Imaging NOTES

EARTH REMOTE SENSING
FOR SECURITY
ENERGY AND
THE ENVIRONMENT

Summer 2012
Vol. 27 » No.3

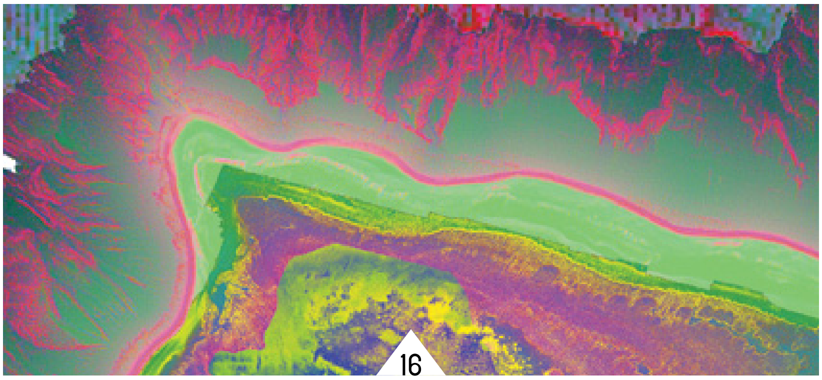
THE GREEN BELT MOVEMENT: HEALTHY ECOSYSTEMS

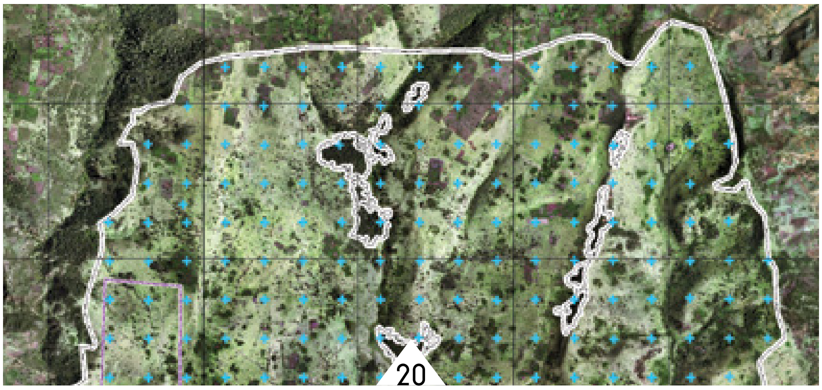
IN MEMORY OF FOUNDER WANGARI MAATHAI

CRS FOR DISASTER RESPONSE

PRIVACY AND LEGAL ISSUES

IMAGERY FOR THE ENERGY SECTOR





Summer 2012

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NASA's "Blue Marble"

COVER IMAGE

Our cover image is a 'Blue Marble' image of the Earth taken from the VIIRS instrument aboard NASA's recently launched Earth-observing satellite, Suomi National Polar-orbiting Partnership satellite (NPP). The Visible/Infrared Imager Radiometer Suite (VIIRS) is the primary imaging instrument onboard NPP, and it acquires data in 22 spectral bands covering visible, near-infrared, and thermal infrared regions of the electromagnetic spectrum.

The Eastern, Western (shown here), and Australian views were created by NASA scientist Norman Kuring. They are composite images using a number of swaths of the Earth's surface taken on January 4, 2012.

The Suomi NPP satellite is in a polar orbit around Earth at an altitude of 512 miles (about 824 kilometers), but the perspective of the new Eastern hemisphere 'Blue Marble' is from 7,918 miles (about 12,743 kilometers). NASA scientist Norman Kuring managed to 'step back' from Earth to get the big picture by combining data from six different orbits of the Suomi NPP satellite. In other words, the satellite flew above this area of Earth six times over an eight hour time period. Norman took those six sets of data and combined them into one image.

Credit: NASA/NOAA.

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Our Mission

Imaging Notes is the premier publication for commercial, government and academic remote sensing professionals around the world. It provides objective exclusive in-depth reporting that demonstrates how remote sensing technologies and spatial information illuminate the urgent interrelated issues of the environment, energy and security.

Imaging Notes has a partnership with Secure World Foundation (www.swfound.org).

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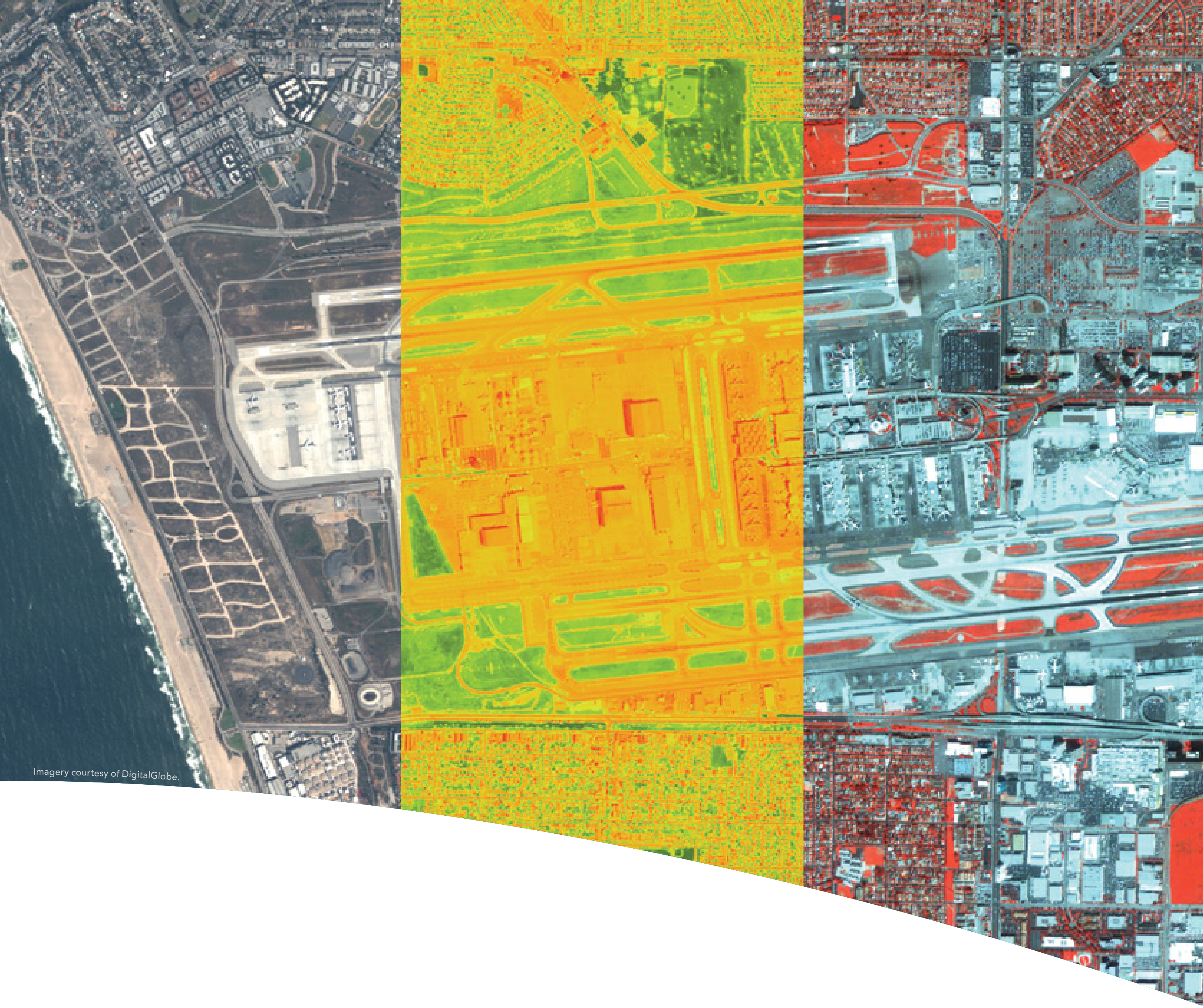
Imagery courtesy of DigitalGlobe.

Remote Sensing for Remote Areas

REPORT FROM THE SPACE CONFERENCE OF THE AMERICAS IN MEXICO

SECURE WORLD FOUNDATION FORUM

What do Chagas disease, volcanic eruptions, health care to isolated rural communities, and agricultural and ocean food production have in common? Though they seem to be totally disparate, independent problems, they are closely linked by the fact that they can all be tackled by space technology.

All these subjects were explored in an April 2012 three-day forum hosted by the Mexican Ministry of Foreign Affairs in Mexico City in its role as the Pro Tempore Secretariat of the Space Conference of the Americas: the Mexican Space Agency (AEM), the Regional Center for Science and Technology Education for Latin America, and the Caribbean (CRECTEALC) and Secure World Foundation (SWF). These organizations teamed up to bring an international set of participants from Brazil, Canada, Colombia, the European Union, Mexico, Portugal, the United States, and Venezuela to explore the utility of space technology for tackling many of the pressing human issues faced by Mexico and other countries of Latin America. The Space Conference

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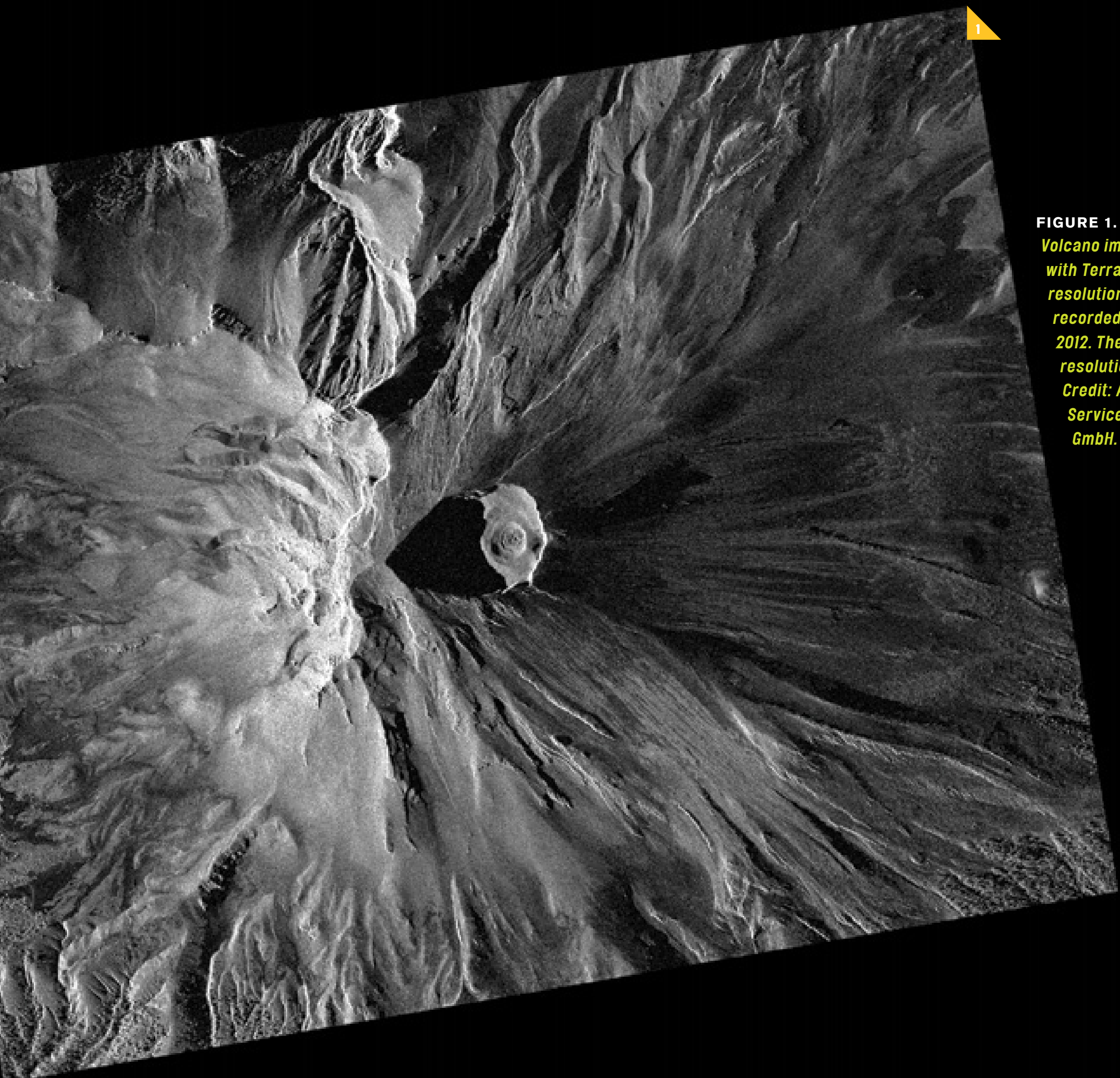
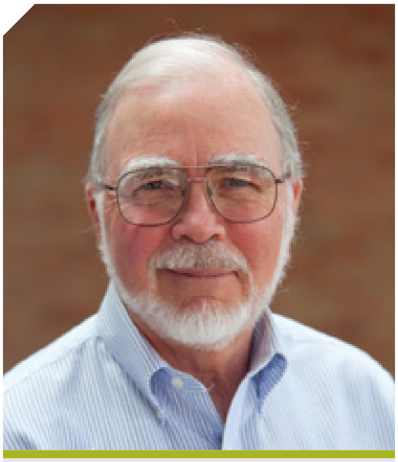


FIGURE 1. *Popocatepetl Volcano image taken with TerraSAR-X High-resolution SpotLight, recorded on May 10, 2012. The ground resolution is 3m. Credit: Astrium Services / Infoterra GmbH.*

of the Americas was also very much a coming-out party for the emerging Mexican Space Agency, which was just created in July 2010, and demonstrated the wide scope of space activities that are already being pursued in Mexico in universities and science institutes. Having a single entity to coordinate its efforts will, among other things, improve Mexico's ability to participate in international cooperative programs, including its plans to develop a remote sensing satellite with the German Space Agency, DLR, focused on detecting wildfires in the wilderness areas of Mexico.

Chagas Disease

The forum demonstrated the value of interdisciplinary solutions to troubling human problems. Take the case of Chagas disease, for example. Chagas is a debilitating, parasitic, vector-borne disease carried by blood-sucking insects, Triatoma infestans and related triatomine species, often referred to as "kissing bugs." These bugs, which feed on the blood of mammals, most commonly appear at night, where they crawl from hiding places to stick their needle-like proboscis into their victims' skin, sucking blood and, if they are infected with Chagas, inadvertently but surely infecting the victim. Chagas affects the nervous system, the digestive system and the heart. Because the disease often lies dormant in the victims' system for months or years, leaving them asymptomatic, they are not even aware they carry the disease, making treatment of a large population of infected individuals very difficult.



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The disease is endemic in certain tropical areas where heat and moisture contribute to a very cozy environment for fostering population growth of the host insects. Chagas occurs mostly in Latin America, where it may infect as many as 18 million people. It can also spread through skin contact, mucus or feces of infected triatomines, blood transfusion, and congenitally from a mother to her fetus. As a result of global travel, the disease can now be found in Spain, France, and the United States, countries that experience significant immigration from countries where Chagas is endemic.

At this time, there is no vaccine for Chagas, and the available parasitic treatments have serious side effects. Combatting the debilitating disease relies largely on limiting exposure to the bug that carries it and introducing improved sanitation into endemic areas.

Here is where space technology can help. First, by identifying geographic areas where Chagas-carrying bugs are likely to exist, imagery from remote sensing satellites, combined with high accuracy positions obtained from GPS receivers of areas of known infection, or where the right climatological and landscape conditions exist for breeding grounds for the bugs, can help public health officials direct their efforts more effectively to areas of need.

Second, broadband satellite Internet and TV service can provide preventive information and health services to these areas, many of which are quite remote from urban centers. Third, satellite services provide a means to deliver high quality medical services remotely to areas lacking qualified medical personnel. Finally, information collected from the infected areas and delivered to medical research experts in urban centers helps in the long term process of finding more effective means of controlling Chagas and limiting its spread.

Participants from Brazil, Mexico, and Venezuela, each expert in at least one of these technologies, presented their research, experience, and future plans at the forum. They also developed a joint public declaration that indicated their intentions to work together in a regional effort to eradicate Chagas as a regional health threat by providing tele-health services, education, and research on a possible cure. Experts from Argentina have since joined the team.

Volcanoes

The forum also provided the catalyst for other follow-on international cooperative programs using space technologies, including one to investigate the recent worrying activity of the volcano Popocatepetl near Mexico City. See ***Figure 1***. In the months leading up to the forum, Popo,

> Participants from Brazil, Mexico, and Venezuela, each expert in at least one of these technologies, presented their research, experience, and future plans at the forum. They also developed a joint public declaration that indicated their intentions to work together in a regional effort to eradicate Chagas as a regional health threat by providing tele-health services, education, and research on a possible cure.

as it is known colloquially, periodically began spewing forth volcanic ash, and just a few days before the forum began, it sent a huge plume into the atmosphere, liberally coating the houses, streets, and vehicles in nearby Puebla and other cities southeast of Mexico City. The daily volcanic activity has continued for over two months.

Over the past decade, the volcano's dome within the crater has grown from increased ash and lava flow, and related seismic activity has increased, amplifying concerns of Mexico's Centro Nacional de Prevención de Desastres (CENAPRED) for the potential danger to the region from the volcano. As a result, officials from CENAPRED, CRECTEALC, the National Institute for Astrophysics, Optics and Electronics (INAOE), and DLR met to discuss the possibility of using satellite radar images to monitor the growth of Popo's dome.

Those discussions have led to the acquisition by DLR of images from Astrium's synthetic aperture radar (SAR) satellites TerraSAR-X and TanDEM-X to monitor the volcano. SAR instrumentation can pierce through the smoke and ash often above the volcano, producing high-resolution images that can be compared to display changes in the volcano's form and structure. U.S. volcano experts are also working with CENAPRED on the volcano's recent activity.

The forum also emphasized the role of space policy and law in space sustainability, SWF's primary theme. It also explored the responsibility of emerging space States in adhering to the international space treaties, agreements, and U.N. resolutions in order to maintain the long term ability to use outer space constructively for peaceful purposes.

Finally, much has been written recently about the so-called Global South, those countries lying south of the Equator, or in some definitions south of the Tropic of Cancer, many of which face enormous and similar issues of poverty, lack of access to resources, and modest or slow development. This forum was a tiny but significant step in providing the thinking needed to tackle some of the problems faced by the Global South, for as participant Dr. Alex Wuenche of Brazil noted, "Latin America is the Global South." To make progress in space for human and environmental security, the countries of Latin America need to cooperate more effectively.

RESOURCES

- swfound.org/events/2012/space-for-human-and-environmental-security-in-the-americas-space-policy,-long-term-sustainability-and-cyber-health
- reach2020.isunet.edu/index.htm
- www.telereach.org/Main_Page

Crowdsource Mapping

BRIDGING COMMUNITIES: SPACE AND DISASTER WITH VOLUNTEER AND TECHNICAL

1

THE CARIBBEAN REGION, WHERE HAITI IS LOCATED, IS ANNUALLY EXPOSED TO HURRICANES and tropical storms, some of which trigger disasters that prompt requests for humanitarian assistance. Hurricanes Georges and Ivan are examples of events that have provoked extensive losses in Caribbean countries in recent decades. In every disaster, response efforts include the assessment of damages and needs, and such damage assessments usually find their way into situational maps depicting impacts on infrastructure, lifelines and other sectors of development. Of particular importance is the mapping of the road infrastructure, as such infrastructure is needed to deliver humanitarian assistance to the affected communities.

While the exposure to hurricanes is very well known to the inhabitants of Caribbean countries, the same cannot be stated about earthquakes. The 12 January 2010 earthquake that destroyed much of Port au Prince as well as surrounding communities in Haiti took the Caribbean islands by surprise, triggering fatalities beyond imagination, limiting response efforts on behalf of many government agencies, and demonstrating the very high but unperceived vulnerability to earthquakes in Haiti.

According to the Pan American Health Organization (PAHO, 2011), more than 200,000 people lost their lives, more than 100,000 houses were destroyed and more than 200,000 houses were damaged. Destroying the facilities of the Civil Protection Agency and the primary and secondary facilities used as Emergency Operation Centers to coordinate efforts, and destroying the facility of the National Geospatial Information Center, the earthquake inhibited these two organizations from rapidly generating and providing maps concerning affected areas in the days that followed the event.

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The humanitarian response to this catastrophe was huge, and many countries from around the world provided support to the response and recovery efforts. As in the cases of other major events, the United Nations' Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) Programme supported response efforts. With the support of the Cartographic Section of the United Nations, it requested the activation of the International Charter: Space and Major Disasters, it mobilized its partners, delivered space-based data and information, set up a dedicated webpage in the UN-SPIDER Knowledge Portal to display information generated regarding this event, and conducted a technical advisory mission.

As part of its activities, UN-SPIDER facilitated communications and cooperation among the Civil Protection Agency, the National Centre for Geospatial Information of Haiti, the United Nations Stabilization Mission in Haiti (MINUSTAH) and the Information Management Unit of the United Nations Office for the Coordination of Humanitarian Affairs, with a view to ensuring that technical assistance could

FIGURE 1. *Photo of expert meeting that was conducted by UN-SPIDER in cooperation with Secure World Foundation at the Vienna International Centre, July 2011. Results of this and the Geneva meeting in November 2011 are captured in the full report, listed in Resources.*

be provided in the event of a future disaster (UN-SPIDER, 2010).

Unfortunately, the extensive damage to the local communications infrastructure inhibited many agencies from sending information generated abroad via typical internet channels, so direct shipments of information in the form of external hard drives and DVDs had to be used to send such information to those agencies in charge of relief operations in Haiti.

In contrast to previous disasters, the Haiti earthquake provided an opportunity for the volunteer and technical communities (V&TCs) such as the International Network of Crisis Mappers (www.crisismappers.net) and OpenStreetMap (www.openstreetmap.org) to support disaster response efforts through the generation of thematic maps using satellite imagery and global navigation satellite systems as a source of data.

What made the difference in this case is the fact that space agencies provided satellite imagery for such communities to access free of charge as a way to assist them in the generation of such maps (UN-SPIDER, 2011).

For example, The International Network of Crisis Mappers is the world's premier hub for crisis mapping and humanitarian response. The network brings together a diverse set of individuals from the humanitarian, human rights, policy, technology, and scholarly communities to help catalyse communication and collaboration among a wide range of different communities with the purpose of advancing the study and applying crisis mapping worldwide. Throughout the year, the Crisis Mappers Network facilitates continuing virtual interaction among its members.

As Jen Ziemke, co-founder of the International Network of Crisis Mappers

comments (Ziemke, 2010), Crisis Mapping encompasses the collection, dynamic visualization and subsequent analysis of geo-referenced information on disasters, contemporary conflicts and human rights violations. A wide range of sources is used to create these crisis maps, such as events data from newspaper and intelligence parsing, satellite imagery, interview and survey data, and SMS. Scholars have also developed analytical methodologies to identify patterns in dynamic crisis maps. These range from computational methods and visualization techniques to spatial econometrics and "hot spot" analysis.

While scholars employ these methods in their academic research, operational crisis mapping platforms developed by practitioners have to carry out their work in support of emergency relief operations using more traditional tools and procedures. The Network of Crisis Mappers has established a series of conferences aiming to bridge the divide by bringing these scholars and practitioners together to shape the future of crisis mapping. The next conference for crisis mappers is scheduled for October 2012 in Washington, D.C.

Recognizing the relevance of such efforts carried out by the Volunteer and Technical Communities, UN-SPIDER and Secure World Foundation have been conducting a variety of activities to identify specific actions that could ensure closer cooperation among the crowdsource mapping, disaster management and space technology communities. Among them, expert meetings have been held, such as the International Meeting of Experts on Crowdsource Mapping for Preparedness and Emergency Response, which was conducted on 5-6 July 2011 in the United Nations Office in Vienna, and the second one, which was organized in the Palais de Nations of the United Nations in Geneva on 16 November 2011.

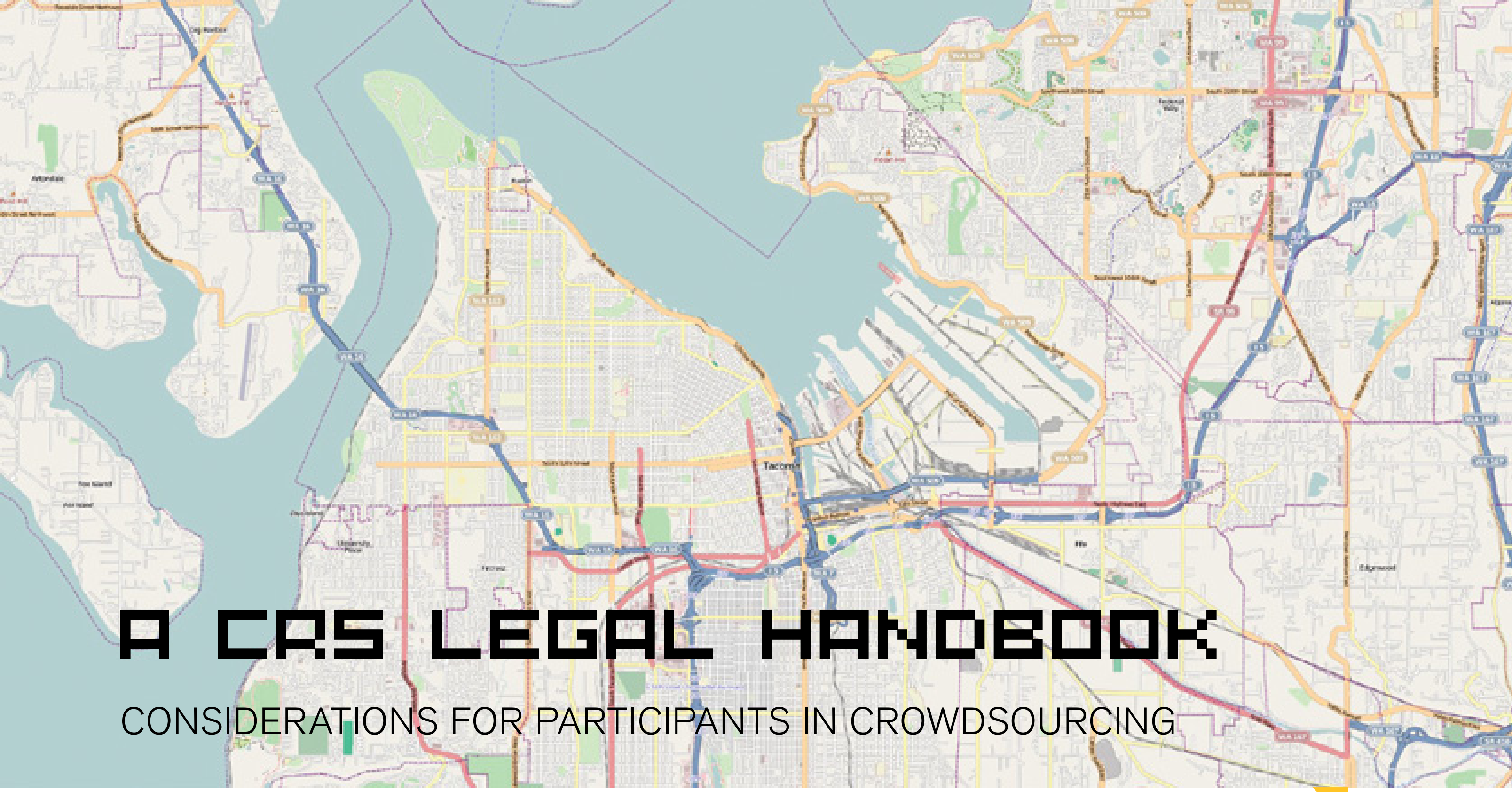
During such meetings, experts from the space and the volunteer technical communities recommended the need to raise awareness within the disaster management community regarding the innovative services provided by volunteer and technical communities. These meetings also contributed to the development of an understanding of the strengths and challenges of the communities (space, disaster management, and volunteer and technical communities) and to the exploration of ways to proceed jointly. One of the recommendations from the meeting was to plan a simulation exercise in Samoa in which the three communities would work together in a coordinated manner for the first time (UN-SPIDER, 2011).

The Cyclone simulation exercise for Samoa was carried out from 30 November to 3 December 2012, providing both a chance for all participating groups to bring their expertise to the exercise and a golden opportunity to test response plans and initiatives. A secondary exercise was conducted on 15 December 2012 to complete the objectives. These objectives included providing a number of volunteer groups an opportunity to train their teams of volunteers in a realistic scenario, several technology developers an opportunity to try their services with the volunteer groups, and the UN-SPIDER programme a chance to test the response and accessibility of space-based information to support such exercises. A detailed report can be found at the following website: http://crisismappers.net/profiles/blogs/report-for-dec-2011-samoa-cyclone-simulation-released. With the lessons learned in Samoa, a similar simulation is being prepared to be carried out in the Kingdom of Tonga in 2013.

The cooperation between UN-SPIDER and Secure World Foundation in this area continues in 2012 through the conduction of follow-up expert meetings (scheduled for Dec. 3-5) and is expected to contribute to the efforts that such volunteer and technical communities can provide when it comes to preparedness and response efforts carried out by the disaster management community through such simulations, exercises and other relevant activities.

RESOURCES

- Pan American Health Organization (PAHO) (2011): *Health response to the earthquake in Haiti. January 2010 – Lessons to be learned for the next massive sudden-onset disaster.* Available in: http://new.paho.org/disasters/dmdocuments/HealthResponseHaitiEarthq.pdf.
- UN-SPIDER (2010): *Technical advisory support activities carried out in 2010 in the framework of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response.* Report A/AC.105/985. Available in: http://www.unoosa.org/pdf/reports/ac105/AAC105_985/985_E.pdf.
- UN-SPIDER (2011): *Space-based information for crowdsource mapping.* Report A/AC.105/985. Available in: http://www.unoosa.org/pdf/reports/ac105/AAC105_1007/49STSC-1007_E.pdf.
- Ziemke, J. (2010): The International Network of Crisis Mappers. *Proceedings of the Fourth United Nations International UN-SPIDER Bonn Workshop.* Available in: http://www.un-spider.org/book/5099/4c-challenge-communication-coordination-cooperation-capacity-development.



A CRS LEGAL HANDBOOK

CONSIDERATIONS FOR PARTICIPANTS IN CROWDSOURCING

1

COMMUNITY REMOTE SENSING (CRS) IS BECOMING A powerful tool with many important applications. CRS means that the community of users contributes data points to certain projects, from the field, from mobile devices, to a centralized digital map serving as a data aggregator. Similar concepts are crowdsourcing (more casual) and VGI (Volunteered Geographic Information).

CRS has the particularity of using multiple types of location data and sources. Analyzing and combining all or some of these different types of data create a new set of data from which information can be extracted, leading to new knowledge. It is the fact of combining all this information that creates a more accurate picture of the situation at hand, whether it is for humanitarian response after a natural disaster, for a scientific study of an ecosystem, for an applied use such as micro-weather predictions in mountainous country, or for many other uses.

As with every human activity, legal issues need to be taken into consideration. At each stage of a CRS project – data collection, data access and usage, sharing and distribution of data and/or information – some legal threats can be found and it is important to be aware of them before embarking on a CRS project.

Four main legal concerns (first identified by Kevin Pomfret, attorney at the Centre for Spatial Law and Policy) are national security, privacy, intellectual property rights, and liability. Failure to address these legal issues when considering a CRS initiative may eventually harm the project or have negative impacts on future projects.

National Security Considerations

A State's national security policy might restrict access to specific data, such as very high resolution satellite imagery, or to aerial imagery of its territory. While this should always be taken into account by CRS projects, and can certainly be a limitation for some, the impact of these policies remains quite limited. In fact, International Law, as well as the United Nations system, has acted in favor of access to data, through the 1986 United Nations Principles relating to remote sensing of the Earth from space, and through the implementation of the International Charter on Space and Major Disasters.

▲ **FIGURE 1.** *OpenStreetMap of Tacoma, Washington, done by crowdsourcing.*

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EDITOR'S NOTE: See story about the report on CRS from the United Nations' Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) on page 10. Also, *LBx Journal's* Spring issue includes a major report on Location Data Privacy. in conjunction with The Location Forum (www.thelocationforum.org).

Much more pressing are the issues of privacy, intellectual property rights (IPR) and liability.

Privacy

Privacy is a complex notion. It has different meanings in different cultures and enjoys different levels of protection according to State law, as each State is sovereign with respect to how it applies the right to privacy on its territory. National legislation mostly protects against violations of privacy by public authorities, but no mention is made of private or commercial intrusions. These cases then need to be dealt with on a case-by-case basis, which does not offer an environment of legal certainty.

Interestingly, cases such as privacy infringements by Google Street View have been dealt with differently in different European States. While Germany declared Google Street View as legal, Swiss courts ruled that Google must take action to protect privacy by blurring out faces and license plate numbers. In some countries, the term "privacy" does not even translate directly and is not protected as a right.

In the specific area of remote sensing data, the issue of privacy is even more complex and less regulated. Issues are likely only to increase with technology developments. Numerous lawsuits about privacy are currently on-going related to social networks and Google's new privacy policy, dated March 2012, coming either from individuals or from governments.

▲ **FIGURE 2.** *OpenStreetMap of Washington, D.C.*

Real threats and perceived threats to privacy are different and the boundary is difficult to determine. It is likely that privacy would not be a major legal issue for most of the data that is being used in CRS efforts, but the laws, regulations and public feelings about it are so complex and diversified that this uncertain situation might actually inhibit the use or collection of certain data.

For CRS projects, it is therefore best to rely on volunteer disclosure of data, instead of random collection on the Web. Using text or photographs coming from social networks like Twitter or Facebook should be an option, but it should always be done with the full awareness and consent of the individual user. With privacy being such an uncertain area of law, this consent will have to be dealt with carefully.

Intellectual Property Rights

Virtually everywhere, a person producing any kind of printed, written or in some other way publicized image, data or text is protected by copyright, by default. This means that the person who created the data needs to receive at least proper attribution when the work is re-used. Copyright is, however, not always the most appropriate way to protect remote sensing data, as it cannot cover raw data, which is not an original creation, but only processed data. Other forms of legal protection may apply to raw data, like database protection, or ownership rights.

Policies are usually in place for using remote sensing data, and in most cases a license needs to be acquired. The license details the conditions under which the data can be used, which can be more or less restrictive. A few typical conditions include:

- **the data shall be used only for the particular purpose for which the license is granted,**
- **it shall not be used for any purpose that would be against the law,**
- **it shall not be altered,**
- **it shall not be further distributed.**

These last two conditions are usually not compatible with CRS projects, as the aim is usually to add information layers and then further distribute the new data.

Very often, there is no particular licensing system in place, and this may result in even more confusion. This does not mean the data are not protected; it just means it is more difficult to know which type of usage is allowed.

Many organizations providing data free of charge, such as Google, do have a policy and terms and conditions for use of their data. However, as each organization may have a slightly different policy, it becomes quite difficult to keep track of all of this in a CRS project, where there are many layers of data. Therefore it is more prudent for a CRS project to rely only on original data created by the contributors or on data in the public domain. This limitation, however, drastically reduces the amount of data that can be used.

A good example of a project that has adopted this angle is OpenStreetMap (OSM). See ***Figures 1-2***. The OSM copyright and license policy, as well as the legal dispositions, specify: "Only sources with compatible licenses – such as U.S. Government information released into the public domain – may be used as bases for adding OSM data. However, it is OK to use Yahoo! Aerial Imagery, as Yahoo! has agreed to allow OSM to use it. Better still, create the data yourself!"

This is a good example of how to avoid legal issues in a CRS project, but it also provides evidence that a legal system with a clear and uniform approach to licenses and with a better overall comprehension of the uses of technology could make such initiatives much easier to handle and also more efficient.

Another complex question concerns the term "derived work" and what it covers. If only a very small part of the data is used to create a new set of data, should the licensing policy of this data apply to the whole compilation? As CRS is usually a compilation of many different data, it can be very complex to attribute a coherent legal status to the compilation.

The solution found by OpenStreetMap is therefore one of the safest ones. All the data used is in the public domain, or specifically created for the project – the contributors having previously agreed to the OSM terms – and the compilation is protected under a Creative Commons license. Initiatives such as Creative Commons are very useful for CRS projects, as they answer their need for a standardized, internationally applicable and legally acceptable way of distributing and sharing the data.

Liability

Liability in the case of CRS is directly linked to data quality. How can the quality and the accuracy of the data be trusted and can it/should it be verified? This is one of the limitations of CRS and of all participatory or "open" projects, like Wikipedia, for example.

The question is, will this liability issue limit the use of CRS data or harm the development of this type of initiative? Whereas it is unlikely that it will harm the development of CRS, the lack of guarantee of data quality might very well limit the uses made of CRS data for critical issues like disaster response or science model building. As noted before, using and sharing are the main purposes of CRS data, and limitations to them should be avoided.

If data can never be 100% guaranteed, still there are levels of trustworthiness, depending on who the contributors are, how and if they are selected, how many people are involved and how the project is managed. Something as wide open as Wikipedia cannot be compared to the GISCorps project, where a small number of professional volunteers are carefully selected for each project and where one volunteer is a designated manager.

Two examples of cases in which uncertainty over data quality could harm the use of CRS data are political pressure and lawsuits. In the courtroom as well as in the political arena, the only acceptable arguments are ones that are verified, verifiable or coming from reliable sources.

It would be counterproductive to force organizations involved with CRS to guarantee their data and to assume liability for them. This would probably be the death of most CRS projects. Another approach would be to standardize the use of liability disclaimers for CRS projects. This aspect goes hand-in-hand with the technical challenge of metadata requirements in CRS, and should probably be tackled simultaneously, through cooperation between technical and legal experts in the field.

Ways Forward

Laws are sometimes uncertain and outdated and usually do not reflect the level that technology and its applications have reached. This is not surprising, as laws are usually reactive and answer a need after a new situation arises. One of the most pressing issues for CRS projects seems to be related to standardization and a common understanding of the rules and the technologies involved.

Concerning privacy, the way forward will probably go through custom rather than through hard legislation. As people grow accustomed to new technologies, their views on the boundaries of privacy change. Over time, cultures change, and in this technological age, cultures seem to change ever more quickly. It is unrealistic for a system of law to keep pace with these changes, and it will probably evolve slowly as an adaptation to a fluid reality.

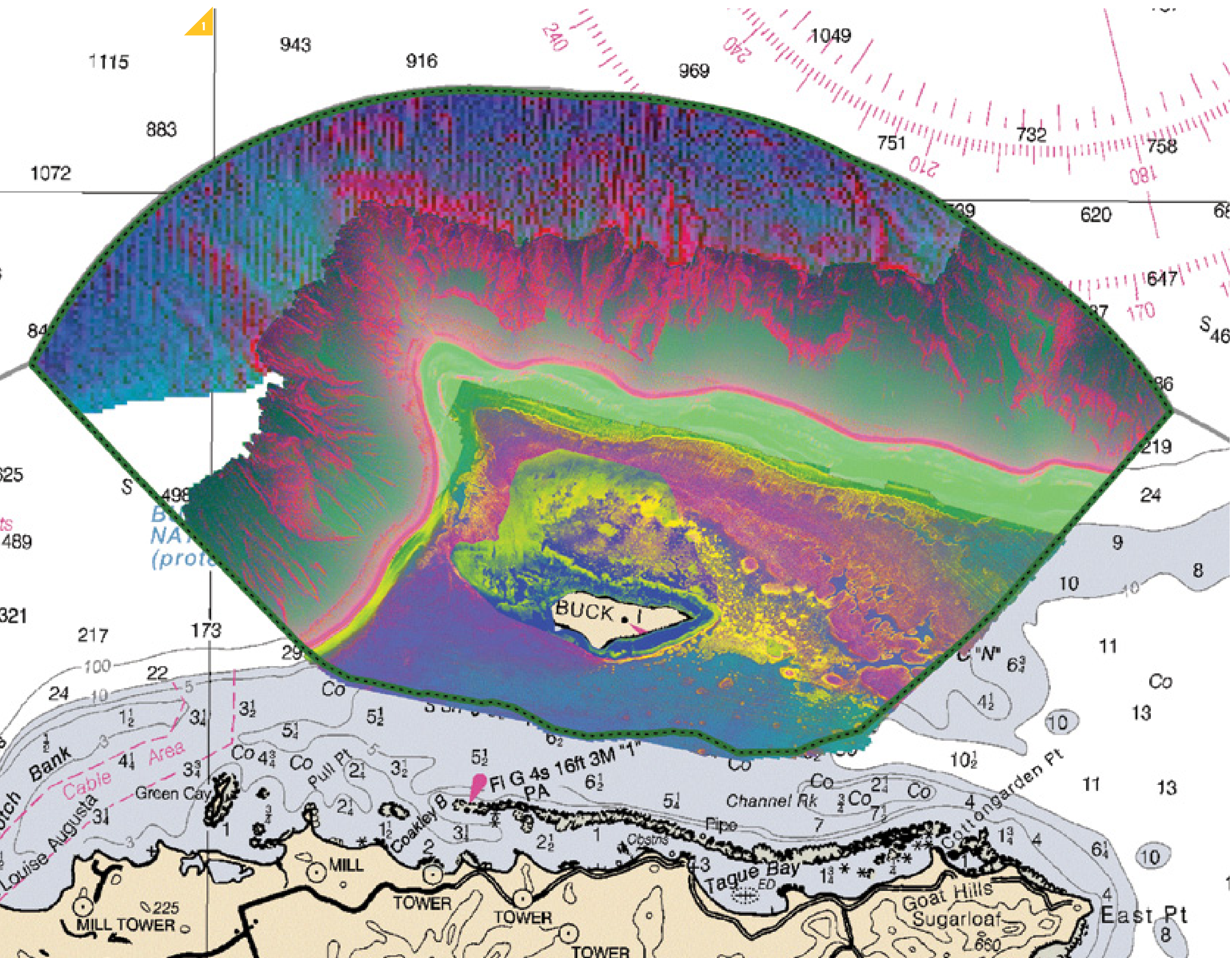
Concerning IPR, without harmonizing the laws worldwide, there could be an effort made to raise awareness about community remote sensing and its goals, which are mainly scientific, educational and related to disaster management and other public good. If specific licenses could be designed for this kind of project and on a global basis, use and sharing of the necessary data might be facilitated. Efforts have already been made in this direction, such as the Creative Commons initiative.

Finally, several international institutions are already working on the different issues at stake. The Data Democracy Initiative of the Committee on Earth Observation Satellites (CEOS) is particularly worth noting. This initiative aims at providing "timely access to key datasets free of charge to build capacity worldwide, especially with respect to developing countries. Additional Data Democracy initiatives include enhanced data dissemination capabilities, sharing of software tools, increased training, and technology transfer to end users. CEOS member agencies recognize that the GEOSS Data Sharing Principles should serve as the basis for data access in this context to contribute data for the public good. In particular, CEOS agencies will contribute to the GEOSS Data Core by making several datasets available on a full and open basis." (Source: CEOS Rio Statement).

The CRS community, as well as all citizens and businesses involved in social networking and crowdsourcing, will probably show the way. As CRS flourishes, a few broad and common principles for these issues should be found and agreed upon internationally.

Mapping & Extracting Sea Floor Habitats

NOAA USES SONAR, LIDAR AND OPTICAL DATA



NOAA COLLECTS AND ANALYZES DETAILED SONAR, LIDAR AND OPTICAL IMAGERY DATA TO DETERMINE the best regulations and practices to preserve vital habitats. They are using ENVI image analysis software to process, analyze, and fuse different types of geospatial imagery and to integrate information with Esri's ArcGIS.

The National Oceanic and Atmospheric Administration (NOAA) uses GIS and imagery for a variety of environmental management and conservation efforts including conserving and managing coastal and marine ecosystems and resources. NOAA provides these services to academic, state, federal and private sector partners. NOAA recently assisted one of these partners to map and extract detailed information about seafloor habitats within a marine protected area. In order to do so efficiently, NOAA needed to develop a new semi-automated approach that would allow them to process, analyze and fuse different types of imagery and provide their partner with the fundamental data needed to make informed decisions.

The National Park Service (NPS) asked NOAA to map and extract detailed information about seafloor habitats in Buck Island Reef National Monument off the U.S. Virgin Island of St. Croix, which has been dubbed "one of the finest marine gardens in the Caribbean Sea." The monument is one of only a few fully marine protected areas in the U.S. National Park System and is home to a coral reef ecosystem that supports a large variety of native flora and fauna, including several endangered and threatened species, such as hawksbill turtles and brown pelicans.

The NPS called upon NOAA's Biogeography Branch to assist by providing products to inform ecosystem-based management in the monument. To do this, NOAA needed an efficient and effective method to map and assess the distribution and ecology of living marine resources.

The resources in Buck Island Reef National Monument are impacted by its visitors, boaters, snorkelers and scuba divers as well as pollution, climate change and extreme weather events like hurricanes. The habitat map with which NOAA provided monument resource managers will be used to understand the current state of the area and how things are changing so that they can determine the best rules, regulations and practices to preserve and conserve its habitats well into the future.

When One Sensor Isn't Enough

After evaluating the area, NOAA determined that traditional marine mapping methods that rely on the manual interpretation of optical imagery couldn't produce a comprehensive habitat map of the monument given its depths, which extend from the coastline of Buck Island to 1,800 meters at its deepest extent. "We had a very unique problem," said Tim Battista, an Oceanographer at NOAA. "There is no one technology or sensor that allowed us to collect the data we needed in the range of depths present at the monument. We had to devise an innovative method that would allow us to both measure sea floor depths as well as characterize its habitats across the entire seascape."

NOAA ultimately devised a new method that fuses the strengths of four different sonar, lidar and optical imagery sensors to gather the information they needed. NOAA chose ENVI image analysis software as a key part of their solution because it combines the latest spectral image processing and image analysis capabilities with automated workflows, allowing users to obtain scientifically proven, accurate results quickly and efficiently. Because ENVI gives users the capability to fuse multiple data modalities such as radar, lidar, optical, hyperspectral, stereo, thermal, acoustic and more, the strengths of different sensors can be exploited together, which creates a rich context that aids decision making.

NOAA recorded depth and other characteristics of shallow areas in the monument using multispectral and lidar imagery. This imagery was acquired from planes that flew over areas up to about 30 meters in depth, the point at which light is unable to penetrate to the seafloor. At depths of more than five meters, NOAA used sonar technology located onboard vessels and ships, such as the Nancy Foster, to scan the sea bed. The Nancy Foster emits more than 3,500 pings per second and receivers on the ship record the time and angle of the echoes returning from the sea floor. Days spent sailing and employing sonar technology yielded bathymetry or depth information. The intensity of the echo also provided information about the sea floor, such as how hard, soft, rough or smooth it is, which often indicates discrete habitats such as coral, sand and sea grasses.

ENVI Helps Distinguish the Sea Floor

The lidar and acoustically collected bathymetry was also used to calculate a suite of complexity metrics in Esri's ArcGIS, such as slope, rugosity and curvature, which emphasize the differences between habitats on the sea floor. As part of their preprocessing work, NOAA used Principle Component Analysis (PCA) to reduce redundancy in the data and better understand the complexity on the sea floor. This information, along with ancillary information including intensity information, was loaded into ENVI, allowing the researchers to draw distinctions between softer and harder sediments in flatter areas of the sea floor.

◀ **FIGURE 1.** *NOAA used ENVI to produce a PCA surface – the foundation for their mapping methodology – from four different acoustic and multispectral datasets spanning the monument's 20,000-acre extent. Image courtesy of NOAA.*

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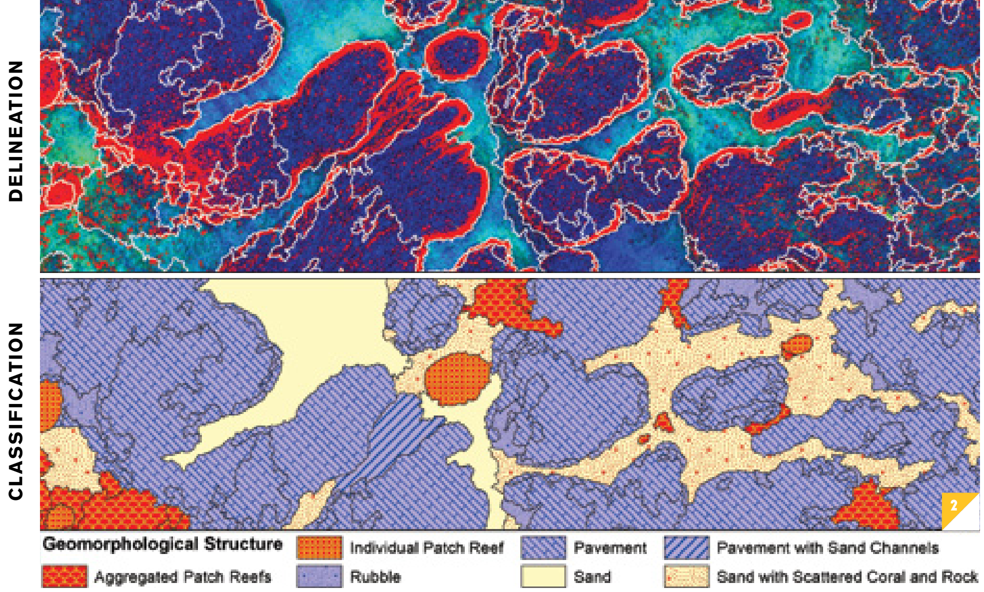

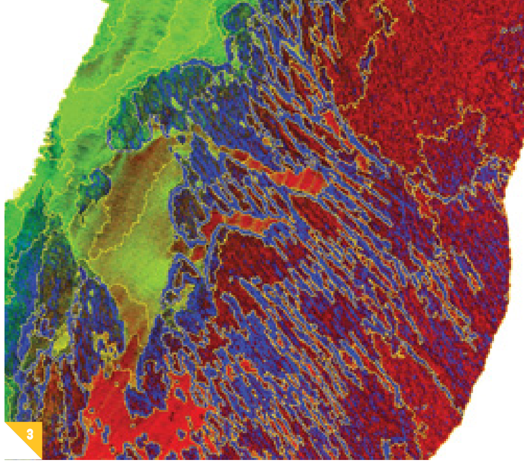

◀ **FIGURE 2.** *NOAA used the feature extraction tool in ENVI to "pull out" unique habitats from the sea floor around Buck Island (above) and assign attributes to the features (below). Image courtesy of NOAA.*

▲ **FIGURE 3.** *The feature extraction process identifies unique objects and habitat types on the ocean floor from a depth-derived PCA surface. Image courtesy of NOAA.*

Using an automated workflow, NOAA staff performed segmentation in ENVI using the software's extraction tool. Following image segmentation, the workflow in ENVI provides users with several options for classifying or assigning attributes to the features in their imagery. NOAA classified features by selecting locations with unique acoustic or optical signatures, and performed ground validation using still and video cameras operated by divers and Remotely Operated Vehicles (ROVs). NOAA's classification scheme used to describe these sites takes into consideration what the sea floor is made of, what is growing on top of it and the quantity of cover.

NOAA then took the segments and classified ground validation points and applied a free ENVI add-on called RuleGen developed by an ENVI user. RuleGen includes a classification and regression tree which was well-suited for NOAA's acoustic datasets. Then, NOAA staff returned to the field and verified the accuracy of the output – a draft classified habitat map.

"Acoustic data is often very noisy and heterogeneous, which makes classification difficult using traditional pixel-based approaches," said Sam Tormey, Marine Spatial Analyst contracted with NOAA through C S S-Dynamac. "ENVI has allowed us to overcome these challenges, so we are no longer classifying a pixel, but rather, an object. We are now able to more objectively and efficiently deal with heterogeneity and make products that meet our partners' needs."

Integrating GIS and Imagery

Finally, NOAA took the habitat maps and other information derived from imagery and moved them into ArcGIS for additional analysis and the creation of applications. This information includes the structure, biological cover and percent cover – key pieces of information that resource managers need to make effective ecosystem management decisions. Information extracted from imagery and added to a GIS provides a complete picture of a geographic area of interest that includes pertinent, current information. ENVI makes it seamless to update ArcGIS with information from geospatial imagery by delivering image analysis tools directly from the ArcGIS desktop and server environments.

One application that NOAA develops for some partners is a Web-based mapping portal so that partners have the option of displaying each habitat class separately, overlaying ground-truth points, viewing the videos and images that were captured and creating custom maps. These portals are especially useful for partners who may not be familiar with traditional GIS software. "The seamless integration of ENVI and ArcGIS allows us to leverage the image analysis capabilities of ENVI with the geospatial tools and statistics in ArcGIS, which gives us tremendous analytical power," said Costa. "It also allows us to put our habitat maps on the Web for anyone to see and use."

NOAA will be delivering the final habitat maps, information derived from imagery, still images and videos and related applications that are developed to monument managers in July 2012. Previously, NOAA staff could only monitor limited areas because the process was very time-intensive and depended on the experiences and interpretation skills of the analyst, which isn't highly replicable.

"Our past mapping efforts were conducted by manually digitizing and interpreting optical imagery," said Tormey. "The new methods that were developed coupled with the power of ENVI allow us to integrate the strengths of multiple acoustic sensors, multispectral and lidar imagery and produce a seamless product across the entire extent of our study areas." NOAA is now able to also produce products at a much finer spatial scale, so maps are more reflective of the true features on the ground. «

From Maps to Healthy Eco

THE GREEN BELT MOVEMENT

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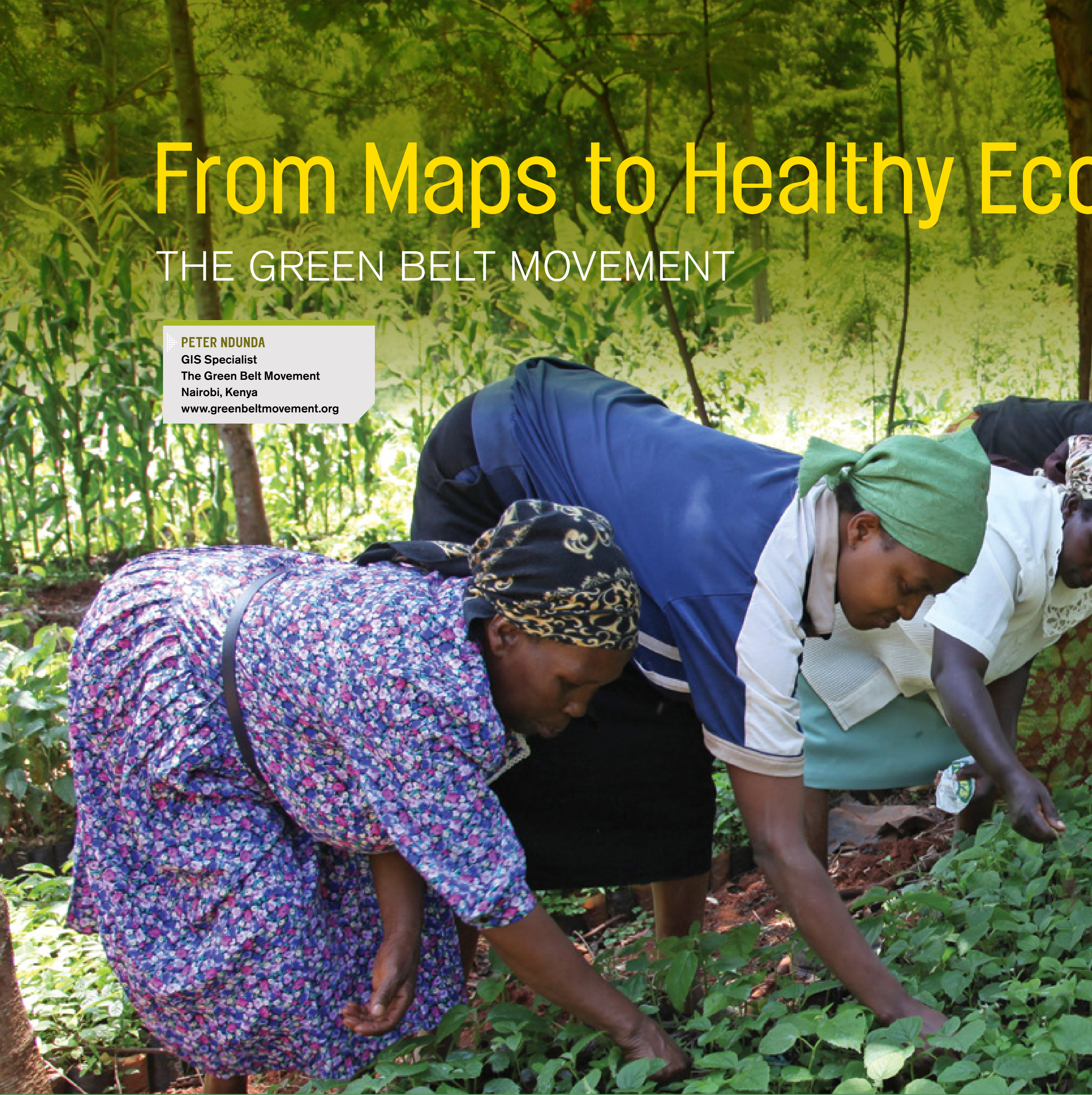


In Memory of Wangari Maathai

This article is in memory of Professor Wangari Muta Maathai (1940–2011): Nobel Peace Laureate, environmentalist, scientist, parliamentarian, founder of the Green Belt Movement, and advocate for social justice, human rights and democracy.

Professor Wangari Maathai was born in the village of Ihithe, near Nyeri, in the Central Highlands of Kenya on April 1, 1940. In 1971, she became the first woman to receive a PhD in East and Central Africa, thereafter the first woman to chair a department at the University of Nairobi, and the first to be appointed an associate Professor.

In 1977, she founded the Green Belt Movement to address the needs of the grassroots communities and for environmental conservation. Today, the Green Belt Movement has supported grassroots communities in planting more than 50 million trees, restoring thousands of hectares of degraded land and improving the livelihoods of hundreds of thousands of local communities.

She was a globally recognized champion for democracy, human rights and

osystems and Livelihoods

FIGURE 1. *Community members working on their tree nurseries. GBM supports more than 4000 community tree nurseries across Kenya that raise and care for more than 8 million seedlings annually. Image courtesy of ManoocherUSAID.*

environmental conservation. In 2004, Professor Maathai was awarded the Nobel Peace Prize in recognition for her work in sustainable development, democracy, and peace – the first African woman and the first environmentalist to receive this prestigious honor. In 2009, the United Nations Secretary General, in recognition of her deep commitment to the environment, named Professor Maathai a UN Messenger of Peace, with a special focus on the environment and climate change. She was also the Goodwill Ambassador to the Congo Forest Basin and a founding member of the Nobel Women's Initiative.

Prof. Maathai died on Sept. 25, 2011, at the age of 71. As she used to remind the world, "we must not tire, we must not give up, we must persist," her legacy will continue to stand as an example to all of us to persist in our pursuit of progress. The Green Belt Movement is determined to build upon Professor Maathai's desire to create a values-driven society of people who consciously work for continued improvement of their livelihoods and a greener, cleaner world.

> *When we plant trees, we plant the seeds of peace and hope.*
>
> – Wangari Maathai, Nobel Peace Prize Laureate, 2004 and Founder, The Green Belt Movement

Founded by the 2004 Nobel Peace Laureate Prof. Wangari Maathai in 1977, the Green Belt Movement (GBM) works at the grassroots to promote environmental conservation, empower communities, and foster sustainable livelihoods. Over the decades, the organization that was founded to respond to the needs of rural Kenyan women – who reported that their streams were drying up, their food supply was threatened and fire wood resources were quickly diminishing – has mobilized communities to plant over 50 million trees across Kenya. By so doing, thousands of hectares of degraded forest land and water catchments have been restored, soil erosion controlled on the community farms and the livelihoods of thousands of local women have been improved.

In spite of 35 years of achievement, environmental conservation and socio-economic development are still enormous challenges in Kenya and throughout Africa. For Kenya to achieve sustainable development, the country needs to have at least 10% forest cover so as to provide all vital services – water resources for the population, electrical power generation, agriculture, wildlife and tourism – that are supplied by this important and yet fragile ecosystem. Today the figure is about 2% closed canopy forest cover.

To increase the forest cover and scale up the impact of the community work on the ground required GBM to develop a landscape scale approach to planning, monitoring and analysis. GBM's experience shows that GIS and remote sensing provide useful tools to develop this capacity and satellite imagery is a critical component for our work.

Introduction of GIS and Remote Sensing at GBM

In 2007, GBM set up a state-of-the-art GIS lab facility that enables the organization to cope with increasing demand for reliable data from the field for decision making in support of the organization's watershed-based approach to tree planting, conservation and community development across Kenya. The development of this capacity marked an important milestone for GBM towards scaling up the impact of community work on the ground.

GBM learned that when local communities are empowered and educated to understand their environment, their natural resources, and the linkage between forests and their own livelihoods, they are more likely to take care of and protect these resources. To realize this, GBM deployed more than 70 field extension staff across the country. Through this network of field staff, GBM has been mobilizing and training the communities on environmental conservation, climate change, governance, empowerment and mapping their natural resources through the GBM's Community Empowerment and Education (CEE) program. The CEE is the community engagement platform upon which all other GBM programs are built. The CEE engages the communities to examine their needs, rights and responsibilities, the links between the environment and poverty, and the challenges that affect them. It also empowers them to develop their own solutions to these problems.

GIS and remote sensing capacity within GBM has provided absolutely critical tools and skills required to carry out analysis on the status of our forests so as to:

- **create awareness across communities in Kenya through the CEEs,**
- **identify areas of forest loss that need immediate intervention in the critical watersheds of Kenya, and,**

↘ **explore solutions for restoration and protection of these watersheds.**

With the use of high resolution imagery, field-based data and local knowledge, forest maps were developed to assist in the assessment and analysis of forest status in Mt. Kenya, Aberdares and Mau forests in Kenya. The end product of this analysis was a priority list of critical watersheds in Kenya that are highly threatened and need immediate intervention. The maps identified and delineated the extent of these degraded watersheds, creating a portfolio of community tree planting sites for rehabilitation.

As a result, GBM is currently working with the grassroots communities in Kenya to restore these critical watersheds (including Gura, Chania, Turasha, Malewa, among others). They produce most of the water for Nairobi, the capital city of Kenya, for Lake Naivasha, and form the catchment of the river Athi and river Tana, Kenya's largest river that supplies water to hydropower plants, which generate over 50% of Kenya's total electricity. In addition to the hydrological, economic and biodiversity benefits of these forest restoration efforts, the restoration and protection of these watersheds will go a long way in helping to solve the growing problems of climate change.

For Kenya to positively contribute to global climate change efforts, it is important to adequately address the drivers of deforestation and forest degradation without jeopardizing the livelihoods of the local communities. This can only be achieved if the local communities are well informed to fully and effectively participate in the various Climate Change program processes (including CDM/Clean Development Mechanism and REDD/Reduced Emissions from Deforestation and Forest Degradation) so as to ensure that the proposed interventions will continue to improve their livelihoods while also protecting the forests. The maps produced in close collaboration with the communities provide powerful communication tools for stakeholders to facilitate discussions, and build consensus on the communities' priorities.

◀ **FIGURE 2.** *A woman putting soil in a potting bag in preparation for growing a seedling. Image courtesy of ManoocherUSAID.*

▲ **FIGURE 3.** *GBM community tree nursery in Nyeri constituency, Kenya.*

At a spatial resolution of 2.5m and .5m, Spot imagery and GeoEye imagery were used by GBM to develop maps that provided the communities with a faithful representation of the reality on the ground. GBM's experience has been that when integrated with the communities' knowledge of their local landscape and values, these maps become incredible tools for helping the communities to easily understand the linkage between the state of the environment, their behavior and actions and their livelihoods. It is when the communities fully appreciate this linkage that they stand up and take action to sustainably manage their natural resources. With the aid of such maps, many GBM communities have been able to define their conservation goals, agree on their forest management plans and design their future.

The outcomes of these GBM's community participatory processes have been remarkable: three community-based Afforestation and Reforestation Clean Development Mechanism (CDM AR) projects in Aberdares and Mt. Kenya have been registered by the United Nations Framework Convention on Climate Change (UNFCCC), two community-based reforestation and

4,034 *Number of community tree nurseries across Kenya that are raising trees to be planted elsewhere*

8,000,000 *Number of indigenous seedlings raised by the community nurseries annually*

50 million *Total number of trees planted from 1978 to date*

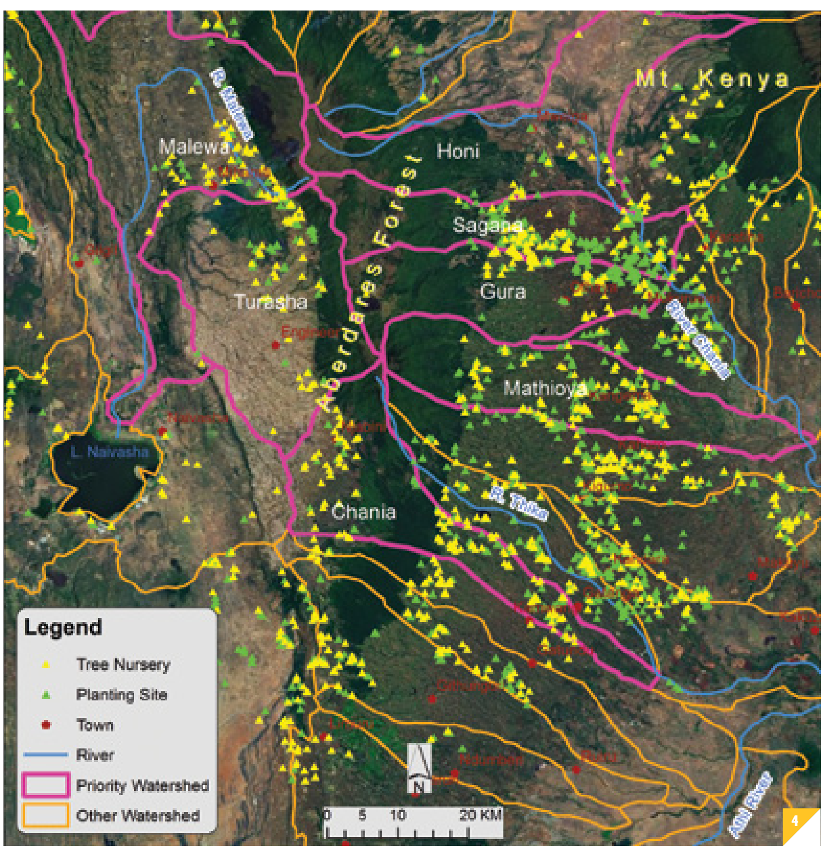
climate change mitigation projects have been initiated in the Maasai Mau forest, among other community development projects across the country.

As GBM rolls out forest restoration work in the identified priority watersheds in Mt. Kenya, Aberdares and Mau forests, we support the communities to carry out an extensive assessment of the numbers of trees required to rehabilitate those areas, the number of seedlings available in the community tree nurseries and the capacity to scale up seedlings' production to meet the restoration targets.

To achieve this, GBM trained its network of field staff on GPS data collection skills, interpretation of satellite imagery maps, and other field-based data collection techniques, and then mobilized them to train and support the communities to map their tree nurseries. So far, a total of 4,034 community tree nurseries have been mapped across Kenya. These tree nurseries raise and take care of more than 8 million indigenous seedlings annually for planting in these important yet highly threatened watersheds - as well as on their farms, public lands, sites of cultural significance and protected reserves.

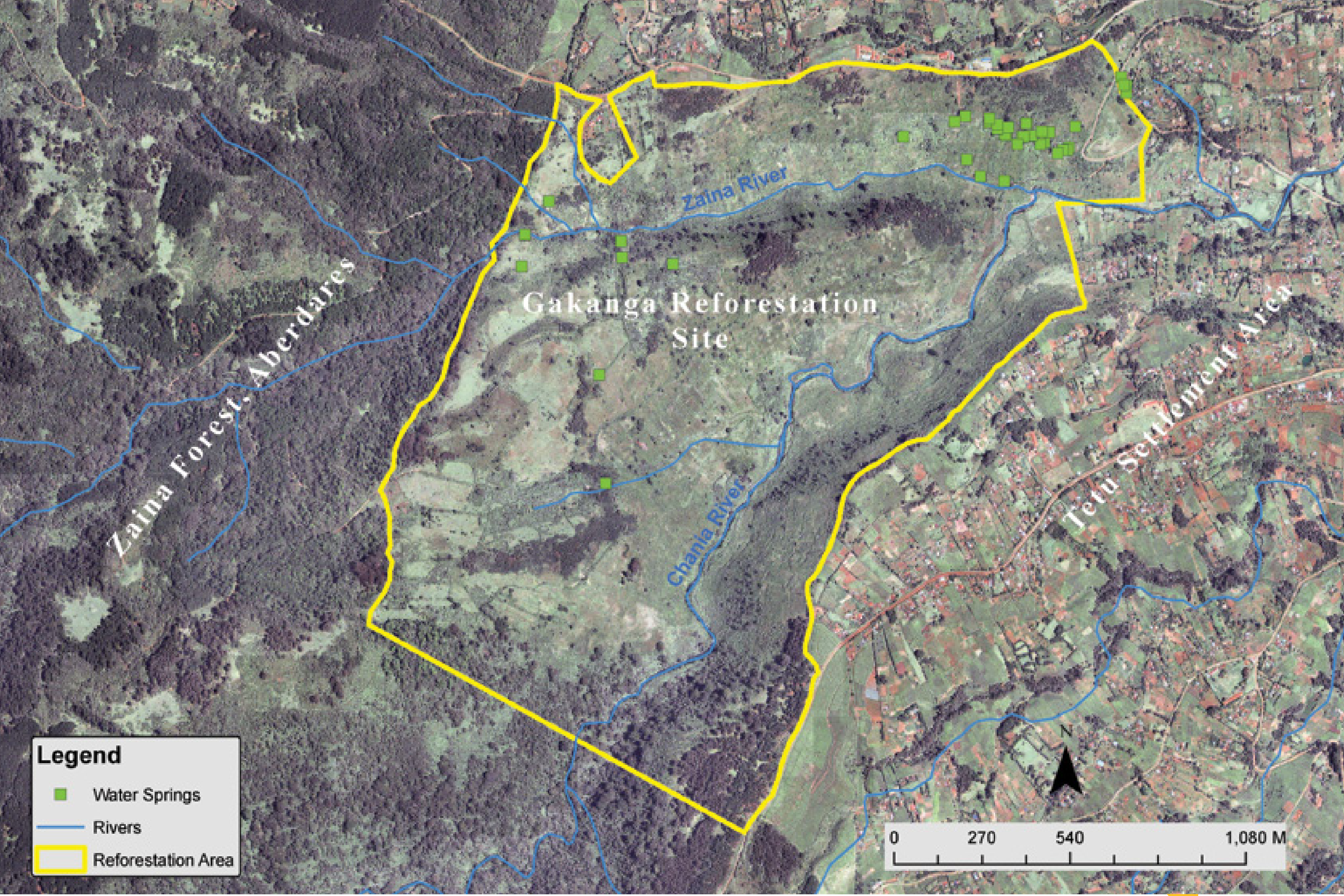
As a result of the data collection, an interactive Web map was developed using Esri's ArcGIS Server so as to share this information with the communities and other project stakeholders. The maps show the location of these community tree nurseries, the name of the community group that takes care of the tree nursery, their seedlings' production capacity and the number of participating households in the nursery group.

This location-specific information on tree nurseries has been invaluable in the process of scaling up GBM's work at the grassroots level. It provides GBM with the ability to assess the availability and distribution of indigenous seedlings required to meet the re-afforestation needs in the critical watersheds in the country. With the help of this information, GBM is able to direct investments



◀ **FIGURE 4.** *Using GBM's watershed-based approach to conservation, GBM works with grassroots communities to identify and prioritize critical watersheds that require immediate restoration. In the Aberdares alone, GBM is working with the local communities to restore 7 priority watersheds that produce most of the water for Nairobi, the capital city of Kenya and form the catchment of the river Athi and river Tana - Kenya's largest river that plays an integral role in the economy of the country.*

▶ **FIGURE 5.** *GeoEye imagery for 2011 showing the Gakanga planting site, and the status of a community reforestation area in Zaina forest in the Aberdares ecosystem. With financial support from USAID, The Green Belt Movement has been working since 2009 with the grassroots communities to plant trees that will restore this critical water catchment area. GBM uses satellite imagery to monitor the growth of these young trees and the progress of the restoration work on the ground. So far, more than 60 springs of water have been revived and protected in this area that forms the water catchment for Zaina and Chania rivers, which are part of the headwaters of the Tana river – the largest river and the most important river for economic growth of Kenya.*



towards scaling up seedlings production in areas with identified gaps.

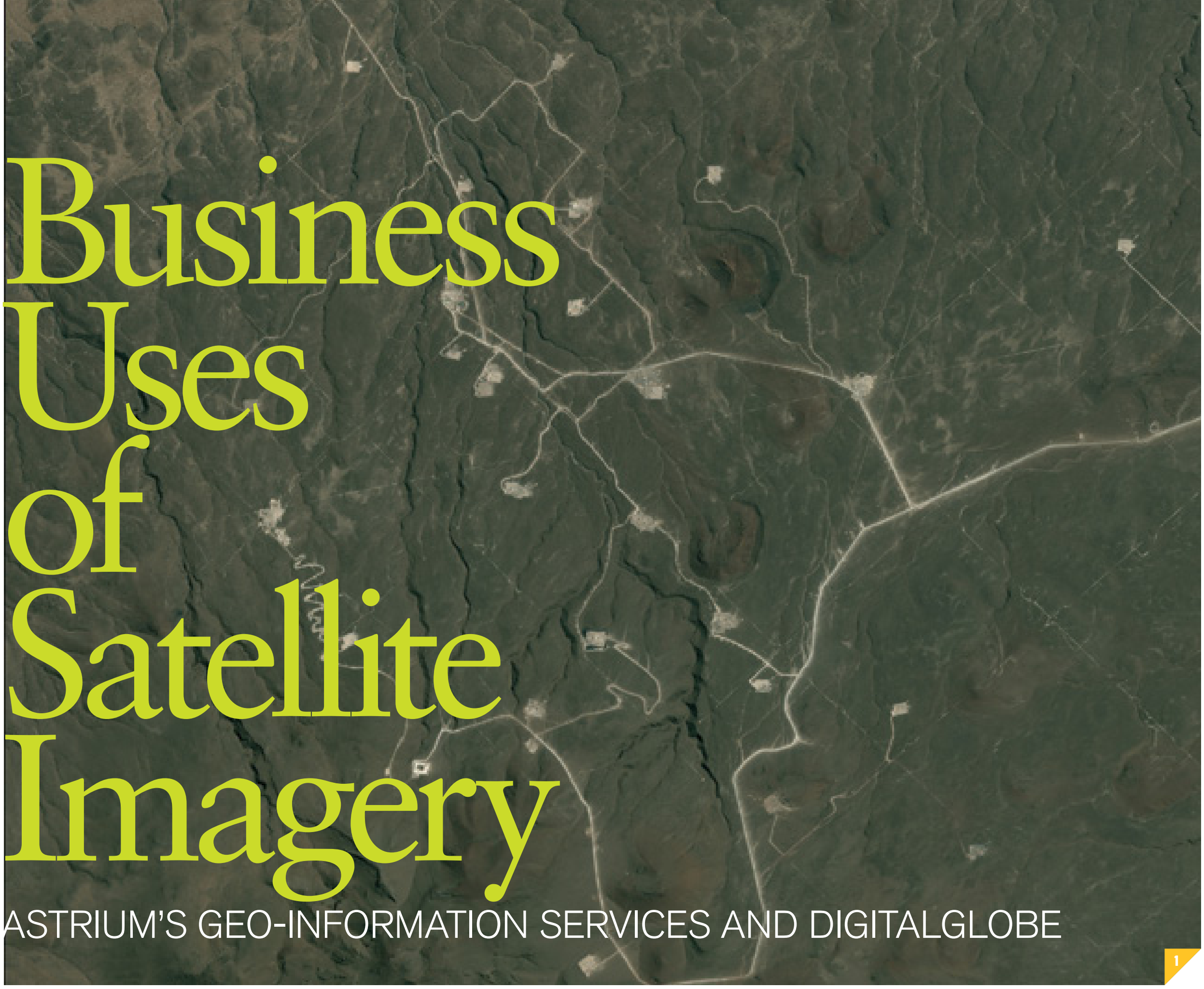
As we continue to work with the communities to plant trees in these critical watersheds, it is important for GBM to be able to monitor the growth of the trees, the change in forest cover and the impact of the restoration work over time.

A values-driven society of people who consciously work for continued improvement of their livelihoods and a greener, cleaner world.

– Vision of The Green Belt Movement

To ensure a high survival rate of the planted trees, we closely monitor the progress and growth of the young seedlings on the ground for a minimum period of three years. GBM field staff support the communities to map their tree planting sites using GPS. They delineate the areal extent for each of their tree planting seasons on the landscape, the species and the number of trees planted on the site for periodic monitoring. To enhance integrity of the data submitted from the field, the Monitoring and Evaluation team periodically visits the sites to validate the trees that have been reported being planted. This team uses Trimble data collection devices running Esri's ArcPad application, which allows them to view satellite imagery and maps of the area, and to access the project's data while in the field. After the 3rd year, satellite imagery was used to periodically monitor the progress of the trees as they grow to full maturity and become a forest.

Geospatial technology has tremendously increased efficiency and effectiveness in planning, implementation, monitoring and reporting of these GBM-supported community-based projects in Kenya. GBM is deeply grateful to Esri, Astrium's Planet Action, Trimble, Blue Raster and Exelis (formerly ITT) for their enormous support in the development of this incredible capacity to plan, monitor and measure the impact of conservation efforts in Kenya.



Business Uses of Satellite Imagery

ASTRIUM'S GEO-INFORMATION SERVICES AND DIGITALGLOBE

1

The public is familiar with satellite imagery through consumer applications — most notably, Google Earth. GeoEye (Herndon, Va.) and DigitalGlobe (Longmont, Colo.) sell their imagery mostly to government agencies. However, there is also a market for business applications of satellite imagery — such as monitoring agricultural production over large areas, counting cars in the parking lots of department stores, or identifying suitable locations for installing solar panels. They constitute a substantial portion of the sales of satellite imagery by DigitalGlobe, GeoEye and Astrium (based in Toulouse, France, with Astrium GEO-Information Services North America based in Chantilly, Va.).

Astrium GEO-Information Services (a subsidiary of EADS with offices worldwide) specializes in Earth observation and navigation services. About half of the sales by its GEO-Information division are to governments, including defense, intelligence, and federal, state and local governments, according to Nicolas Stussi, the company's director of business development in North America. The other half, he says, are to businesses — mainly oil and gas and agriculture, but also Web mapping, location-based services (LBS), and other emerging technologies. However, in the United States and Canada, the government share of the company's sales is closer to 70 percent. Astrium does not currently have a major focus on sales to consumers, but it is pursuing opportunities on a case by case basis, through partners.

DigitalGlobe gets roughly 60 percent of revenue from its work with the U.S. government and the balance from a combination of international civil government, LBS, and other verticals, according to Aaron Crane, the company's vice president of product management.

From Delivering Pixels to Delivering Services

Large, global enterprises, such as mining and oil and gas companies, rely increasingly on satellite imagery — for example, to perform environmental impact analyses for particular operations or to monitor their assets, such as equipment and buildings, especially in remote locations. "We're seeing mining pick up globally," says Crane. "Satellites are global. Therefore, global businesses, which need to have knowledge somewhat centrally about global events, lend themselves to us."

Oil and gas has always been a key market for Astrium, Stussi says — especially projects such as monitoring pipelines and offshore platforms, using medium-resolution imagery. The new trend in this market is the use of data as part of services. "We are all moving away from, essentially, delivering pixels because there are so much data out there that I think the differentiator now is on the service-level agreement you can offer to your customer using your contents. We have full control of the contents and now we can develop dissemination systems around our content to deliver these services. So that's really where we make the difference."

◀ **FIGURE 1.** *Image from Astrium's Plêiades satellite of an oil field in South Argentina, taken Mar. 2, 2012. Image courtesy of CNES and Astrium Services.*

▶ **FIGURE 2.** *WorldView-2 image of El Chino mine in New Mexico, taken Dec. 9, 2010. Image courtesy of DigitalGlobe.*

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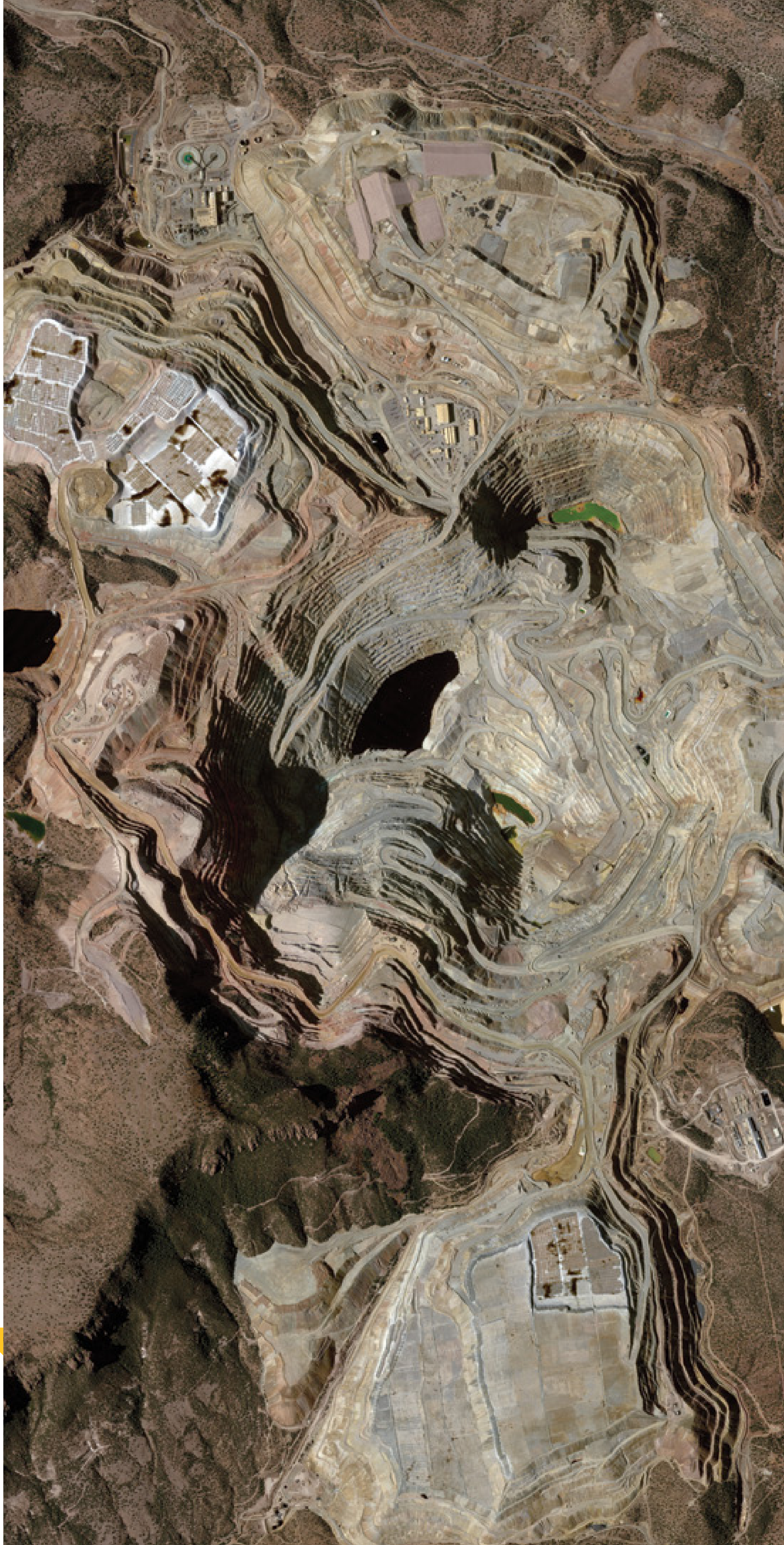
EDITOR'S NOTE: This article is based on interviews that the author conducted with Nicolas Stussi, Director of Business Development, Astrium GEO-Information Services North America, and Aaron Crane, Vice President of Product Management, DigitalGlobe. For similar information about GeoEye's business uses of imagery and services, see article on page 30.



For example, an oil and gas company might ask Astrium to monitor an oil platform in a very remote area that would be very expensive to monitor by sending people on the ground. It would want to know whether satellite imagery could provide the information it required and would need Astrium to guarantee that it could provide that information reliably. "We deliver change detection maps or reports at the end of the day over given areas and it's almost irrelevant, from their perspective, what type of imagery we are using to deliver that information," Stussi said. See ***Figure 1***.

Astrium has been expanding this type of service with its Pléiades satellite, which has a 50-centimeter resolution and a footprint of 20 x 20 kilometers, with its constellation of SPOT satellites and with its synthetic aperture radar (SAR) TerraSAR-X and TanDEM-X satellites. It launched Pléiades 1A in December 2011 and is scheduled to launch Pléiades 1B later this year.

Other satellite imagery companies' images are used for energy as well, from oil and gas to mining, solar and wind. See ***Figures 2 and 3***.

Agriculture has long been Astrium's largest market segment, because it has had enough assets to provide the large, repetitive coverage required. The key element to be successful on the agriculture market, Stussi explains, is not the resolution, the number of spectral bands, the revisit time, or even the number of satellites, but the ability to deliver data reliably, within 24 hours of collection, and in a form that is usable by the end customer. See ***Figure 4***.

Business Intelligence

The use of satellite imagery for business intelligence is growing. For example, shopping malls and big box stores want to know how much traffic they get, day in and day out, over a period of months, so that they can correlate these data with their advertising campaigns and other promotional activities. They also want to monitor their competition's traffic. To do this, they can count the cars in their own parking lots and in their competitors' much more quickly and cheaply by using satellite imagery than by deploying people on the ground, provided that the revisit rate is sufficiently high. Pléiades allows Astrium to address this need, says Stussi.

Location-Based Services

An emerging market for satellite imagery is LBS, which is constantly hungry for content. "We include in the LBS sector the map makers, the companies that are actually building maps using our information," says Crane. For example, he points out, Nokia's Location and Commerce business unit creates its maps by overlaying vector data on top of DigitalGlobe's imagery.

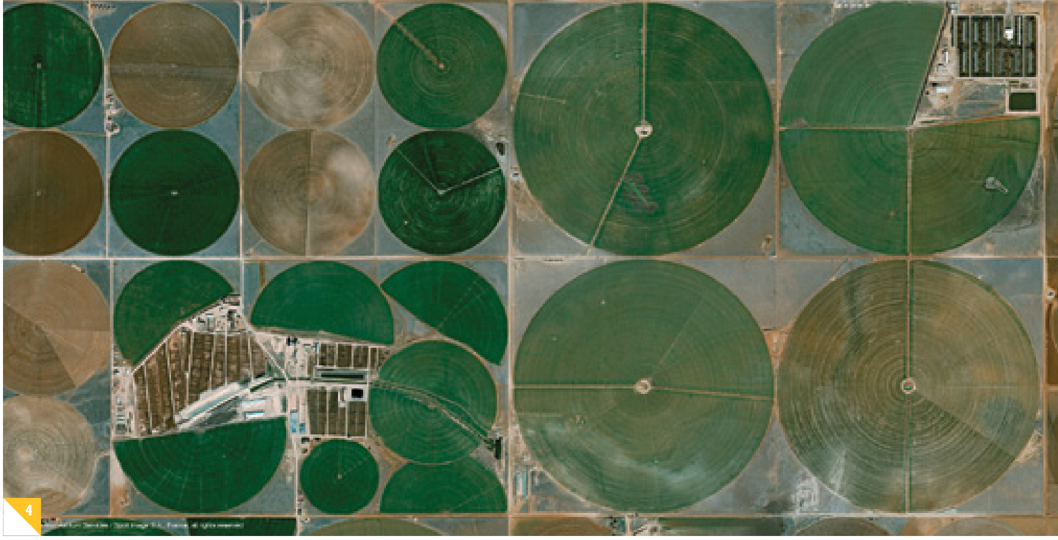
Pléiades will also address the LBS market very well, Stussi says, because, typically, it requires very high resolution imagery. However, SPOT imagery at 2.5-meter and 5-meter resolution is sometimes also very useful for LBS applications, he points out, because it allows much greater coverage to fit in the memory of mobile devices for use in disconnected environments (i.e., where they do not have network access).

Planning Cellular Towers

Another vertical segment with significant growth potential is planning the locations of cellular towers. For the development of next generation LTE or 4G networks, the exact location of towers in urban areas is even more critical than it was for 3G networks, Crane explains. This requires very good data on land use and topography, as well as high-resolution imagery that network designers can use to make location decisions without having to visit each possible site.

◀ **FIGURE 3.** *Solucar Towers in Seville, Spain image taken Mar. 1, 2011 by WorldView-2. Image courtesy of DigitalGlobe.*

▶ **FIGURE 4.** *Pléaides satellite image of crop circles from circular sprinkler systems in Texas, taken Jan. 27, 2012. Image courtesy of CNES and Astrium Services.*



Aerial Imagery

In addition to its satellite imagery, DigitalGlobe also has aerial imagery that it has worked with Microsoft to collect. In July, it will complete its coverage of the continental United States, wall-to-wall, at 30-centimeter coverage, RGB and near-infrared, says Crane. "We have this unique dataset that is really quite powerful. As part of that collection, we also collected, at a slightly lower resolution, stereo panchromatic data, with which we can also create surface models of the United States. We are doing the exact same wall-to-wall collection for Western Europe and it will complete a little bit later this year, probably in October."

This aerial imagery, Crane explains, will enable the creation of 3D terrain models as well as inspect what is on the ground and measure the sizes and angles of roofs. This, for example, will allow companies that sell or install solar panels to identify suitable houses without having to visit them individually.

Insurance Companies

Insurance companies are also interested in gathering such information as the square footage of rooftops and typically engage outside contractors to provide it, says Crane. "We can provide the latest imagery of a particular event — like an unfortunate tornado, hurricane, landslide, or earthquake. Often, we can get our first images of some kind of crisis within 24 hours. That's faster than you can scramble planes." This imagery helps insurance companies to quickly determine which properties were hit by the disaster, and therefore clearly qualify for coverage, and which were outside of the disaster area, and therefore where to require an inspection to verify a claim. Additionally, the imagery helps insurance companies with the logistics of emergency response, when they have to deploy staff to disaster sites, Crane explains. For example, it can help them decide where to park their vehicles and where to deliver supplies.

3D

Last year, DigitalGlobe began to deliver its data in elevation format. "Our satellites are capable of capturing different viewpoints of the same location," Crane explains. "We can use them with fairly standard photogrammetric techniques to create digital surface models and from that, to create a digital terrain model." By repeating this type of modeling on more than one frequency, it is possible to measure changes in volume. Therefore, users of this service include mining companies that want to monitor the size of their open pit mines.

The launch of DigitalGlobe's WorldView satellites greatly increased the amount of high-resolution multispectral coverage. "All our satellites — WorldView-1, WorldView-2, and QuickBird — can do the stereo collection, but it's very easy to purpose WorldView-1 for large amounts of stereo collection and then build 3-dimensional models from those collects," says Crane. "We are starting to see more growth in this sector."

Competitive Advantage

"Astrium is and will remain the only data provider today that has a full spectrum of assets, from mid-res view to high-res view and SAR, and I think that is really unique in the marketplace," says Stussi. "If we want to be successful in services, the best way is to be able to control the content." Astrium will soon have seven satellites it can use to provide these services. "It is going to be the first time that so many resources will be available and accessible for commercial companies to tap into."

DigitalGlobe's set of sensors differs from those of other satellite companies, Crane points out. Its 8-band sensor is particularly useful for environmental monitoring and land classification. "The WorldView-3 satellite will have an additional eight bands in the shortwave infrared range. We have panchromatic, eight multispectral and eight shortwave infrared bands, which provide the first super-spectral satellite — it is both hyper-spectral and it is high resolution. With those bands, there are a bunch of applications in mining and in oil and gas exploration that we expect to support in the coming years, once WorldView-3 is launched."

Astrium, DigitalGlobe and GeoEye all are gaining strongholds with enterprise customers, mostly in ag, insurance, energy and LBS. These industries are very important to their growth and long-term sustainability. While we did not cover GeoEye in this article (see page 30 for an article about the solar power industry), all three offer unique solutions for their enterprise clients.

INNOVATION IN THE ENE

EARTH IMAGERY FOR SOLAR AND OIL & GAS

Due to unprecedented energy needs around the world, governments, corporations, NGOs and consumers are grappling with a number of difficult issues as they seek affordable and efficient energy solutions. In order to address these issues effectively, the energy industry is increasingly looking to companies that can supply Earth imagery, geospatial expertise and enabling technologies in order to deliver clear, deep and timely intelligence.

Companies using geospatial technology are playing an increasingly important role in providing insight that enables better decision making in three major areas: growing the renewable energy market, supporting oil and gas exploration, and planning out new energy infrastructures. Innovations like these help make renewable energy sources accessible; they also address the global desire to maximize the impact of finite energy supplies.

Renewable energy sources have become increasingly important to creating sustainable energy supplies, providing cleaner energy and saving money. In particular, solar power has become one of the leading sectors in the energy industry. Worldwide, the solar industry has been growing by 50 percent annually. In the United States, renewable solar power is quickly becoming a mainstream, affordable energy option – when taking into account current tax incentives, solar energy now costs less than many Americans pay for electricity. Solar energy is also a boon to the United States' overall economy. Per dollar invested, solar is the highest job-producing energy industry in the country. According to National Solar Jobs Census, the solar industry had created more than 100,000 jobs by 2011, with another 25,000 anticipated in 2012.

But despite improvements in photovoltaic panel technology, which has decreased the cost of solar panels systems, identifying productive locations to install solar panels has remained a costly process due to the intensive manual labor required to determine the value of a roof, including manual surveying and hand measurement. And this is precisely why some are slow to embrace solar energy: it can be prohibitively expensive to discover whether or not it will ever be worth the investment of time and money.

Solar Power Predictive Analytics

One promising venture to help make renewable energy cost-effective for both businesses and consumers is being led by Geostellar and supported by Earth imagery provider GeoEye.

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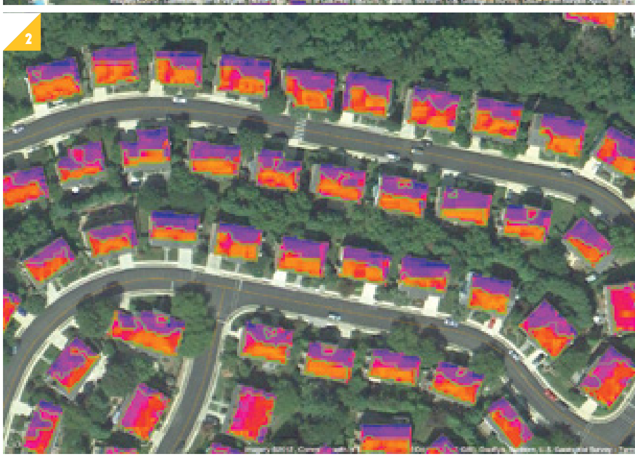
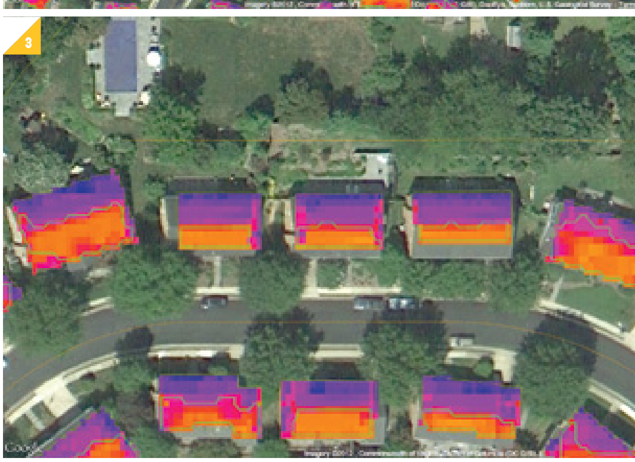
RGY INDUSTRY





Geostellar created a breakthrough analytics platform that automatically determines how quickly a given property owner can recoup an investment in solar energy. Its predictive algorithms allow site owners in target solar markets to easily determine key factors including rate of return, potential electricity savings and environmental benefits.

Using 3D simulation, Geostellar models solar production and financial performance for the potential project site. The result is an accurate assessment of "solar score" for each property, including unbiased recommendations on equipment, financing and installation options. This solar value is analogous to the FICO scores used by the financial services industry.

Geostellar's web-based software uses data streams from sources such as roof slope, shadows, weather patterns, local utility rates and solar energy subsidies to automate the assessment process. In the past, this was done piecemeal, using LiDAR data collected by airplanes, which was an expensive and time-consuming collection process with disparate municipalities.

This is where GeoEye helps take the process to a much higher level. Digital surface models (DSMs) derived from Earth imagery enable Geostellar's model to work on a national scale. To extend coverage nationally, Geostellar will now source remote sensing data from GeoEye and apply image processing capabilities developed by GeoEye Analytics to provide the data required to develop solar maps for every key metropolitan market in the United States.

With the combination of Geostellar's analytics platform and both data and analytics provided by GeoEye, the potential exists to inform the domestic market for solar power, to decrease the cost and to increase the speed with which a consumer or business can assess the value of switching to solar power on their buildings. There is clearly a great deal of excitement in this work, as Geostellar closed a large Series B round of funding in May to support a national rollout in 2013 and launch a true solar marketplace.

▶ **FIGURE 1.** *Aerial imagery shows a neighborhood in northwest Washington D.C. that demonstrates the high variability of solar potential for different houses in the same neighborhood. The houses that are oriented east to west are showing mostly red and purple solar values, indicating less sunlight. The houses that are oriented from north to south have much more yellow and orange on the south-facing roof facet, indicating more direct sunlight. Credit: Geostellar.*

▶ **FIGURES 2-3.** *Aerial imagery shows individual structures up close. The green lines delineate where solar panels could be optimally placed. Credit: Geostellar.*

GEOSTELLAR CREATED A BREAKTHROUGH ANALYTICS PLATFORM THAT AUTOMATICALLY DETERMINES HOW QUICKLY A GIVEN PROPERTY OWNER CAN RECOUP AN INVESTMENT IN SOLAR ENERGY.

Oil and Gas Applications

Beyond renewable energy sources like solar energy, Earth imagery and geographic information systems (GIS) have been applied to improve site selection for productive fields in oil and gas exploration. For one energy client, GeoEye Analytics demonstrated the predictive analysis capabilities of its advanced geospatial application tools to identify deepwater oil and gas fields in the offshore in the Gulf of Mexico in the U.S.

Analysts used their tools and expertise to combine data layers such as geologic strata, temperature, thickness and gravity/magnetic levels with productive wells in the Gulf of Mexico to create a productive well assessment. In addition to site selection, analysts were able to rank exploration efforts in the order of most revenue efficient, providing the client with valuable insight to make difficult business decisions.

Geospatial technology is also used in energy infrastructure planning. One successful example is found in determining where the sea portion of a pipeline should be constructed for one of the most complicated installations of a natural gas pipeline. High resolution imagery taken by GeoEye's IKONOS satellite was used by GeoEye's customer ScanEx to evaluate the 1,830-kilometer Sakhalin-Khabarovsk-Vladivostok gas pipeline built as part of the Eastern Gas Program, coordinated by OAO Gazprom in Russia.

The pipeline was slated for construction through the Nevelsky Strait, the narrowest part of the Strait of Tartary, which separates the Russian island of Sakhalin from the mainland. During the winter, the strait can become hazardous for infrastructure and facilities, because it is covered with ice measuring an average thickness of one meter. To aid in risk assessment of hazardous ice formations for the pipeline, high-resolution IKONOS satellite imagery of the Nevelsky Strait was used to prepare a Digital Elevation Model (DEM) of the shore ice in the strait using advanced software and the highly accurate Earth imagery data as a basemap. Thanks to satellite imagery, specialists were able to assess the features of the shore ice morphology in the Nevelsky Strait and determine the exact locations and sizes of ice formations. This data was incorporated into the survey and planning work for the pipeline to minimize construction in high-risk areas.

These examples clearly demonstrate that there are many valuable uses for solutions that combine Earth imagery, geospatial expertise and enabling technology to deliver clear, deep and timely insight in the energy industry. In fields such as solar power, the impact could be almost transformative, helping create a clear marketplace where, before, labor intensive manual processes reigned. In oil and gas, such solutions will help speed up the process of identifying new sources and reducing risks associated with transportation.

As the energy industry evolves, governments, corporations, NGOs and consumers will all require information to make faster and better decisions to consider potential benefits and risks of any investments. These examples clearly illustrate the benefits geospatial technologies will have in transforming the energy industry.

COIN: The Future of Counterinsurgency

ALTOGETHER QUANTITATIVE, SCARCELY ANALYTICAL...

THE MILITARY SETS CONDITIONS THAT EITHER INSPIRE a native population to embrace the efforts of a counterinsurgency (COIN) in an exhibition of solidarity, and thereby rejecting the legitimacy of an insurgency, or that motivate a population in an entirely different, inauspicious direction. Thus, operationalizing and analyzing key variables of combat effectiveness and, to a greater extent, the human terrain, aid commanders in producing acutely sensitive understanding of the battlespace – one of often complete and otherwise certain ambiguity in irregular warfare.

Successful counterinsurgencies, both tactical and strategic, require certain computational rigor. Without such rigor, decision makers inadvertently support quite incorrect conventions. These incorrect conventions lead to seriously misplaced and spurious conclusions. As a community, data scientists and social scientists alike must develop a framework that uses data to rationally generate, test, discard, and modify operational alternatives, theoretical constructions, and conventions of all types.

The burden of COIN however, is the measurement of largely misunderstood human, social and political factors of attitudes and behaviors over time and space. Any lack of computational rigor is exacerbated by poor measurement, vis-a-vis, one never validating the other. Without good analysis, the value of measurement is never known, while misplaced value on measurement marginalizes analysis. The efforts on behalf of the International Security Assistance Force (ISAF) and ISAF Joint Command (IJC) in measuring, analyzing and ultimately understanding the tepid human terrain (Heimann, 2011) and insurgency landscapes continue to be suspect.

It has been said that those who do not learn from history are ultimately doomed to repeat it. If true, what ought to be learned after ten years and two concurrent wars? Lessons of previous wars, especially shadows cast by the more recent ones, no matter how unsuitable, overwhelm commanders and policymakers alike. Compounding matters is data collection of vast proportion, at varied scale and complexity both within and among campaigns, presenting certain challenges for decision makers.

The unabated blending of these cognitive pitfalls and computational hurdles leads to so-called "big data" problems of consequential significance, the basis of which

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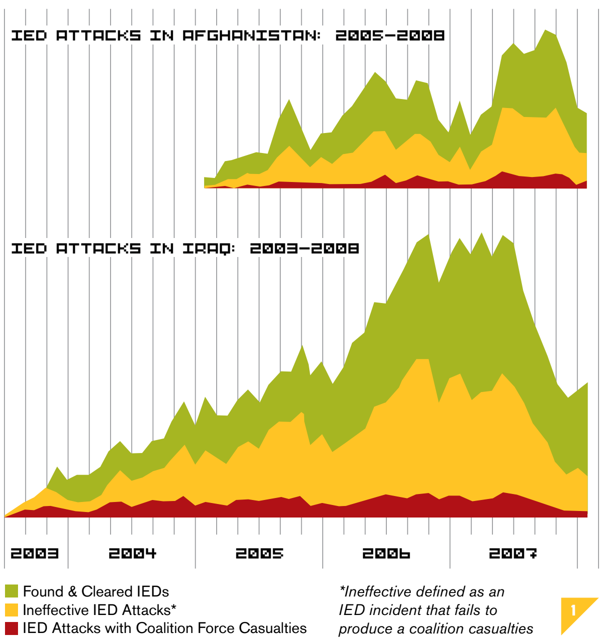
COIN is a data-rich, but theory-poor environment. The lack of a theoretical framework is the paradigm for big data and necessitates exploratory analysis and large-scale pattern discovery and recognition.

is the lack of a sound theoretical COIN framework. A notional problem is that "… we (often) have more data than [we] think, but (often) need less data than [we] have," (Hubbard, 2010). Hubbard is suggesting, quite evidently, that data lacks uniform utility or explanatory power. This fact informs measurement and analysis in ways that have not yet been realized.



▲ **FIGURE 1.** *IED attacks are a rather common tactic of insurgents and represent one kind of SIGACT. Trends are reported to commanders and decision makers in a fashion similar to Figure 1, ignoring spatial patterning and any de-trending of time-series data.*

Theoretical Framework

Henry Kissinger poignantly summarized Vietnam when he said, "We fought a military war; our opponents fought a political one. We sought physical attrition; our opponents aimed for our psychological exhaustion. In the process, we lost sight of one of the cardinal maxims of guerrilla war: the guerrilla wins if he does not lose. The conventional army loses if it does not win."

While many deny the parallels between the wars in Vietnam and Afghanistan, certain parallels do exist. One striking example is the strong desire for measurement and quantitative analysis, underscored by the lack of a theoretical framework. The Military Assistance Command Vietnam and ISAF measured the battlespace of irregular warfare and rightfully so. The number of engagements by third-party counterinsurgencies has been plentiful over the past 100 years, and given the military superiority of the U.S., it seems plausible that the irregular model will be used with feverish frequency.

Historical third-party counterinsurgencies include the French in Algeria, the British in Malaya, and the U.S. in the Philippines, Vietnam, Iraq and Afghanistan. The empirical perspectives are rich and noteworthy, but may also be deterministic. COIN suffers from physics envy; it is a data-rich, but theory-poor environment. The lack of a theoretical framework is the paradigm for big data and necessitates exploratory analysis and large-scale pattern discovery and recognition.

Tommy Franks noted how counting bodies would not be used as a metric for success. Major General Michael Flynn too noted that old-school metrics like body counts were being focused on too much, perhaps remembering the credibility problems of measuring body counts during the Vietnam War or the dubious inference associated with the analysis of body counts and other kinetic events. One certainly has to wonder what is to be measured if body counts are not. It seems that in the absence of body counts, commanders instead rely on Significant Activities (SIGACTS). SIGACTS are the counting of violent attacks by or on coalition forces. The most notable perhaps are Improvised Explosive Devices (IEDs).

Measurement errors do exist with SIGACTS. The system that stores the data, Combined Information Data Network Exchange (CIDNE) is certainly not perfect. However, the source provides an unusually objective and consistent base of information. The error inherent in the data seems rather systematic. Put differently, the errors appear to be irregular, and over and under counts seem to be random and lack any structural regularity.

The most important acknowledgement however, is that measurement occurs only when coalition forces are present to observe the act. This type of observer bias relies on an inductive inferential model built upon uncertain ground. The Joint IED Defeat Organization (JIEDDO) estimates that 50% of IEDs go undetected (Erwin, 2010), adding additional complexity with forms of a selection bias to an already enfeebled approach to measurement.

The real issue with SIGACTS is the weak inferential model. The United States spent $3.63B in 2006 on a largely technical, engineering-based Counter IED effort, most of which went to JIEDDO. JIEDDO has certainly saved lives and this article does not contend with that fact. However, the ability to understand the true nature of violence has been remarkably elusive. JIEDDO relies on rather primitive statistics to justify its claims of success. See ***Figure 1***. These metrics do not effectively capture or accurately reflect performance of COIN. IEDs prevail due to their ease of assembly, small support structures as well as their psychological impact on both friendly and civilian populations. For an organization that originally funded human terrain, little is known about the relationship between SIGACTS and COIN effectiveness. More attention ought to be paid to violence as a process rather than a rather broad and imprecise act. As a process it would be understood in the context of counterinsurgency rather than a result of an insurgency and comparatively to other types of violent acts. Counter-IED research draws too often off of its own dependent variable.

George Box said that all models are wrong, but some are useful. The best models in Afghanistan rely on primitive statistics and ignore any spatial structure. Worse, analysts seem impotent to adapt. Certain isotropic properties are exhibited in all time-series analyses. The isotropic properties of time-series analysis are easy to understand but do not contain the merits of spatial analysis, most notably anisotropy. The unidirectional nature of time-series analysis is a simpler model, but not the most useful, as it fails to account for the true multidirectional nature of COIN. Spatial data, as it turns out, is special.

Stathis Kalyvas wrote in *The Logic of Violence in Civil War* (2006) of the non-monotonic function of violence (i.e. decreases in violence don't always require mission effectiveness). An insurgency is simply more than violence and COIN is more than counting violent acts. The measurement of SIGACTS in COIN has value; these measures are not an elixir, however, and are misused with a frequency close to their rate of exploitation. For example, interdicted weapon caches give a false sense of success; the insurgency can still win the population, as the French learned from their interdiction efforts in Algeria. On the other hand, COIN cannot win the war and lose the country, akin to Vietnam where tactical success did not equate to strategic success. The insurgency wishes to out-administer the counter efforts, not necessarily defeat efforts tactically.

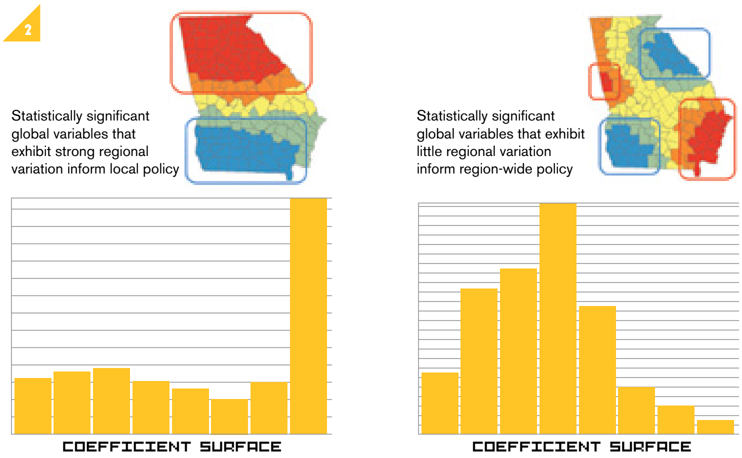
Understanding SIGACTS requires acknowledgement of a bidirectional causal model. In a rather counter-intuitive manner, coalition forces' mere presence accounts for the variability in the data, despite intuition suggesting that increased patrols will have a negative relationship with SIGACTS. An increase in SIGACTS may simply be a reflection of our own increase in activity if only influenced by force strength.

COIN operations, in this case, are not exogenous. This is instinctively known by commanders but misunderstood by data analysts. Sadly, commanders falsely accept this defective model because it is what is reported. Broadly, the loop of causality between the independent and dependent variables of a COIN model leads to endogeneity. The simultaneity between the two factors highlights the weak causal model and may suggest reverse causality. The near complete disregard for endogeneity indicates a fundamental failure in empirical COIN research. The model is measurably complex; useful models, however, should remain the goal, and SIGACTS should be used with caution.

Computational Counterinsurgency - Spatial Pattern Recognition and Spatial Statistics

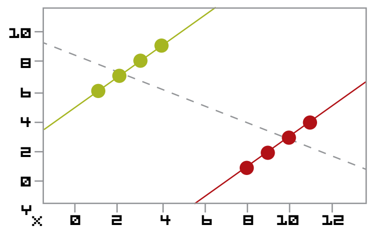
David Kilcullen (2009) explains that today's conflicts are a complex hybrid of contrasting trends that counterinsurgencies continue to conflate, blurring the distinction between local and global struggles, and thereby enormously complicating the challenges faced. Kilcullen steps through local and global struggles and outlines the importance of commensurate policy. This process can be characterized roughly as useful spatial models whose statistically significant global variables exhibit strong regional variation to inform local policy, and as statistically significant global variables that exhibit little regional variation to inform region-wide policy. See ***Figure 2***.

Unfortunately, computational COIN relies on time-series data almost exclusively, thus collating all actors into one fighting force operating on an assumed homogeneous population base. Operational analytical workflow consists of mere plotting of temporal patterns and describing discrete time {Xt-1} over time {Xt} change. The nature of insurgency, like most phenomena, is change over time and space. Kalyvas examines how strategies vary temporally and spatially, focusing on the spatial variation of control



▲ **FIGURE 2.** *This figure reflects the utility of localized statistics. Variables that show little regional change (right) inform global COIN, and variables that show significant regional change (left) inform local COIN.*

on the part of the counterinsurgency and the spatial variation of violence. Kalyvas concludes that violence is nonrandom and nonstationary. Insurgency, he concludes does not resemble a Hobbesian world. In other words, violence does exhibit spatial structure and commensurate spatially explicit theory should follow a blended idiographic and nomothetic methodology.



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▲ **FIGURE 3.** *Global regression models represent an average COIN. One best of fit line must be made whereas local regression fits multiple local averages to better represent the counterinsurgency landscape.*

Time-series analysis shares some similar challenges as spatial analysis. Shared challenges include the modifiable time unit problem, analogous to the well known modifiable areal unit problem, intrinsic heterogeneity, and others. The most interesting perhaps is Simpson's Paradox and the spatial companion, Spatial Simpson's Paradox (SSP). SSP represents the analytical equivalent to Kilcullen's central thesis (see **Figure 3**), where poor COIN operations for one group or location and poor COIN operations for another group or location are good for everyone, if analysts just collapse over the grouping variable or over space. COIN operations that achieve a significant positive effect on average might still be undesirable because they leave a large fraction of the population worse off.

Uprooting insurgency, for example from city centers, has shown to have a negative correlation with civilian casualties as well as an impact on insurgent tactics. Spatially explicit theory, e.g. proximate casualty hypothesis, (Gartner, Segura, and Wilkening 1997) is in greater need for COIN operations and provides theoretical evidence to support certain operations. Temporal patterns just fail to have the same impact on COIN planning and policy as does spatial data, driven by measures of spatial dependence and spatial heterogeneity. Statistically significant local statistics prevent the Lake Wobegon Effect of a uniformly above average battlespace, decomposing patterns and exposing spatial spillovers, spatial externalities, structural instability, spatial drifts and spatial regimes.

Big COIN Data

Certain computational complexities are evident in COIN, whether small data or big data. Due to turnover caused by multiple deployments, one wonders if the same lessons have been learned one year at a time for ten consecutive years versus an enemy with better memory. The reality is that no one knows more on their last day of a deployment and less on their first. Big COIN Data provides an expedited learning curve and fluid understanding of the human terrain from campaign to campaign, deployment to deployment, and region to region.

Direct observation and *blink* (Gladwell 2005) qualitative assessments by battlespace owners will always outpace the timeliness of computational counterinsurgency. These qualitative assessments, however, tend to be empirically deterministic and thus inappropriate for the construction of COIN theory. The transition to computational COIN is not one of mere desire but of absolute necessity.

The journey, however, has not been without missteps. The efficacy of computational COIN has seen only limited success. That limitation is due to a number of factors, but mainly that results often describe known variation, in a choropleth map or time-series, for example, due to known factors. If Big COIN Data is to be successful, then results must relate the unexplained components of variation, particularly spatial variation for analysts and decision makers. Our visual-cognitive system is ill-suited to the task of mentally removing known components of variation, envisioning the patterns in residuals, and relating these patterns to other variables.

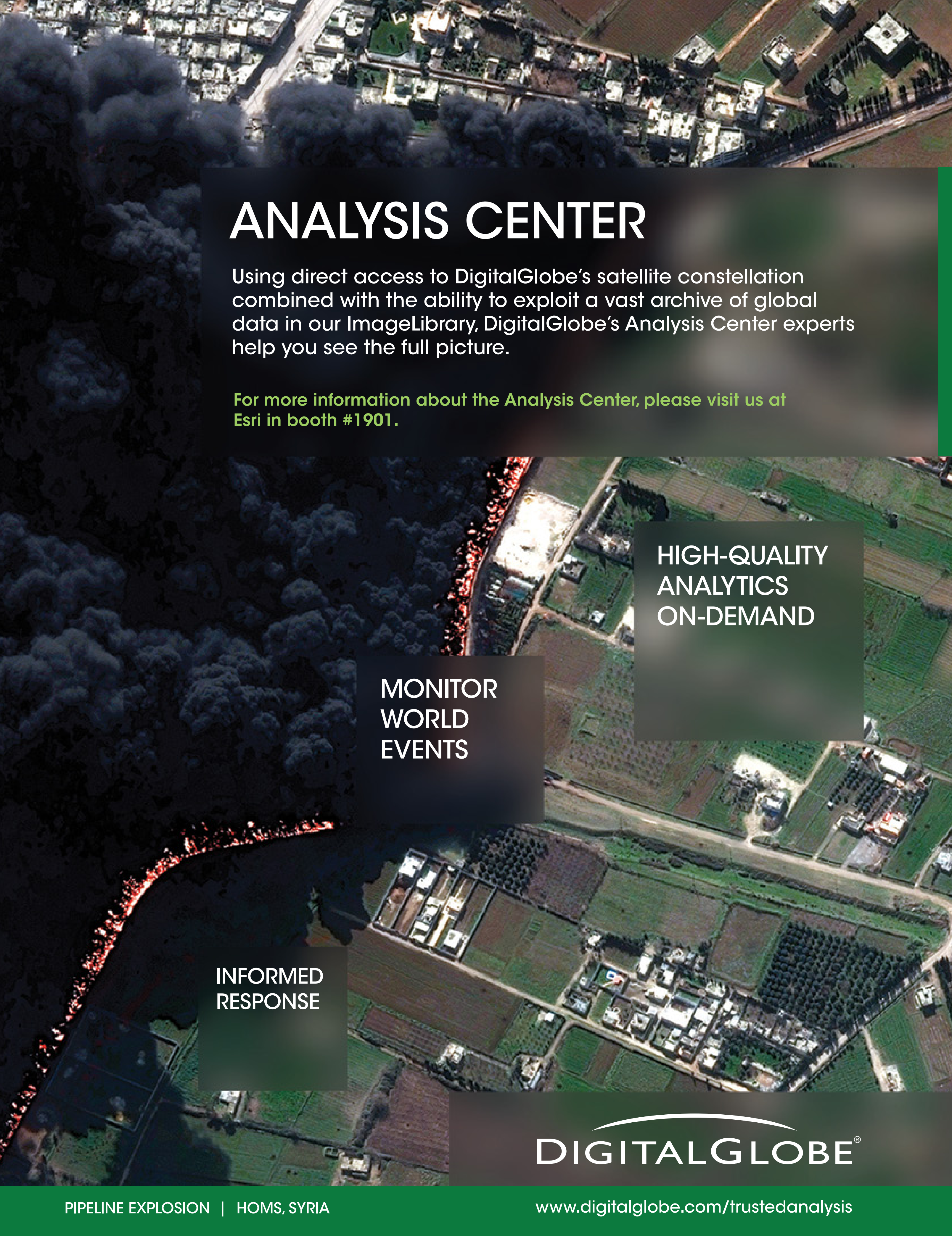
"You have to understand not just what we call the military terrain...the high ground and low ground. It's about understanding the human terrain, really understanding it."

-Gen. David H. Petraeus,
U.S. Director of CIA

Furthermore, certain social processes cannot be explained without greater incorporation of space. The inflexibility of traditional social theory and COIN theory, regardless of space, is slowly giving way to new spatially explicit COIN theories. The current developments and interest in computational COIN are aided by broader trends in computational social science, data science, and spatial statistics.

Kurt Vonnegut, a 20th century American writer, is quoted as saying that any search for the one will ultimately prove to be incomplete. Computational COIN is built upon the idea of heuristics. The pursuit of an exhaustive singular metric to understand a complex space is not realistic. Spatial data analysis offers a balanced blend of idiographic and nomothetic laws, offering local and global understanding of an insurgency and of the native population. The emergence of big COIN data allows all available data to be analyzed. It may challenge the traditional laws of parsimony, finding elusive omitted variables causing the Simpson's Paradox, and calibrating local spaces causing Spatial Simpson's Paradox.

Big Data deviates significantly from traditional methods of analyzing geographic data, the birth of which dates back to the quantitative revolution in geography during the 1960s. Perhaps the emergence and merging of these efforts solve a number of enduring problems in calibrating the battlespace of irregular warfare. The times of quite idiographic surveying of local tribes and inventory of body counts, SIGACTS, and other kinetic and combat-related metrics are waning.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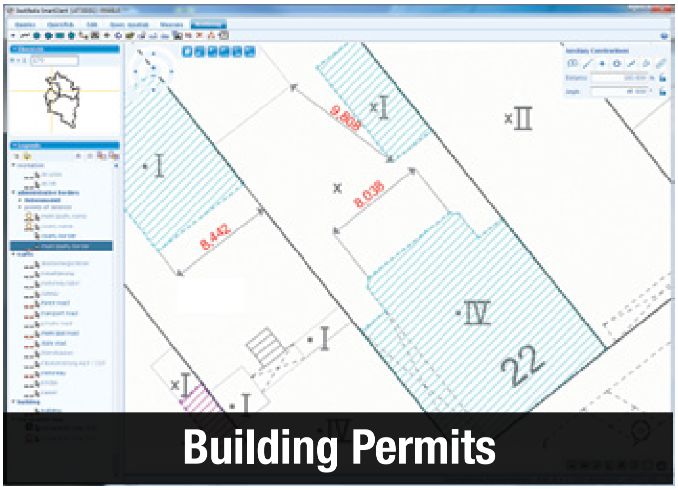
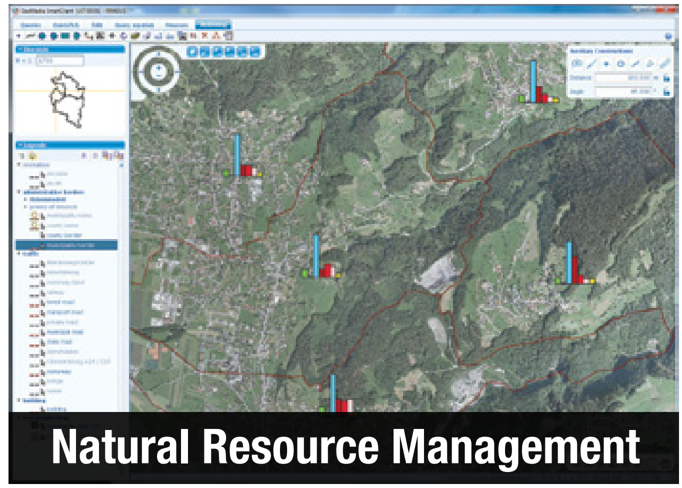
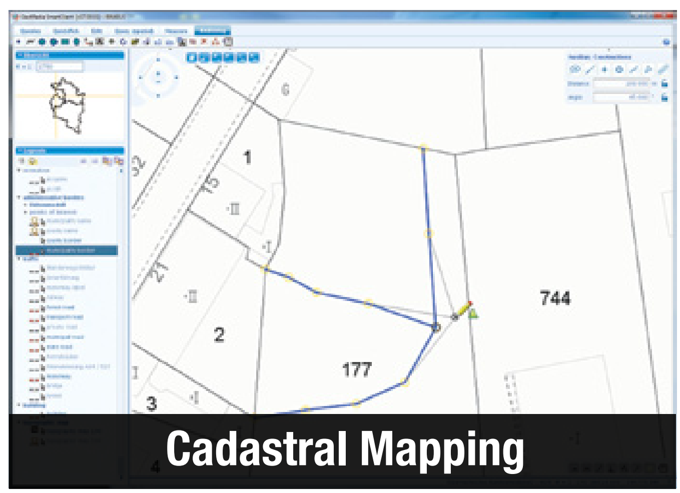

Building Permits


Natural Resource Management


Urban Planning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