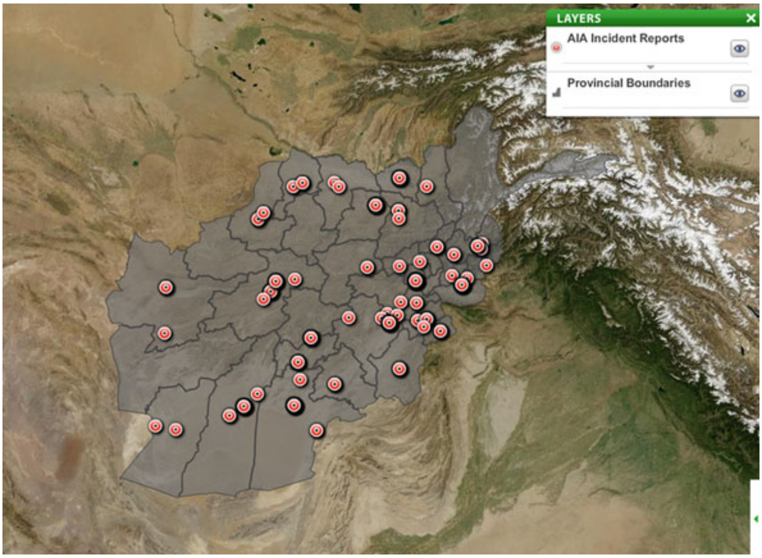

Fig. 7.6 Citizen reported election day incidents

called Ushahidi. The platform was developed during the Kenyan elections to allow citizen reporting and monitoring of violence. It was subsequently made available as a free open source platform to be used across the world for related efforts. To date this has included monitoring strife or election fraud in Gaza, India, Uganda and Kenya. The map of Election Day incident reports is shown as Fig. 7.6.

The maps provide two different perspectives on Election Day irregularities. The first map's data was generated by the Independent election Commission of Afghanistan, the official government election agency. The second map was generated by volunteer efforts which anonymized citizens' reports. While both maps show concentrations in the Kabol area, the anonymized data from Alive in Afghanistan shows a divergent pattern from the official government reports. It is beyond the scope of this brief survey to analyze these patterns, but there are rich opportunities for examining the intersection between volunteered geographic information and official source information. This is especially true when there are concerns of fraud or corruption from official source data.

To further inspect the potential for fraud and corruption in the official source information the data from the Independent Election Commission seen in the previous map provided the opportunity to run fraud models with the data collected from the field. Specifically, a fit to Benford's law was run to detect the potential for fraud in the preliminary vote results. Benford's law states that in lists of numbers from several, but not all, real-life sources of data, the leading digit is distributed in a specific, non-uniform way. More precisely Benford's law posits "the null hypothesis that the first digit in the candidates' absolute numbers of votes is consistent with random selection from a uniform, base 10 logarithmic distribution modulo 1" (Roukema,

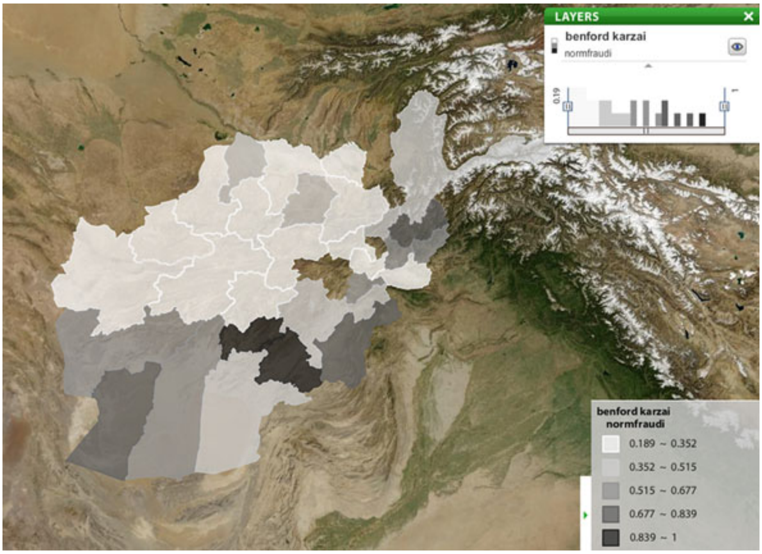

Fig. 7.7 Benford fraud analysis of Afghanistan election results

2009). Applying this technique to the Afghanistan election results produced the map shown as Fig. 7.7.

The areas in dark grey illustrate provinces where the likelihood of fraud is high because the numerical distribution of digits is far from what would be expected according to Benford's law. This provides an interesting contrast to what was seen in the official fraud reports. There is a distinct divergence between the two, although there are similarities between Benford analysis and what was reported by citizens through the "Alive in Afghanistan" service.

It is not the intent of this paper to delve into the methodological details of using Benford's analysis to scrutinize voter fraud, but more detailed reviews of the technique applied to the topic can be found in papers by Roukema (2009) and Mebane (2009). The results of the fraud analysis do provide a good example of how data collected in the field can be leveraged by researchers to produce derivative products and then share those back with stakeholders to create mutual benefit. Researchers get access to higher quality and more recent data while field contributors get access to analysis of their data to better inform their efforts on the ground. Further, researchers can receive valuable feedback from the field on the accuracy of their models to provide better error bounding and validation for future work.

7.6 Conclusion

Engineering earth covers a wide variety of human endeavors, and perhaps one of the most challenging is building stability in conflict regions around the globe.

Afghanistan is one of the most difficult environment encountered having challenged the British, Soviet and American attempts to provide stability to the region. While it is debatable whether or not it is the roles of external powers to stabilize and build sovereign nations this paper has outlined a piloted attempt to facilitate better information sharing and transparency between indigenous and external stakeholders. Transparency around the political process is one key aspect to providing confidence in government by citizens and thus a key pillar to nation stability. While engineering is often associated in the building of physical things, increasingly information infrastructure, both technical and tacit, is critical to providing the foundation for human endeavors.

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