Imaging NOTES

EARTH REMOTE SENSING FOR SECURITY ENERGY AND THE ENVIRONMENT

Fall 2012
Vol. 27 >> No. 4

Augmented Reality

Java, Indonesia image taken Sept. 12 by Astrium's Spot 6 satellite, launched Sept. 9, 2012!

ArcGIS ONLINE: SaaS

UAVs/UAS

EYE ON EARTH

GIS HELPS KENYA TAX COLLECTION

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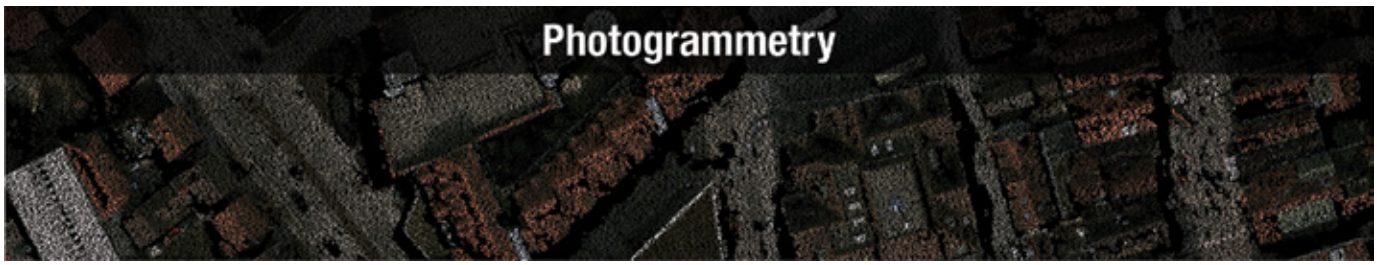

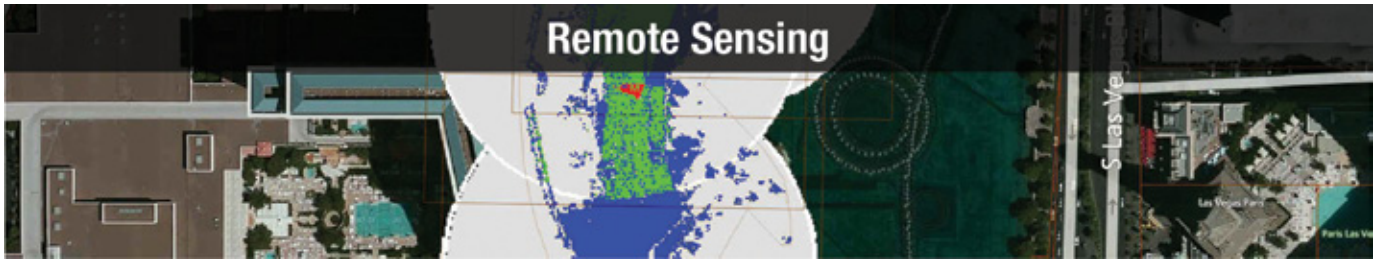

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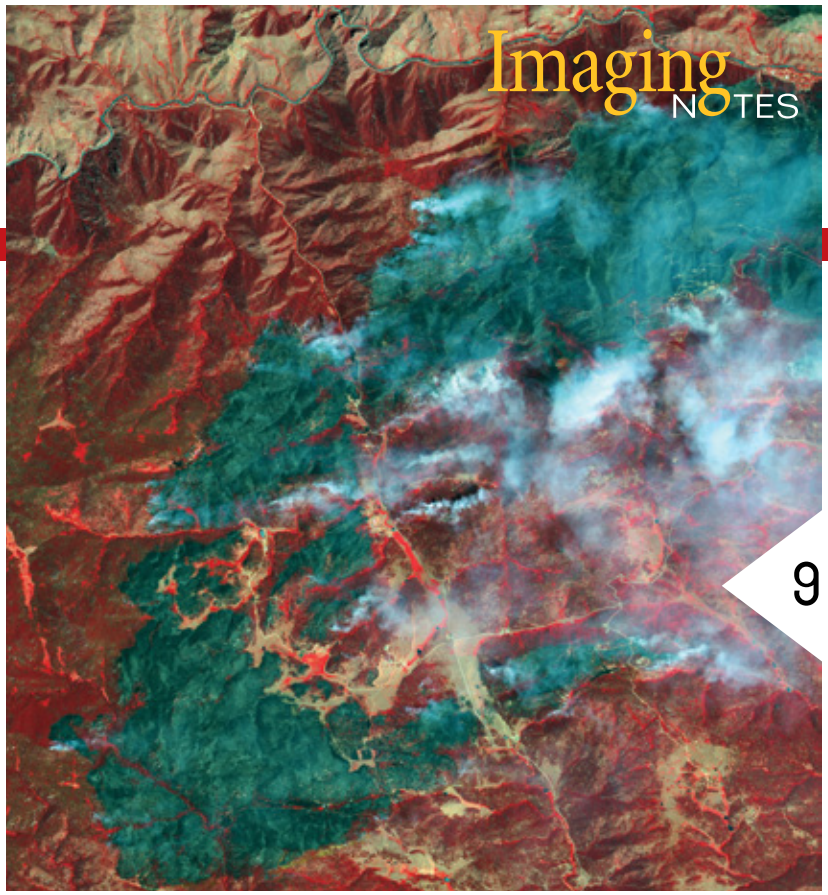

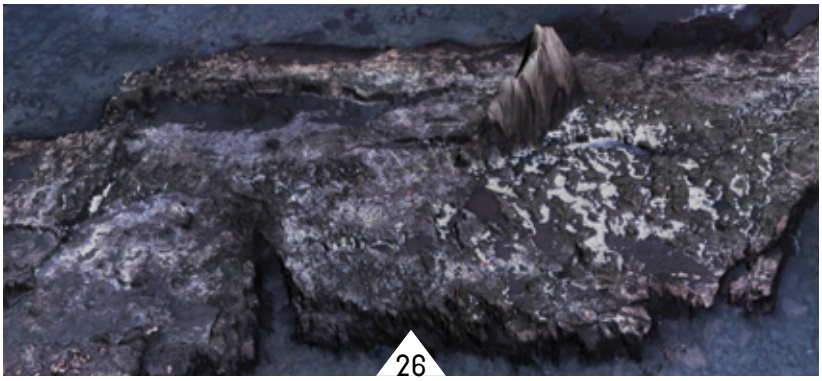

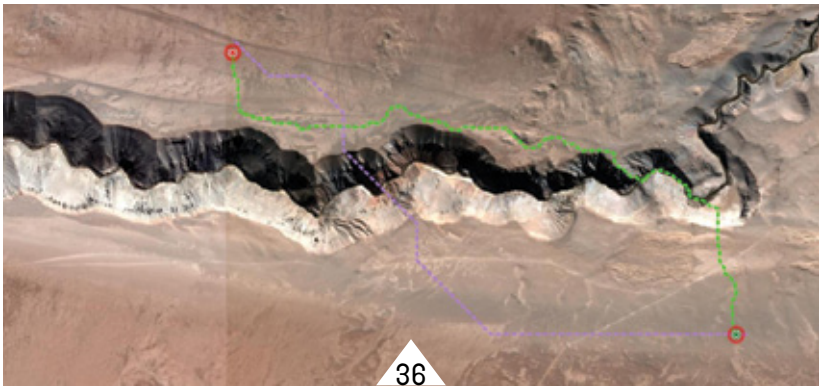

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Java, Indonesia

COVER IMAGE

Astrium's SPOT 6 satellite launched on September 9, 2012. This image of Semarang, on Java Island, Indonesia was captured only days later, on September 12.

The image is a 15x15km extract of an optical pansharpened 60x120km strip, with resolution of 1.5 meters. Final image quality will be achieved by the end of the 3-month commissioning phase.

This island represents many that are at risk with rising sea levels around the world. Imagery and geospatial tools are essential in addressing these and many other urgent issues. See the Secure World Foundation Forum on page 6 for more about the ways that these tools are being used to address mainstream sustainability issues, and about several gatherings coming up soon where people will discuss addressing them.

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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.

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FOLLOWING ARE THE TOP TEN NEWS STORIES FOR EACH MONTH PRIOR TO this issue as recorded via visitor views to the daily updates on *Sensors & Systems* (www.sensysmag.com). The stories at the top received the most views for the month. All these stories can be found here: http://bit.ly/TxewvU.

JULY	AUGUST	SEPTEMBER
CORPORATE NEWS Location Analytics Developer GeoIQ Joins Esri *http://bit.ly/OtEPiP*	*POLICY/RESEARCH* GIS Technology at the Heart of New Medical Study *http://bit.ly/SqPReB*	*GLOBAL CHANGE* Next Generation of Advanced Climate Models Needed, Says National Research Council Report *http://bit.ly/S2ovJs*
CORPORATE NEWS Pictometry Connect Unveiled; Integrates Aerial Imagery and Customer GIS Data in a Secure, Cloud-Based Platform *http://bit.ly/Qsd1hp*	*CORPORATE NEWS* 2012 Is the Year of GIS *http://bit.ly/NQYEot*	*POLICY/RESEARCH* Pioneering UK Project to Improve Land Carbon Intelligence, Accuracy, and Reliability *http://bit.ly/RVAjgt*
CORPORATE NEWS DigitalGlobe and GeoEye Agree to Combine to Create a Global Leader in Earth Imagery and Geospatial Analysis *http://bit.ly/U0LTEO*	*ENERGY* Maps Show the Incredible Potential of Renewable Energy *http://bit.ly/NQZ2Ue*	*FOOD/AGRICULTURE* Big Data Helps Farmers Weather Drought's Damage *http://bit.ly/QeLtJW*
CORPORATE NEWS Esri User Conference: GIS Opening Our World *http://bit.ly/Ts5Mc1*	*POLICY/RESEARCH* Solar-Powered Drone Can Conduct 14-Hour Surveillance *http://bit.ly/Qnaf9L*	*CORPORATE NEWS* First Images from SPOT 6 Satellite *http://bit.ly/Q7bmvj*
GLOBAL CHANGE Preserving Biodiversity in the Age of Climate Change *http://bit.ly/Q9MEeb*	*FOOD/AGRICULTURE* Trimble Introduces GreenSeeker Handheld Crop Sensor for Agriculture *http://bit.ly/Qse8gS*	*CORPORATE NEWS* PERILS to Provide Flood Footprints Based on Satellite Data *http://bit.ly/RWmmAk*
CORPORATE NEWS Exelis Visual Information Solutions Works with Esri to Provide Imagery Everywhere *http://bit.ly/P22x56*	*POLICY/RESEARCH* Researchers to Collect Detailed 3D Models to Assess High Park Fire's Effects and to Support Recovery *http://bit.ly/Q4wd5g*	*CORPORATE NEWS* Fugro Awarded Contract to Survey Coastline of Lake Michigan *http://bit.ly/PqsbCa*
PRODUCT NEWS Altus Positioning Systems Introduces New Portable Integrated System for GIS Applications *http://bit.ly/Uyo6hM*	*POLICY/RESEARCH* Scientists Explore Changing Arctic Ocean *http://bit.ly/RUbz4g*	*ENVIRONMENT* Solar-powered Wireless Sensors System Monitors the Environment *http://bit.ly/OS3MVs*
GLOBAL CHANGE Biodiversity Decline in Tropical Wildlife Reserves More Destructive than Climate Change: Study *http://bit.ly/Q4wCo7*	*ENERGY* Genscape and DigitalGlobe Provide Expert Analysis of Nation's Energy Infrastructure Using High Resolution Satellite Imagery *http://bit.ly/RkAraw*	*POLICY/RESEARCH* IUCN Launches New Report on Protected Areas *http://bit.ly/Plwpah*
PRODUCT NEWS PCI Geomatics Releases Geomatica 2012 Service Pack 3 *http://bit.ly/U0N07A*	*CORPORATE NEWS* New Indoor Positioning Alliance, In-Location, Promotes Indoor Services and Solutions *http://bit.ly/QkzuiC*	*POLICY/RESEARCH* Study Maps Social Vulnerability to Climate Change in California and Identifies Need for Adaptation Planning *http://bit.ly/Qj3Osn*
ENVIRONMENT Buffalo River: An Urban Waterway's Comeback *http://bit.ly/SsjK8i*	*OCEAN* How Ocean Currents Affect Global Climate Becoming Better Understood *http://bit.ly/U2m3EP*	*CORPORATE NEWS* Wanted: Best Cloud-Computing Applications for Earth Observation Data *http://bit.ly/RdiWtf*

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Remote Sensing in the Mainstream

SEAMLESS INTEGRATION FOR URGENT USES

The more rigorous our tasks, the more important it is to step back from time to time and look at what we have accomplished in perspective. This is particularly true for those of us interested in remote sensing and Earth observation, since at its root everything we do is about enhancing perspective.

In January 2011, as Cyclone Yasi bore down on Australia, where I was on assignment for the International Space University, I was struck by the extent to which newscasters and public officials alike routinely referred to space-based data that only a decade before would not have been nearly as available. Of course, there were the satellite storm images from weather satellites that so many of us have come to take for granted, but there were also elevation charts showing the risk of flooding for coal mines and analysis of coastal areas at greatest risk from storm surges. All were amply illustrated by satellite imagery, and all the imagery was presented as if it were the most natural thing in the world to have ready access to visual illustrations captured by highly effective instruments orbiting Earth high above the tempest.

We may occasionally feel frustration that so much of what we have struggled to make possible through inventive science, demanding engineering and skilled analysis goes unappreciated by people who see it as just another part of the universe of images with which they are confronted every day. In fact, there is reason to feel elated that we have contributed to the creation of tools so effective that they have been integrated into many of the most critical moments in human life, and especially into the most challenging moments of preserving it.

In the interest of bringing some of this perspective of accomplishment to bear, I want to share just a few of the upcoming events in which the technology and technique we have labored to develop is being presented to audiences whose interest in satellite imagery and multispectral data comes more from their quest for tools equal to down-to-Earth challenges than from a fascination with any aspect of how the data is gathered.

MICHAEL SIMPSON, PhD
Executive Director
Broomfield, Colo.
Secure World Foundation
www.swfound.org

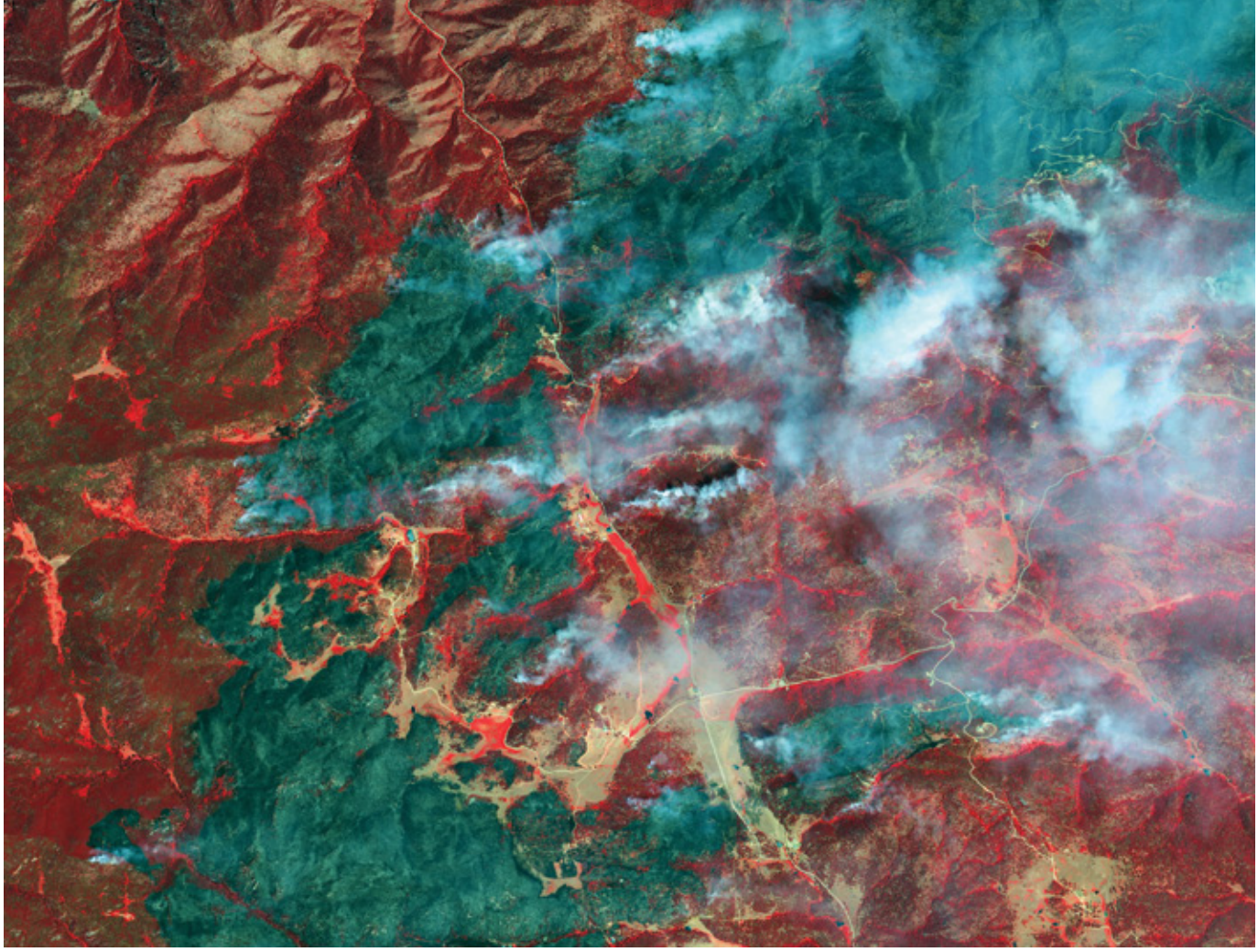
In late September, Space Generation, the largest organization of young professionals in the space sector, will gather for their 2012 Congress under the banner of "Space for Humanitarian Relief." Imaging technologies will be high on the list of satellite applications tailor-made to address problems cause by both natural and anthropogenic disasters. In this sophisticated audience, we can expect full awareness of the technical prowess that underlies these technologies, but we can also expect more.

The rising leaders of our space sector not only want to increase the use of space, they also want to make major progress improving life on Earth. Like the Instrumentalist philosophers of the Nineteenth Century, they see an integrated system between tool and result, and they want the system to benefit human kind.

These young professionals are thus simultaneously the heirs of the huge progress we have made in the barely 50 years since the beginnings of satellite remote sensing and the progenitors of creative applications for the benefit of humankind of which we can only dream. Expect to read more about the preliminary results of their work in future issues.

Fortunately, it is not just the youngest of our colleagues who have gotten a firm grip on the tools we have been fashioning with the intent of carrying out humanitarian work. In May of this year, the Polish Government organized a simulation workshop entitled, "Satellite observations – Support in Crisis Situations." Heavily focused on the use of satellite Earth observation data, this simulation assembled participants from both governmental and non-governmental organizations from inside Poland and beyond to address a scenario based on massive flooding.

This fall, many members of parliaments from around the world will gather in Naples during the annual International Astronautical Congress to explore the topic, "Satellite Applications: Tools for Policy Implementation and Verification." In October, the Organization for International Cooperation and Development (OECD) will hold a one-day invitation-only meeting on the subject, "Monitoring Global Threats: The Contribution of Satellite Technologies."



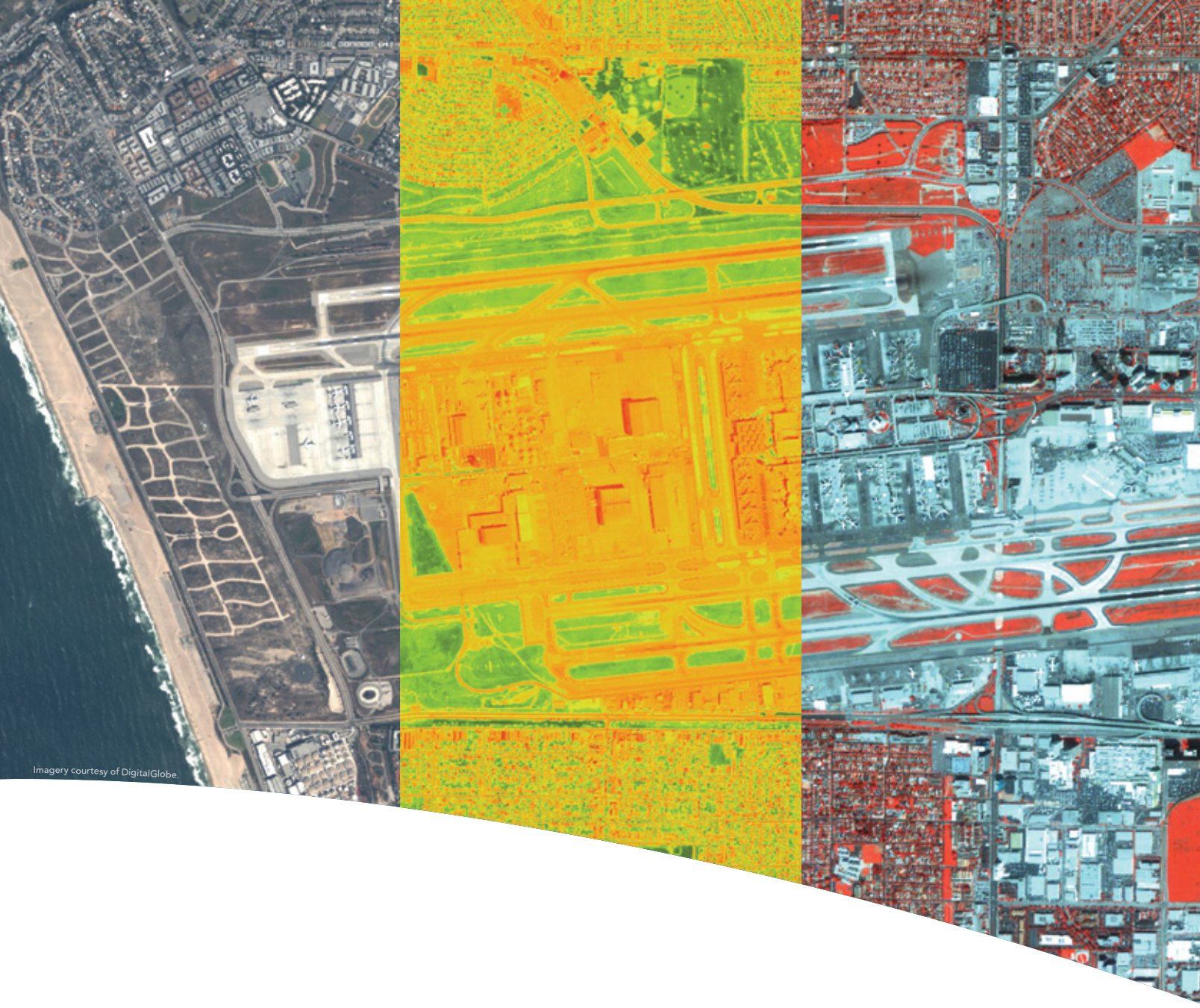
WE HAVE CONTRIBUTED TO THE CREATION OF TOOLS SO EFFECTIVE THAT THEY HAVE BEEN INTEGRATED INTO MANY OF THE MOST CRITICAL MOMENTS IN HUMAN LIFE, AND ESPECIALLY INTO THE MOST CHALLENGING MOMENTS OF PRESERVING IT.

In November, representatives of many African countries will meet in Kenya for a workshop on how best to use the satellite imagery now beginning to become available to address challenges of community planning, flash flood management, and coastal development. This coming January in Adelaide, Australia, the International Space University's Southern Hemisphere Summer Space Program will challenge its students to develop a white paper on the use of space assets to support sustainable development on Earth.

There are, in fact, even more examples. What I have shared with you is only a portion of those with which the Secure World Foundation has been privileged to be a partner. What these examples tell us is that we have managed to integrate space-based imagery into the fabric of policy making and humanitarian planning. We have overcome difficult challenges in the lab, on the test bench, and in the field and have given our species one more example of what seems to set us most apart from other living things: tools.

However you approach the fascinating articles in this issue, I invite you not to forget that, for a growing number of people, what matters most is that the imagery we have been able to create is an indispensable part of the positive impact they are working to achieve. So next time you engage in some self-observation in the mirror with those two sensors in your eye sockets, give yourself a thumbs up for helping make the world a better place, and then keep the science and engineering coming. «

▲ **FIGURE 1.** *This image of the High Park Fire near Ft. Collins, Colorado (taken June 10, 2012) shows how imagery is being used during emergencies. This is a false color satellite image, where red areas are healthy vegetation and black areas are burnt. Image courtesy of DigitalGlobe.*



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EXECUTIVE INTERVIEW

Jack Dangermond

President/Founder of Esri

This interview was conducted by Matt Ball, and originally appeared in *Sensors & Systems*, where he is editor. A longer version can be accessed online at www.sensysmag.com/dialog/interviews.

Geography as a Platform

ARCGIS ONLINE PROVIDES MAPPING FOR THE MASSES

ESRI HAS BEEN FRAMING AND working for some time on a cloud platform that has recently culminated in the launch of ArcGIS Online. Matt Ball corresponded with Jack Dangermond, president and founder of Esri, regarding this move toward Software as a Service (SaaS), and the impacts that it will have on the geospatial market and Esri's customer base.

BALL *How has Esri's software architecture evolved over time, and how does ArcGIS Online extend the functionality?*

DANGERMOND In the late 90s, our main technology pattern was stand-alone Windows desktops that were networked and integrated with database servers. Today, our users continue to use the desktop pattern extensively but have also deployed approximately 100,000 GIS servers within their organizations and on the Web. These enterprise GIS servers manage geospatial data and provide the foundation for enterprise applications ranging from lightweight apps in browsers and mobile devices to traditional desktop applications. While the desktop continues to be very popular for GIS professionals, the GIS technology has matured into an enterprise platform that is being employed to provide access to a wider audience of users.

ArcGIS Online extends Esri's enterprise technology by providing an integrated cloud offering. This platform implements many of our server and geospatial content management capabilities in the cloud and also offers a new and easy platform for mapping as well. Our traditional users are embracing these capabilities and integrating them into their existing systems, making their data and these new capabilities for easy mapping available to users across the organization. In many ways, this is a whole new market of users who want access to simple mapping and location analytics that this platform offers. We expect ArcGIS Online will rapidly grow the use of maps and geographic information within organizations. We refer to this as "geography as a platform."

BALL *What are the technology underpinnings of this new offering?*

DANGERMOND ArcGIS Online operates on cloud infrastructure offerings from Microsoft and Amazon Web Services but can also work in private clouds and data centers. Esri is providing ArcGIS Online as a subscription or a SaaS-based offering. In the first month, we have seen thousands of user organizations register to ArcGIS Online both from our existing users as well as from a whole new market of organizations. All these users wish simply to make maps and do locational analysis with their enterprise data.

BALL *GIS, like all data-driven systems, relies heavily on quality data to achieve its true promise. While traditionally you provided software, you've made significant investments in data.*

DANGERMOND In recent years, we have made large investments in the content part of our product. We have included ready-to-use authoritative content as a significant component of the system. These include basemaps, demographic data, and imagery delivered as services for our users. We have also taken the approach of integrating the best available public content with a number of commercial and Esri-created datasets. This content is often shared by our

"Users who participate share their content, get to use the integrated services, and maintain the intellectual property rights of any content brought into this system."

end users in a "community approach," which both integrates and harmonizes data from multiple sources, while at the same time supporting users retaining the ownership of the content. Basically, users who participate share their content, get to use the integrated services, and maintain the intellectual property rights of any content brought into this system.

BALL *How does ArcGIS Online address both your current market and new markets for your technology?*
DANGERMOND ArcGIS Online is an enterprise mapping platform. Beyond mapping, it provides other services like global geocoding, routing, and the ability to integrate/mash-up data from multiple sources. These maps can be created by ordinary people, using a host of open data types such as csv files. They don't require an expert. This will make mapping more essential and a powerful common language across many industries.

For the traditional GIS users, ArcGIS Online provides geospatial content management in an elastic cloud infrastructure for hosting and easy integrating with the ArcGIS server environment.

The second market for ArcGIS Online is what we call "location analytics in the enterprise." The location analysis extends to more substantial Business Intelligence (BI) platforms. This capability is also being provided for Microsoft Office and SharePoint environments.

The third market is Web developers. ArcGIS Online provides this market with consumer-focused mapping services and provides a stronger and richer suite of APIs for developers.

BALL *Much is being made of the online "Map Wars" between Google and Apple, with even Amazon re-entering online mapping with a recent acquisition. What is your view of this battle, and how does ArcGIS Online differ?*
DANGERMOND We recognize that mapping and location-based servers are becoming pervasive in the consumer Internet and device space. We believe this is a good thing for our field as it drives great spatial literacy and understanding. While ArcGIS Online apps and services are increasingly replicating the consumer app experience, our focus is on the professional GIS and enterprise community. This work, while in some ways similar, requires different data models and functionality. It also requires integration with the enterprise computing environment.

Our work is directed toward this, as well as integrating the Web and device app into the geospatial professional workflows that need more advanced geospatial capabilities for their work. While there is some confusion, our experience is that organizations figure it out and there is strong demand for our approach and capabilities in both public and private organizations.

BALL *Our world is going through profound changes that force us to look more closely at our impacts and the interrelated issues of sustainability. What role does GIS and mapping play in making sense of these changes?*
DANGERMOND ArcGIS Online provides the opportunity to share authoritative source data and tools that help people more easily visualize, analyze and understand their world. It's going to change the world. As our organizations become more spatially aware, they will see relationships and patterns that will cause people to think more deeply about geography. Whether it's the environment, land use, social issues, or policy issues, society will become more spatially aware.

MY HOPE IS THAT THIS PLATFORM WILL SUPPORT A WHOLE NEW CULTURE OF COLLABORATIONS. MAPS, DATA MODELS, WORKFLOWS AND APPS FROM MULTIPLE ORGANIZATIONS WILL BE SHARED, COMBINED, AND USED TO ADDRESS THE CHALLENGING PROBLEMS OUR WORLD IS FACING TODAY.

My hope is that this platform will support a whole new culture of collaborations. Maps, data models, workflows and apps from multiple organizations will be shared, combined, and used to address the challenging problems our world is facing today. For example, we may see new approaches to land use planning, conservation, and natural resource management, as well as new understandings in human health and the environment. Organizations will consider various kinds of social and environmental data as part of their thinking about future development. All of this will increasingly be possible as we realize the vision of geography as a platform.

EXECUTIVE INTERVIEW

Alex Philp

Founder/CTO of TerraEchos

Predictive Analytics

INTO PROACTIVE DECISION MAKING

MONTANA MAY SEEM AN UNLIKELY place for cutting-edge sensor systems and computational solutions to the big data problem, but there is a cluster of companies with Alex Philp at the helm that are on the forefront of that problem space. Matt Ball spoke with Philp about GCS Research, Adelos and TerraEchos, as well as the trends with systems and sensors that are giving rise to a whole new awareness of our interactions.

BALL *I find it inspiring how you've made a transition from academic research to an entrepreneur, where you've founded several successful companies. What's the history of how that came about?*

PHILP I entered the University of Montana grad school here in Missoula (Montana) in 1992, and my Masters was in geography with an emphasis on GIS (geographic information systems). I started my doctorate in historical landscape ecology using GIS and remote sensing, and halfway through that I had an opportunity to work at the Goddard Space Flight Center on the convergence between remote sensing data types, satellite-derived data products, and GIS, as it was becoming early Web-enabled. We built a great team of people who were active between 1998 and 2002.

As part of that four-year process, my doctorate essentially shifted into telling geographic stories in a meaningful way to support business process or educational experience. I tied that all around the Lewis and Clark Bicentennial and developed that map story with systems within systems within systems that were doing much of what is called the cloud now. We had geospatial distributed analytics, distributed systems, map services, and terabytes of data spread across machines to educate and tell that story. That was all fairly applied GIS research.

I started GCS Research in 2002, and very early on I was able to bring in outstanding business partners. Mike Beltz and John Waterman, two GIS people from the University of Montana, became partners in GCS Research, and we built that company into what it is today.

BALL *When did you branch into sensors?*

PHILP I started to think about sensors everywhere after working with sensors on satellites and aircraft. It wasn't news to me that we'd have an explosion in mobile GPS. I became very interested in sensors, and sensored systems, and elements of the sensor Web. I had an opportunity to work with the Navy on a project with a very high-end fiber-optic sensor. Think of it as thousands of microphones buried in the ground, using fiber-optic cable to support those digital sensors.

We licensed that technology from the government and formed a new company called TerraEchos to focus on that activity in 2006. By 2008, we had our first prototype, and then through 2011, we were building and delivering systems to the U.S. government, working with the Navy and the Department of Energy.

We were doing next-generation physical security, the idea being that you need to create a physical perimeter using five or six different types of sensors – cameras, microphones,

"I describe the opportunity as the '3V^{i} over network equation' – that is, the convergence of high volume, high velocity, high variety (3V) with the exponent of intelligence, over network."

geophones, magnetometers, biometric arrays, millimeter wave radar, airborne assets... As our work evolved, I realized that it wasn't enough to focus on just our sensor system, but that we needed to interoperate and interact in real time, both spatially and temporally, in identifying, classifying, tracking and localizing that threat. We started extending and expanding that into Adelos, which is the Greek word for hidden. We proved some phenomenal things with that system, and gained some recognition for it.

BALL *Getting recognized by IBM is certainly a validation of a high order in terms of your technical expertise. How did the alliance with IBM come about?*

PHILP I became aware of an IBM technology that they referred to as "System S," and if you recall that their original code name for the first relational database management system (RDBMS) was "System R," then it's pretty significant. The technology is now known as InfoSphere Streams, which is a paradigm shift in how we do computing.

I'm interested in associative memory and analytics that lead to synthetic solutions, theoretically, conceptually or otherwise. You have multiple sources, you do interdisciplinary calculations, you do computationally intensive work in real time, and what comes out are answers that provide automated and semi-automated predictions and decision support. All of that we were doing around Adelos, and we achieved some major success in 2010 and 2011, to the extent that we earned significant industry awards from IBM and others based on the innovation.

BALL *How have you capitalized on all the recognition?*

PHILP We were interested in going somewhere with this analytical capability, so venture capital investors took a serious look and we created a whole new company just around the central nervous system of Adelos. We literally ripped the cerebral cortex out, and named that product Kairos, the Greek word for right timing. We take data from multiple sources – some of it is big, some is slow, some is small, some is structured, some is unstructured, some is video, some is text, some is audio, etc. – and we bring all that together into an associative and correlative processing engine.

BALL *Is geospatial an input to the Kairos "big data in motion" product?*

PHILP It is and it isn't. What we're trying to figure out right now is where your standard geographic information system begins and ends, and where does Kairos begin and end? As you know, your traditional geographic information systems, with classic database-driven GIS, are not very good at dealing with these kind of compute problems. I've been working for years on trying to inject sensor systems into GIS, and to greater and less success. We've been doing that over and over again for customers.

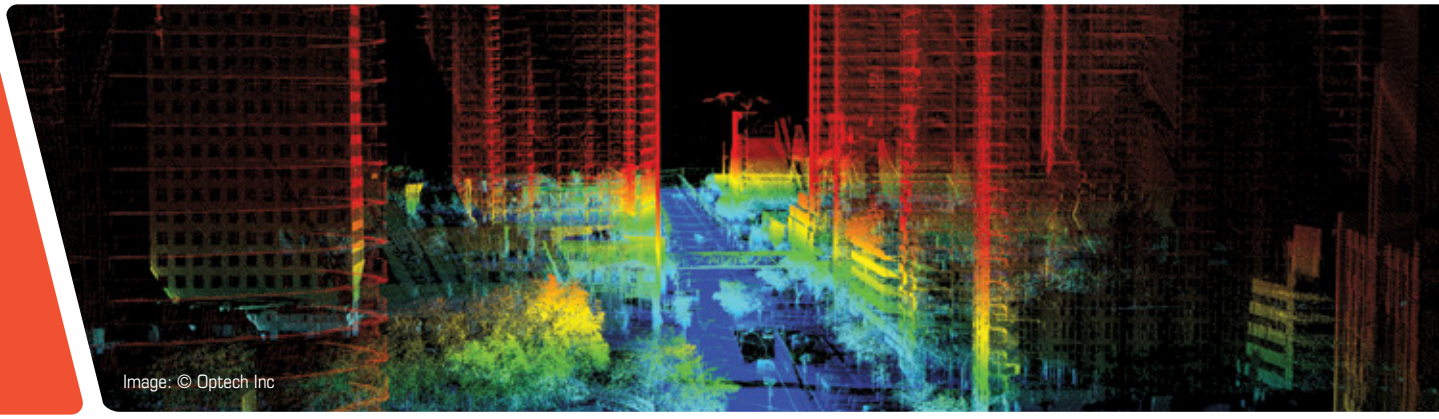
The best thing I can say is that we pull data from GIS technology, primarily Esri, whether it is a file, a table or a database as a source, and we write and publish back to the source. We're pulling what's meaningful and necessary from GIS as part of our calculation, and then, when we have an answer, we put the answer back into GIS to support those workflows and systems. We're not trying to make a GIS analytics fusion machine; we're trying to find the right interoperability at a technical level with reading and writing the right raster, vector and record as part of a service.

BALL *There seem to be so many opportunities. How do you go about focusing on specific industries or problems?*

PHILP To make sense and to extract meaning today requires the right combination of software, hardware, analytics and network. I describe the opportunity as the "3V^{i} over network equation" – that is, the convergence of high volume, high velocity, high variety (3V) with the exponent of intelligence, over network. This is the kind of equation that we're creating with Kairos. What we're working to identify are specific industries that are hitting the wall on velocity, variety, volume, analytics or network, and we're trying to bring our solutions to them to achieve 100 to 1,000 to even 10,000-fold improvements on optimization.

Primarily it's about saving time. If my problem currently takes me 34 seconds, and if I can derive that value in one one-thousandth of a second, now we're really starting to buy time. We're starting to manipulate time for existing and past functions, and to do a better job of reacting. But, we don't just want to react better, we want to be more proactive for our customers. «

International LiDAR Mapping Forum DENVER 2013



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EXECUTIVE INTERVIEW

Shoshanna Budzianowski

Partner Group Program Manager, Business Platform Group, Microsoft Corporation

Eye on Earth

MICROSOFT CONTINUES INVESTMENT IN NETWORK

THE EYE ON EARTH (EOE) NETWORK has garnered a great deal of praise for providing European environmental data openly and transparently, including widespread kudos for a new platform that was launched at the Rio+20 meeting this year. EOE started out as a joint project of the European Environment Agency (EEA) and Microsoft, and Esri recently joined the effort. Special correspondent Matteo Luccio spoke with Shoshanna Budzianowski, Partner Group Program Manager, Business Platform Group, Microsoft Corporation, who heads up the EOE project, about the ongoing development, the evolution to a cloud-based platform running on Microsoft's Azure platform, and the addition of Esri's ArcGIS Online.

LUCCIO *What do you do at Microsoft? How did you get involved with the Eye on Earth Network?*

BUDZIANOWSKI I do strategy and partner development for the Information Services team in the Data Platform Group at Microsoft. I also run an incubation team and an incubation called SQL Azure Labs. I do development, I scale out software, and I promote SQL Azure and Windows Azure.

I've now become an advocate not only for Microsoft technology but also for creating sustainable environmental solutions. I am neither a scientist nor an advocate of green solutions; I am a technologist. When I look at environmental issues, a lot of the problem is to figure out how to baseline what we have now and let the world share it, so that we can create science that measures against that baseline. With the EOE Network we've made it possible not only to create that baseline but also to share it with every citizen in the world in virtually every language. I look at this as a science problem and an engineering problem.

LUCCIO *How did the project start?*

BUDZIANOWSKI EOE started out as a joint project of the European Environment Agency (EEA) and Microsoft. Two individuals formulated the idea: Professor Jacqueline McGlade, Executive Director of the EEA, and Ludo De Bock, Senior Director for the European Union and NATO for Microsoft Corporation. Ludo, who works out of Belgium, is very environmentally conscious and wanted to help create a solution, with the EEA, that could provide information to European citizens about their environment. When this solution was first developed, in 2007, there was no other solution like this. There was pent-up demand for information about the environment from European Union citizens, but no way of conveying that information.

We first developed EOE at Microsoft and released it in May 2008, with WaterWatch. It takes data from 22,000 monitoring stations across Europe and publishes them in the application, so that citizens can see the water quality and then provide their own assessment of the water quality. That was wildly successful, to the point that we at Microsoft decided to continue to support the solution. The next year, we added AirWatch to the solution, which was released in November 2009. That takes data from more than 1,000 air quality monitoring stations across Europe and makes it available to citizens as well.

"We now have in place EOE Network, which allows virtually anyone in the world to create environmental information solutions and share them for free."

LUCCIO *Who funds the project?*
BUDZIANOWSKI The EEA has some funding for developing the solution. The majority of the funding, including for the last version, has come from Microsoft, which has continued to invest in it.

LUCCIO *How did EOE develop into the EOE Network? What was your role?*
BUDZIANOWSKI I am part of the product development team at Microsoft that produces our cloud database product, called SQL Azure, and our database products, such as SQL Server. We have a very long history of creating enterprise-scale, highly complex database systems. My team got involved because we ran a bunch of incubation projects for new cloud services and we decided to take on this project as a prototype for what we thought would be a cloud application.

We decided that, if we want everyone to be able to participate in this work, we have to drive the participation cost down to practically zero and make sure that the platform will scale. So, instead of creating a custom solution, we now have in place EOE Network, which allows virtually anyone in the world to create environmental information solutions and share them for free. So, we switched from creating a custom solution to creating a platform.

LUCCIO *What was Esri's role?*
BUDZIANOWSKI My team and I developed the EOE Network with the help of Esri. When we were trying to figure out how to create the scaled-out platform, I was already working with Esri and some other partnership-style solutions for publishing environmental information. I was fully educated and aware of ArcGIS Online, which is a complete cloud-based solution based on Windows Azure. So, I invited Esri into this engagement with Microsoft and the EEA.

It's been just a boon for the solution, because we took the custom map solutions and decided that we could host them on ArcGIS Online. Also, because of the functionality and capability of ArcGIS Online, we are now able to allow people to create free map applications and then have them published into the EOE Network.

We recently re-designed EOE Network with Microsoft SharePoint. We did that because SharePoint, which most people think of as a document management system, can also be used to create Web-facing applications, with a whole content management system behind it. So now, instead of being a custom solution, the EOE Network uses SharePoint and ArcGIS, all hosted on Windows Azure and SQL Azure. It means that non-technical audiences can now use this platform without having to do custom development for it.

LUCCIO *Who will provide the content? How will you handle quality control and edits?*
BUDZIANOWSKI We expect governments, the scientific community, certified citizen scientists, industry, NGOs, and even commercial organizations and independent software vendors to provide data to the system. The EEA administers the Network. Anyone can submit a map-based solution for publication, but they will be published only once they are certified by the EEA, which takes quality control responsibility for the maps that are published on its site. For the information that goes up there, it tends to work with trusted organizations, such as NASA, and trusted scientific communities.

We've been very careful to ensure that we understand who owns the data and where it comes from. The crowdsourced data that is part of the solution is always rendered separately, so that you know when it comes from the crowd and you know when it is published by the scientific community. If you go up to any of the air, water, or noise watches, you find ratings from monitoring stations and separate ratings submitted by citizens that may have different opinions on the subject. We've been very careful about making sure that there is a distinction between those two different data types.

Over time, crowdsourced data might become buried in environmental data. However, it has to be statistically significant and you need to have a very active citizen scientist community around it. Now, there are some citizen scientist groups and scientists — it could even be school teachers around the world — who can be certified by the EEA to submit solutions to this site. So far, the solutions that I've seen that have been submitted to the site are only from scientific organizations. There's a role for everyone on the site, but there is also a role for making sure that you understand who owns the data and where it comes from. «

FIGURE 1. *An AR view of Boston Common in Boston, Massachusetts. Photo courtesy of Intergraph Government Solutions.*

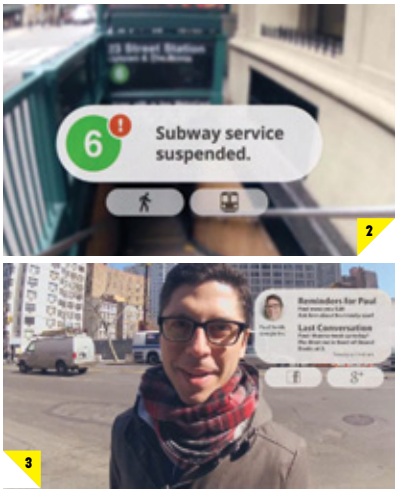
Our Augmented Reality

AN INDUSTRY PERSPECTIVE ON THE FUTURE OF AR TECHNOLOGY

In today's world of technology, it's certainly exciting to work in the geospatial industry and experience first-hand the vividly colored images and richly detailed 3D models of our planet. However, we also appreciate that there is inherent value beyond just the visual beauty. The processing, analyzing and integrating of this geospatial information brings increased value to many beyond those who work in the industry.

As we examine key trends in our market and in the broader IT sector in general, such as cloud computing, the explosion of social media, and mobile application integration, we see that these trends are collectively driving new and exciting ways in which we take advantage of geospatial information. However, some of the future applications of geospatial information and technology may be processed in a behind-the-scenes way as a "geospatial engine" powering technology from the background. These applications may be processed in such a way that the end users don't see an image, a map or a 3D model. In some cases, they may not see any visual representation at all. Augmented Reality (AR) operates this way, and continues to grow in potential within our industry.

Today's tablets and smartphones are already equipped with many sensors - GPS chips for determining a position on the planet, accelerometers for determining your orientation to your environment and for recording fine movements...



▲ **FIGURE 2.** *AR depiction of train information at a New York City subway stop, courtesy of Google.*

▲ **FIGURE 3.** *AR information can show past and current information on friends in a social network. Courtesy of Google.*

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Smartphone cameras visually capture our surroundings and use microphones to record voices and other sounds.

Other innovative applications also take advantage of these sensors to make our lives easier. GPS data are integrated with navigation systems. Star gazing apps understand our position on the planet and display a depiction of the night sky right in front of our eyes as we peer upward. Voice recognition allows us to engage in a more conversational experience as software translates our spoken questions to text and sends them directly to search engines.

Cameras also scan barcodes and QR codes that instantly interpret and explain meanings behind a puzzle of lines and numbers. These codes instantly link us to retail or marketing information, or in some cases pass a snapshot to a web service "in the cloud" that recognizes details in the picture. The pictures transmit images, such as a product logo or even someone's face. Augmented Reality brings all of these sensors, and others, together in an integrated, real-time manner to create a more immersive, productive, and exciting experience.

Essentially, Augmented Reality blends the real and digital worlds. The concept is that your surroundings are instantaneously sensed and processed and a derived digital set of information is transmitted back to the viewer, perhaps through seamless integration into eyeglasses, visors on helmets, vehicle windshields, or even an audio cue. True innovation, then, occurs when the digital information is transparently rendered onto these fields of view and dynami-

AS DEVICE FORM FACTORS SHRINK FROM DESKTOP TO LAPTOP TO TABLET TO SMARTPHONE, IT IS IMPORTANT TO SEE THAT THE NEXT DEVICE ACTUALLY HAS NO FORM FACTOR AT ALL.

cally synchronized with the actual view of scenery. See ***Figures 1-4***.

One industry already does this integration well. Hollywood has already perfected the art of blending the digital and real worlds – even in 3D – whether it is digital dinosaurs integrated into a live jungle or computer-generated imagery (CGI) Transformers bounding through a real city.

Augmented Reality also does that type of hybridization, but with at least two key differences:

- **All individuals have their own unique perspective on the environment at any point in time, so each user will receive slightly different information from the geospatial engine.**
- **And, this all happens in real time.**

Geospatial information and technology play critical roles in an AR solution. The first role is in the creation of a detailed representation of the environment that viewers may eventually walk, drive, or fly through in the future, such as a mountain pass or an urban cityscape. The second role is fulfilled by a "geospatial processing engine" that provides powerful frames of reference and models to which comparisons of the real world can be made. Once these steps occur, a number of geospatial processes may happen, in order to send some type of derived digital information back to the user – all depending on the user's needs and interests at that point in time. That information may consist of a digital geospatial "cue" such as a direction arrow or simply a signpost displaying detail about the object currently being viewed.

As device form factors shrink from desktop to laptop to tablet to smartphone, it is important to see that the next device actually has no form factor at all. Instead of utilizing a stand-alone computing device with a screen, the information is instead seamlessly integrated into already existing equipment. Even though modern vehicle navigation systems include audible instructions and voice command recognition, which do a great deal to reduce driver distraction to keep their eyes on the road, there is still a moving map display on the console.

Augmented Reality solutions will take this one step further, where no limited dashboard real estate is taken up with any map display. Appropriate details are displayed on the car's windshield, thereby reducing distraction to the driver. GPS glyphs, such as turn arrows and distance indicators could even be projected semi-transparently on the car's windshield.

Augmented Reality solutions can enhance much of our daily lives on a personal level, especially since they drive a strong convergence of social media and collaboration technologies. Tiny video cameras built into a pair of eye glasses will allow friends and colleagues to see the wearer's viewpoint in real time while a conversation occurs via an integrated microphone and speakers. See ***Figure 5***.

A recent online video from Wired magazine highlights "Project Glass" from Google, an exciting prototype of an AR solution that provides a glimpse into the vast possibilities that will someday be available. This video shows a few basic consumer examples of the powerful application of Augmented Reality, and we can really start to see how remote resources can play a more active role in a local activity: http://bit.ly/LLkp6J.

Google's official page for Project Glass is here, featuring fashion designer Diane von Furstenberg wearing "Glass": g.co/projectglass.

When we expand beyond the consumer space, we can see there are also many vital applications for field-based activities, such as physical plant inspections, fighting forest fires, and even military operations. An engineer walking through a petrochemical plant could be presented with vital pieces of spatial information and other annotations about the facility displayed on a pair of safety goggles. This allows him to perform his tasks in the most efficient manner possible. A first responder tackling a large forest fire would greatly benefit from having cues displayed on his visor that indicate the location of other fire fighters or key resources in his vicinity. Special Forces personnel that are storming an insurgent's safehouse could see a continuous display readout of the locations of their teammates and could realize safer and more effective missions, as friendly fire incidents would be reduced and mission objectives could be carried out more safely and quickly.

Augmented Reality solutions will require speed of processing and reliability of wireless connectivity in order to be successful. As ***Figure 6*** shows, this process involves:

1. **collecting data in real time,**
2. **transmitting back to a central geospatial engine, which then**
3. **compares the input to existing models and datasets,**
4. **generates artifacts, and**
5. **sends that information back to a user – all happening in real time.**

Initial implementations may be relatively basic – just taking advantage of GPS and accelerometer data – but the real value will be when the vast archive of geospatial information becomes an integral part of the process.

Terrain models based on LiDAR collections are creating a rich and detailed 3D representation of many places on this earth. These models may someday play a central role as part of an AR geospatial

Figure 4. AR information displayed on a smartphone screen, courtesy of Glogger.

processing engine. The models become the baseline to which continuous streams of input from sensors are compared, generating some derived piece of information. This can range from the name or address of a building to the height of a mountain in the distance, and even to details about the subterranean geology.

Below are a few additional examples of how derived geospatial results can enhance an AR solution:

1. **Displaying pop-up messages with street address numbers on your windshield as you drive down the street.**
2. **Displaying elevation contours on the inside of your sunglasses as you bike up a mountain trail or view a ridgeline from a distance.**
3. **Re-running your last run – as you head out of your house in the morning for a brisk run you can follow the dashed line representing the last route that you ran – a modern version of "follow the yellow brick road!"**
4. **Displaying location markers on the visor of an explosive ordnance technician, indicating locations of all previous improvised explosive device (IED) placements as he walks down the street.**

▶ **FIGURE 5.** *Google's Project Glass uses glasses to bring Augmented Reality information to the wearer. Courtesy of Google.*

▼ **FIGURE 6.** *The Augmented Reality process, courtesy of Intergraph Government Solutions.*

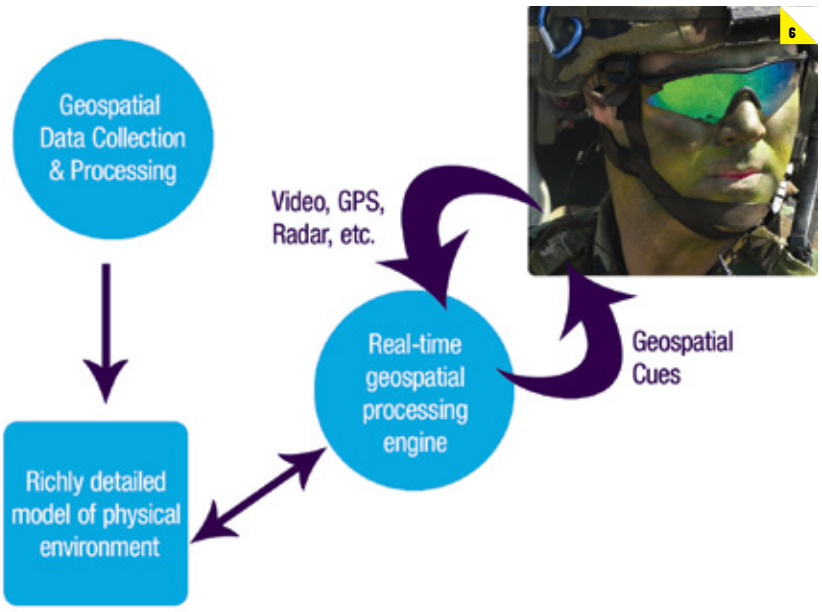
These are just a few initial examples of how integrating geospatial technology and information into Augmented Reality solutions can enrich the way we live and work. And we are at a stage where geospatial information is truly becoming a vital part of our everyday lives and is playing a role in more ways than ever before.

We are becoming more dependent on geospatial technologies, and in some cases, such as vehicle navigation systems, technologies have become such an integral part of our lives that we take the technology and its daily benefits for granted. Geospatial resources have evolved into an infrastructure - like running water, electricity, or the Internet.

Because of this quickly growing business, those of us in the geospatial industry have a large responsibility to ensure that these resources remain available and that they provide accurate results. Additionally, information initially collected for one specific purpose today may actually have some unforeseen important usage tomorrow – possibly as an integral part of an AR solution.

One of the key steps to take now is to adhere strictly to open geospatial standards for collecting, storing and sharing geospatial information. Open standards allow geospatial information to exist in a vendor-neutral format, to be shared with a wider variety of users, and to play a key role in a wider variety of applications. Open geospatial standards do a great deal to foster collaboration among many organizations and individuals. This collaboration increases the overall diversity of technologies and services, which in turn accelerate innovation collectively within the community.

I attended Hexagon 2012 earlier this year – Hexagon's annual international conference. During that event, I learned about many of the latest innovations in geospatial technology across the family of Hexagon companies. These included the latest in remote sensing solutions from Leica Geosystems, state-of-the-art LiDAR processing and Dynamic GIS solutions from Intergraph Security, Government and Infrastructure (SGI), and an intelligent, rule-based 3D design environment from Intergraph Process, Power, and Marine (PPM), to name just a few. It was during that conference that I could see more clearly than ever before that our industry was heading toward an exciting future where Augmented Reality would truly become our reality.



Now is a fascinating time for those of us in the geospatial industry. We are continually developing new and improved solutions for collecting, processing, analyzing, visualizing, and sharing geospatial data. These systems are providing great value to a broad set of consumers. Knowing that these awe-inspiring images, 3D models, and other types of geospatial information may have a purpose beyond the current, obvious usage is a responsible viewpoint to take.

It is important to realize that, in some cases, the most valuable result of a process that, in the end, produces a stunning high-resolution image or 3D model may not be the image or model itself at all. Rather, it may be a very simple, but extremely important, artifact derived from automated analysis of that data – an 'X' marks the spot, an arrow indicating which way to turn or a distance readout to an entrance of a safe house. As a community, we have a responsibility to set the stage for the future of Augmented Reality through the growth of our existing geospatial technology. We should completely embrace open geospatial standards and store and share data in formats that make it possible to integrate that data with the most diverse set of technologies possible.

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UAS INDUSTRY POISED FOR EXPLOSION

AWAITING FAA REGULATIONS

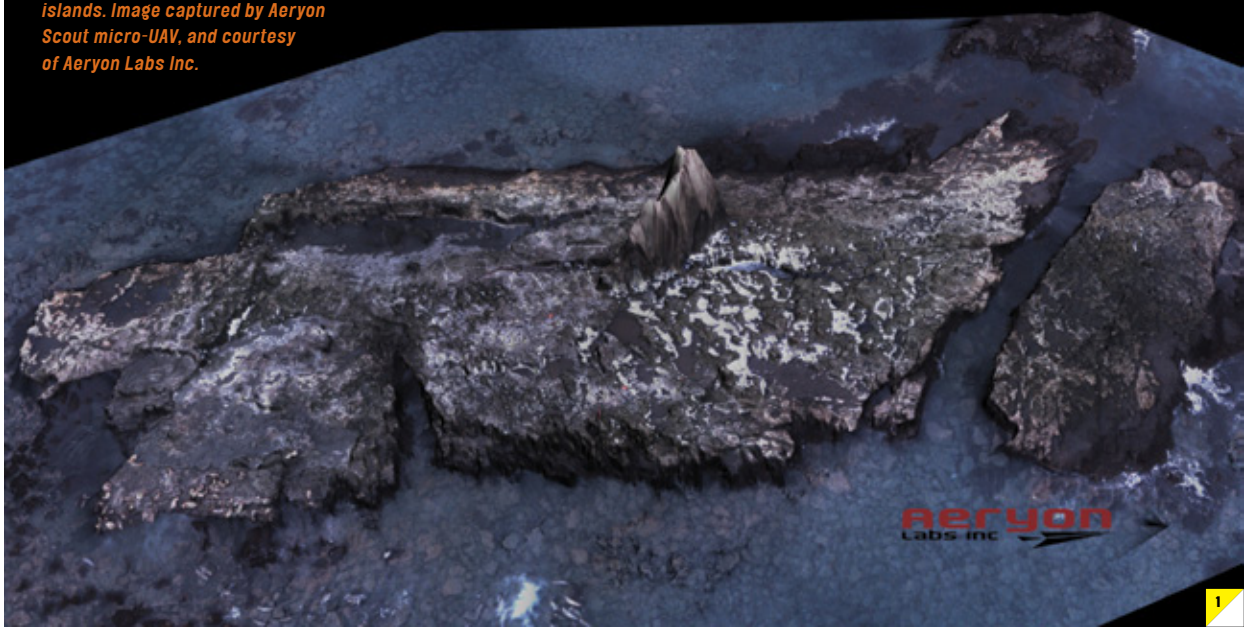
Unmanned aerial systems (UAS, formerly called unmanned aerial vehicles), which the U.S. military has routinely used abroad for more than a decade, will soon be a standard tool for many civilian applications — including police surveillance, fire mapping, border security, real estate photography, and surveying structures after natural disasters.

"There is really a shift happening in the market, from the military side to the civil side, with future growth on the commercial side of the industry," says Gretchen West, Executive Vice President of the Association for Unmanned Vehicle Systems International (AUVSI). The association has about 7,000 individual members and about 600 corporate members, most of whom are involved in the unmanned aircraft industry.

In the near future, changes in the regulatory environment will influence this market as much as technological developments. In the United States, the Federal Aviation Administration (FAA) is creating guidelines and standards for the use of UAS, projecting that 30,000 will be flying above the country by 2020. The agency is required by law to publish a final rule on the integration of small UAS into the national airspace by August 2014 and to complete their safe integration by September 2015.

"Once the FAA streamlines the processes, allowing for integration of UAS into the national airspace, we believe that we will see a much broader use of them for civilian purposes," says West. In particular, she sees a huge demand for surveying. UAVs, which are cheaper and easier to operate than piloted aircraft, will soon be the remote sensing platform of choice for photogrammetrists, surveyors, and other

FIGURE 1. *Quick 3D render of Aleutian islands. Image captured by Aeryon Scout micro-UAV, and courtesy of Aeryon Labs Inc.*



geospatial professionals, and many new applications will emerge to take advantage of this new capability.

"When Trimble bought Gatewing, they put that product under their survey group, rather than their airborne group, which is really a telltale sign of what their market research says," points out Matt Bethel, Director of Technology at Merrick & Company. "Our main competitors are probably ground-based laser scanners rather than aerial mapping companies," says Rowland Harrison, International Sales Director at Hawkeye UAV Ltd. "It seems that the main adopters of our technology now are surveying companies."

Uses

UAS can accomplish safely and efficiently a variety of remote sensing tasks that would be too dangerous, difficult, or expensive to perform with piloted aircraft. In April 2011, when the Red River flooded in the Midwest, UAS were used to survey the damage and provide critical information on a real-time basis. In Japan, after the March 2011 tsunami, they were used to approach the damaged Fukushima nuclear power plant.

They can be flown through volcano plumes or hurricanes to collect data about them, or used for event or port security. The Arlington, Texas, Police Department has been using a small Leptron helicopter UAS — which weighs less than 25 pounds — to survey multi-car crashes on interstate highways. "That puts troopers out of harm's way, because they don't have to be on the highway and it is a faster way to survey the damage and clear congestion," West points out.

Ben Miller, with the Mesa County, Colorado, Sheriff's Office, uses UAS for search and rescue missions and to take aerial photography of crime scenes. He estimates that it costs his agency $25-75 per hour to fly its UAS, compared to about $250-650 per hour to operate its manned helicopter. See ***Figures 1-3***.

Recent Developments

The key improvements in UAS over the past few years have been miniaturization, automation, and integration with image processing software.

Miniaturization has enabled the production of UAS that weigh just half a kilogram to three kilograms. This was essential to address the high safety concerns in the civilian market, says Andrea Hildebrand, Director of Sales and Marketing at senseFly and the company's founder.

Automation has made UAS much easier to operate for the typical user — such as a surveying company. For example, Hildebrand says, senseFly's Swinglet CAM is very easy to operate right out of the box. "Flight planning is quick, the launch is very easy, and it is all autonomous." See ***Figures 4-5***.

Likewise, Gatewing's X100 enables a user to map an area by selecting the area he wants to fly, performing a few checks, and then putting the vehicle on the launcher, says Peter Cosyn, the company's Director of Research & Development. "It will fly truly automatically. The user no longer needs to give any remote control inputs."

Gatewing, senseFly, Hawkeye, and other manufacturers of micro-UAS have also fully integrated their hardware with image processing software. They either provide it to their clients directly or refer them to trusted providers. "In the past few years," says Bethel, "rigorous software has been emerging that produces accurate products in a black box form, such that someone who is not a photogrammetrist or a remote sensing scientist can process pretty accurate data."

There has also been a big effort to make the systems comply more with future regulations by adding all kinds of automatic safety procedures, such as routines to handle GPS errors, Cosyn points out. "Many of these things already existed, but typically not on board these small UAS."

Together, these developments have enabled low-altitude photogrammetry. "Aerial mapping companies typically capture 50, 100, or 200 large-format images per flight," says Harrison. "A UAS at low altitude captures about 1,200 images per flight."

Future Developments

In the next two or three years, UAS will become even more user-friendly, argues Cosyn. "Routines might be introduced to meet particular regulations. The sensors are becoming larger, but they are very compact, so that they fit in a very small aircraft. This is improving the quality of acquisition, which means that the quality of the data is improving. Soon, you will have photogrammatic systems that will compete with LiDAR quality."

"A big improvement," says Harrison, "would be sensors better optimized for the different types of markets — near-infrared, multispectral, and hyperspectral. All of those sensors are becoming more miniaturized. There hasn't been a demand for miniaturization, but now there will be." According to Hildebrand, one of the next big developments will be obstacle avoidance and mid-air collision avoidance. "This will make UAS operations even safer and more integrated into the air space."

According to Bethel, the market will converge on medium-size UAS, such as the Buckeye, which are able to carry a few hundred pounds. "That's plenty good for most remote sensing capabilities," he points out. He expects "the next big leap" to be a move toward medium-format cameras. "Right now, one of the biggest complaints about UAS-based image collection is that there are so many images to deal with. You collect one square mile area and it might take 50 or 100 images to cover. Many vendors are

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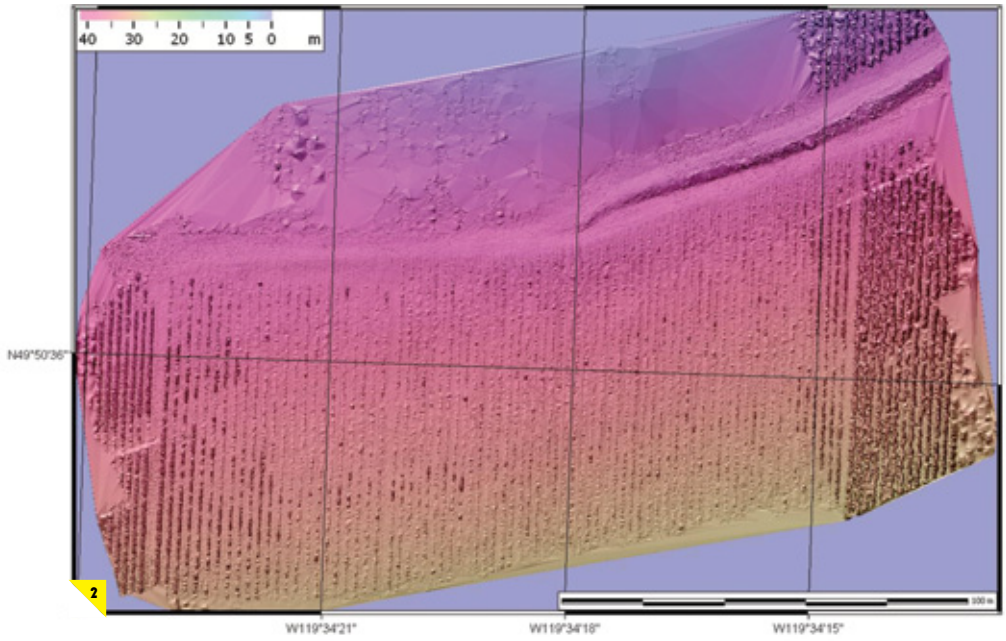

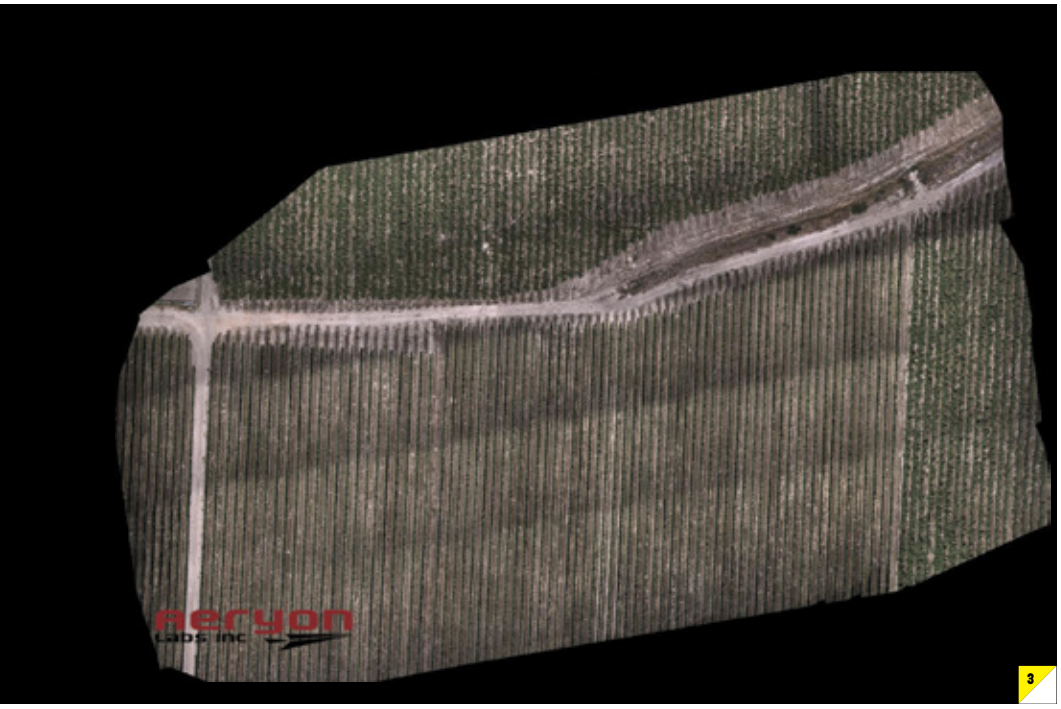

▲ **FIGURE 2.** *Digital elevation model of vineyard showing watershed analysis. Image captured by Aeryon Scout micro-UAV and courtesy of Aeryon Labs Inc.*

▲ **FIGURE 3.** *7.5 acres of vineyard orthomosaic imaged in 8 minutes at a resolution of 1.6 cm/px. Image captured by Aeryon Scout micro-UAV and courtesy of Aeryon Labs Inc.*

moving in the direction of combining multiple medium-format cameras to cover larger areas in a single flight swath."

Trade-offs

How do the capabilities and operating costs of UAS compare with those of piloted aircraft? The capabilities of some of the bigger UAS are closer to those of piloted aircraft, while micro-UAS are very complementary to them. Piloted aircraft are more efficient for covering large areas. However, a UAS enables a user to cover an area frequently — say, cover a mine twice a week — and perform change detection, which would be prohibitively expensive with a piloted aircraft. Additionally, Hildebrant points out, micro-UAS are silent and do not pollute.

UAS are easier to deploy and fix, cheaper to operate, and more flexible than piloted aircraft. "You can typically bring with you extra UAS parts or even an extra UAS," says Bethel. Additionally, pilots, being human, can get sick, and miss important weather opportunities for flying, or get distracted, and miss flight lines. "A UAS is more predictable and more reliable." Currently, he acknowledges, there are trade-offs in square miles per day. "However, we all expect that over time, UAS are going to be able to go to higher altitudes, to cover larger areas; sensors are going to improve, and so on."

One reason UAS are much cheaper to operate than piloted aircraft is that the latter require both a pilot, who flies the aircraft, and an operator, who operates the sensors — while a UAS requires only one person. "So, labor fees for salary, hotels, and incidentals are cut in half," says Bethel. "You go from a minimum of two people to a minimum of one person."

Contrasts in System Stabilization

The smaller an aircraft is, the more it is subject to turbulence, which is especially present at low altitudes. There are a few main ways to deal with this: in flight, by making course corrections every few milliseconds, or post-flight, either by geo-referencing the imagery on the basis of data from an onboard GPS-IMU (inertial measurement unit) or by pixel matching. Typically, these methods are used in combination.

"We deal with turbulence by briefly

4

switching the control from normal GPS navigation to a mode where we stabilize the UAS in a level position while it takes the photo," explains Hildebrand. "This ensures that the photo is not blurred and is properly oriented towards the ground. The residual orientation variations are estimated and compensated by the photogrammetric post-processing of the images."

"Turbulence is corrected in your photogrammetry technology, which has to handle off-nadir positions," says Harrison. "You cannot get into direct geo-referencing. You are not going to get the quality inertial measurement units into a UAS and, if you do, you end up with an ITAR-restricted product that you can sell to only a few countries," he argues, referring to export restrictions in the International Traffic in Arms Regulations.

"You can buy a remote sensing system for as little as 10,000 Euros," says Cosyn, "but then you are limited to flying in good weather conditions. You can buy a system for 50,000 Euros and be able to fly it in most weather conditions, so that the actual cost of your project is very low. If you use very small systems, weighing only a few hundred grams, then you depend on the weather. If you have a fast system that weighs about 2 kilograms, it can fly in practically any condition very close to the surface and still deliver a dataset of 2-3 centimeter ground sample resolution without any problems."

The accurate angle and position information, he explains, comes from the pixel matching. However, in order to have quality data, you need to be sure that you can have a consistent dataset, with consistent overlap. "This means that, although your aircraft can move a bit and it can take pictures at small roll or pitch angles of deviation from the vertical, it needs to do this within a certain limit. Having a few degrees of roll and pitch is no problem at all. The sensors on board the UAS are not accurate enough to register these small angles up to second level. The computation of the actual value of these angles is then done by the software, via pixel matching, which is very accurate."

For wide-area mapping, the LiDAR and the camera do not need to be rigorously stabilized, says Bethel. "We fly many sensors on board a helicopter that vibrates quite a bit and as long as the IMU can model that vibration it can put every point and every pixel right where it needs to be within our accuracy specification."

Meanwhile, a lot of R&D work is focused on developing extremely stabilized rotor-based UAVs, either in typical helicopter form or as multicopters. "They are taking hundreds of measurements per second to counteract the potential vibration of the aircraft," says Bethel. "So, in the lower altitude, rotor-based UAV market, that stabilization is already at an excellent level for any type of collection and an IMU can account for any remaining vibration."

Differences Among the United States, Europe, Japan and Australia

Regulations on the use of UAS vary from country to country. "While Europe is aggressively working towards implementing standards for UAS use," says West, "Japan is already allowing UAS use commercially and Australia (which has a less congested airspace) is also aggressively pursuing UAS flight. Through the International Civil Aviation Authority, work is being done on a global basis to create global standards for UAS integration and the various countries are bringing their varying regulatory practices to the table for discussion and thought.

"We see the regulatory environment converging on both sides of the Atlantic," says Cosyn. "In the end, there will be little difference between the European Union and the United States."

"There will be a huge surge in adoption of UAS, for example by surveying companies, because the quality of these point clouds is really getting very good and the value that they add to projects is very high," says Cosyn. "While bigger companies will buy UAS, smaller ones might rent a system or do projects with larger companies that have one." ⟪

▲ **FIGURE 4.** *senseFLY's swinglet CAM has a wingspan of 80 centimeters. Photo courtesy of senseFly.*

▶ **FIGURE 5.** *The Aeryon Scout is a vertical take-off and landing (VTOL) micro unmanned aerial vehicle used for tactical, over-the-hill aerial intelligence. Photo courtesy of Aeryon Labs Inc.*

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New GIS Promises to Revoluti

EDITOR'S NOTES: This article is based on an interview conducted with Samson Ngengi Njuguna, Revenue Officer, Kenya Revenue Authority, on Aug. 1, 2012.

The "cadastral divide" between developed and developing countries is also addressed in the June 2012 issue of Geospatial World. See http://bit.ly/SVn8is.

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▲ **FIGURE 1.** *Samson Njuguna with a traditional paper map on the wall of the KRA office*

IN DEVELOPED COUNTRIES, MOST PEOPLE TAKE FOR GRANTED CERTAIN basic public goods, such as clean drinking water, public education for children, and a tax collection system to finance public expenditures. By contrast, many developing countries lack the basic infrastructure of a modern state, such as a cadastre (land registration) system. Often, only a tiny portion of land parcels are mapped and official records consist solely of paper maps.

A cadastre is the core of a land administration system. It contains up-to-date information on each parcel, including a record of ownership and interests in the land, its value, and, usually, a geometric description. The first cadastral maps were found in Egypt, dating back to 3,000 BCE; the cadastral system was revolutionized in the 19th century by Napoleon. Beginning in the 1990s, radically new concepts were developed as to how to build cadastres and how to utilize them to improve land management, with a focus on sustainable economic development and the eradication of poverty.

Secure title to their land enables people to protect it from encroachment or outright theft and to use it as collateral to obtain loans. Modern, digital cadas-

tres have played an important role in diminishing corrupt and non-transparent land management practices. Such systems also improve the structure and accessibility of records, facilitate knowledge-based decision making, and promote wider data dissemination.

For these reasons, international development agencies, the governments of industrialized countries, and private foundations have financed numerous projects to build cadastres in developing countries, increasingly relying on geographic information systems (GIS). However, in many countries, such systems are still woefully inadequate or entirely non-existent.

Samson Ngengi Njuguna

In one such country, Kenya, Samson Ngengi Njuguna, a revenue officer with the Kenya Revenue Authority (KRA), has developed and tested a new GIS-based system to map rental properties and tie the information to other records about the properties, thereby enabling his agency to collect taxes that have never been paid before. See ***Figure 1***. KRA is the main agency mandated to collect revenue on behalf of the government of Kenya. Njuguna's core responsibility at KRA is to register and recruit taxpayers, as well as devise new and innovative ways of raising revenue.

Njuguna, now 30, was born as the fourth of 11 children in the western slopes of the Great Rift Valley in the Republic of Kenya. In the widespread ethnic violence that followed the 2007 election, more than a thousand Kenyans were murdered and hundreds of thousands were displaced from their homes. "My father was murdered in cold blood alongside 13 other family members," he recalls. Yet he is involved in peace building as the Chairman of the National Youth Resource Centres, a youth empowerment organization in Kenya that works with young men and women at the grassroots level to carry out peace-related activities as a way of restoring stability in the community.

At Jomo Kenyatta University of Agriculture and Technology in Nairobi, Njuguna earned a Bachelor of Science degree in Geomatic Engineering and GIS. Later, during his two-year training as a revenue officer at the KRA Training Institute, he developed a GIS application called Geospatial Revenue Collection Information System (GEOCRIS) as an automated tool that would assist KRA to tap property-based taxes. He was then deployed to the Real Estate Tax Office to further develop the proposed system into a workable and scalable solution.

The main objective of his research, Njuguna later wrote in his business case for GEOCRIS, was "to demystify the use of GIS technology in revenue collection based on the premise that any taxpayer operates from a particular physical location (which has geospatial positional attributes) that can easily be defined, quantified, and integrated into computer-understandable format, whether those positions are static or mobile."

In 2012, he came to the United States, principally to study cadastre workflows and processes, so as to improve the efficiency of GEOCRIS, especially with regards to editing and processing information on land parcels. "A lot of research (on cadastres) has been conducted in the United States and there are numerous best practices from which to learn," he says. "Also, there are experts on cadastre systems whose input would prove valuable to the work we are doing in Kenya."

The Problem

Worldwide, Njuguna explains, the rental property sector is notoriously difficult to tax, especially in developing countries. The bulk of housing is constructed outside of the formal process — i.e., without planning permission and without financing from banks or mortgage institutions. Few units are recorded with regulatory bodies, a small percentage of land is formally registered, and tenants are reluctant to report details about their landlords to the authorities. Therefore, accessing property information for taxation purposes is both difficult and expensive. Despite a recent building boom in Nairobi, tax collections have remained largely flat.

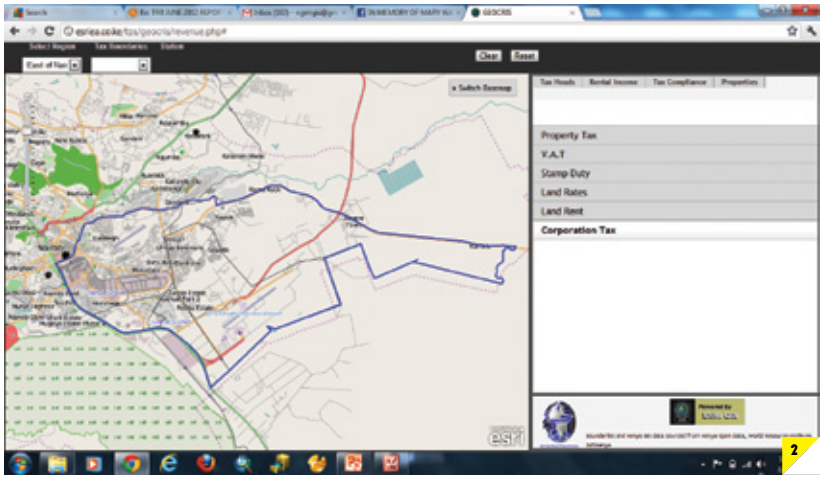
"We don't have any reliable property tax collection system in Kenya," says Njuguna. "Everything is manual,

onize Tax Collection in Kenya

on paper maps, which is a recipe for widespread corruption and inefficient service delivery. It is a sad situation that requires urgent remedial action. Information is power and lack of the same is definitely lack of power."

Moreover, data that may be used to improve the level of compliance are scattered among various arms of government, and there is no unifying database of any kind in place yet. For example, data on owners of all land parcels are held by the Ministry of Lands, while KRA is the custodian of PIN information and tax status of such owners. KRA does not receive copies of documents certifying the transfer of ownership of properties or parcels, so it has no way of knowing who sold which property or parcel to whom. "Even when equipped with the details of land ownership, it has not been easy for KRA officers to identify those plots that have been developed that may be subject to tax," Njuguna wrote.

Kenya faced the daunting task of devising technical, legal, and administrative means of raising tax compliance in this sector — thereby making resources available to improve the lives of millions of Kenyans. Njuguna took up the challenge of developing a technical solution and proposed a system that could drastically boost property tax collection. "I believe firmly that Kenyans can solve their own problems," he says.



▲ **FIGURE 2.** *East of Nairobi map on the GEOCRIS Web dynamic maps*

GEOCRIS

GEOCRIS combines geospatial, mobile phone, and information technologies to optimize the collection of rental property income taxes and other taxes using a minimal staff. See ***Figure 2***. It also assists the revenue authority to spot audit cases, while supplying it with key information about the targeted taxpayers.

The process involves mapping all the premises that generate rental income and entering them into a database. The activities and properties of the owners can then be tracked and a small number of revenue officers can follow up on non-compliant cases using GPS-enabled and Web-connected smartphones that synchronize with the system the attribute and location information that they collect in the field.

GEOCRIS, Njuguna explains, will enable the government of Kenya to identify tax defaulters and map the location of all of their properties. See ***Figure 3***. It is a scalable solution, because it includes an interface that can be developed for use with other taxes without requiring a redesign of the entire system. Additionally, the mobile phone platform will make it easier for the KRA to monitor the integrity of revenue officers.

GEOCRIS consists of a desktop platform, a Web platform, and a mobile platform. See ***Figure 4***. When fully functional, it is expected to support several business processes, including tracking the physical location of taxpayers, capturing taxpayer information, linking to pre-existing KRA systems, and allowing taxpayers to calculate and pay their taxes online or through their phones, and to file complaints.

According to Njuguna, the systems could raise the level of compliance from less than 2 percent currently to about 75 percent, thereby raising the revenue base by approximately 60 billion shillings from the current 1.5 billion shillings. "Tax compliance is a mandatory requirement for both natural and legal persons according to Kenya's new constitution," he says. "This means that GEOCRIS operates within the law as a tool to enhance better governance in Kenya."

Digitizing the Maps

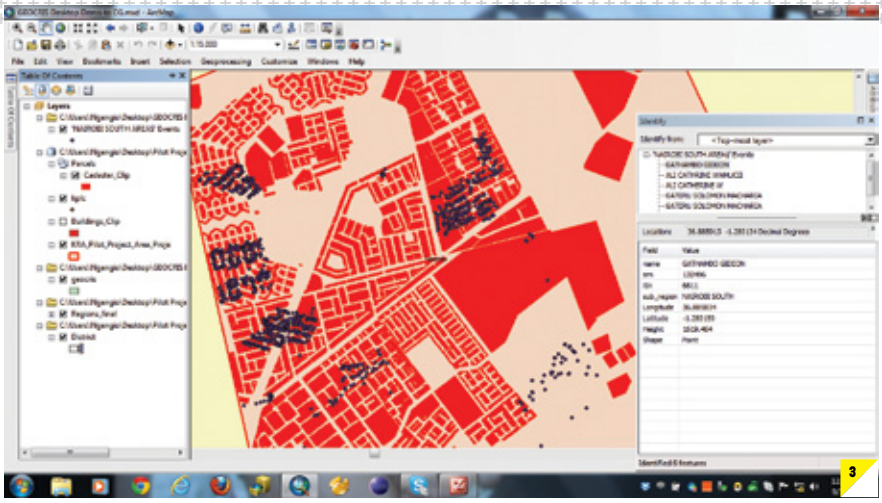
The Survey of Kenya is the government agency charged with demarcating boundaries and developing and maintaining the country's land records. However, it has no automated cadastre.

In Kenya, cadastral maps are contained within development plans for towns and cities. Njuguna has been able to scan and digitize about 20,000 sheets of land parcels for the city of Nairobi and about 8,000 sheets for the city of Mombasa; he is currently working on the cities of Nakuru, Kisumu, and Thika — single-handedly taking a major step toward digitizing his country's land records. This, he points out, proves that if the Government of Kenya were serious about automating its land information system, it would not be as Herculean a task as it has intimated. "GEOCRIS shows our government that the process is viable, but there is no good will to implement it," Njuguna says.

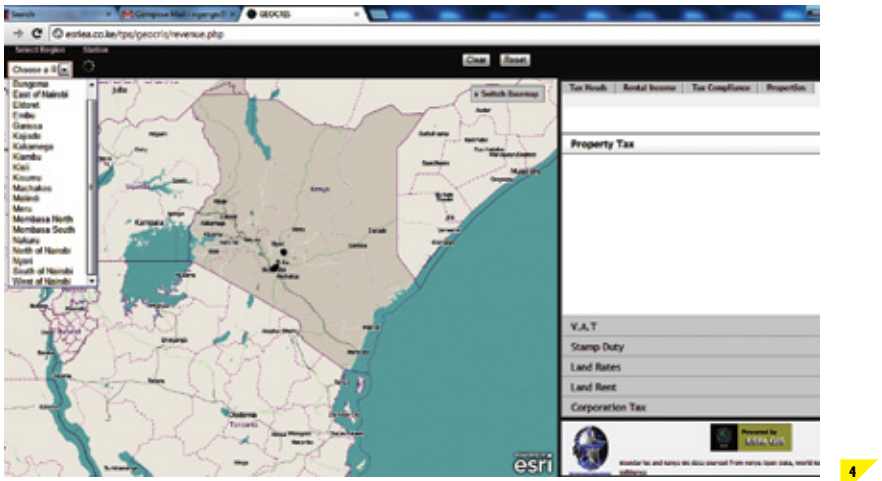
Implementing the System

The project is currently in the pilot phase but has already proved its significance by increasing revenue in the pilot area in Nairobi, according to Njuguna. See ***Figures 5-6***. The Minister for Finance, in his annual budget speech to the National Assembly, declared that the government is ready to nationalize the concept, which is expected to revolutionize revenue collection in Kenya. Meanwhile, the KRA has been carrying out a massive marketing campaign in the national media.

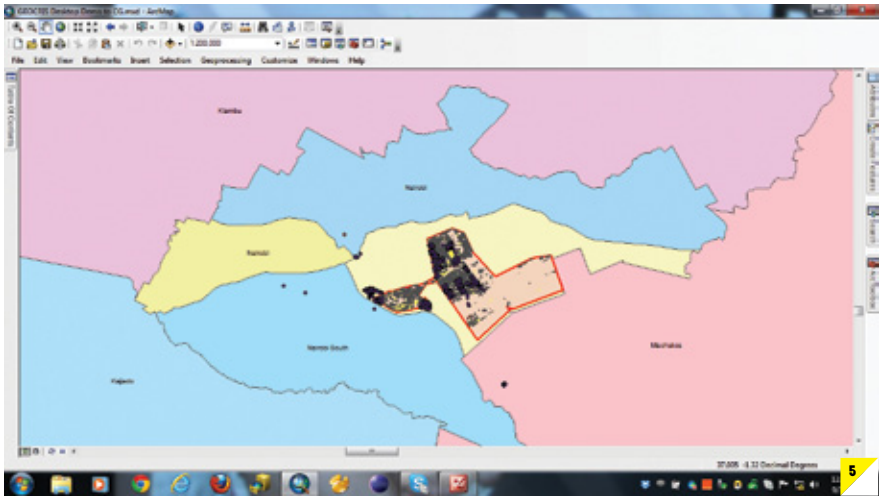
Implementing a national system will take about one year, Njuguna says, because it will require creating an enterprise GIS, which entails concep-



▲ **FIGURE 3.** *Parcel information in GIS*



▲ **FIGURE 4.** *GEOCRIS Web platform showing all revenue stations in Kenya*



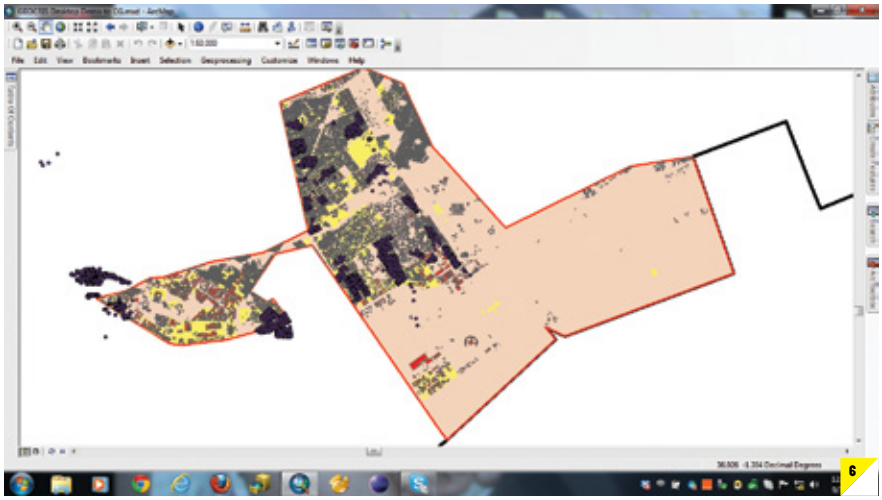
▲ **FIGURES 5.** *Digital format of Nairobi City*

tualizing many other factors, such as access and reliability of data from key government agencies.

Once digitized, the maps are published in a GIS. The second step involves cleaning the data and integrating them with the already published cadastre maps. The data are acquired from utility and water companies, the national company registration bureau, mobile phone service providers, and security agencies, among others. For instance, the more electric connections or water meters a property has, the higher the chance that it consists of rental units.

"We need to know where our people are and what they are doing, whether they are paying tax or not," says Njuguna. "Then we shall be able to quantify easily who makes how much money and where. Through the power of GIS technology, we are using different datasets to make sense of that information, which has never happened before in Kenya. Each government agency wants to hold on to its information and does not want to share it with other agencies. This is because the same information has always been used as an agent of corruption by the various parts of our government and there are managers who are hell bent to maintain the status quo."

Now, however, Kenya's new constitution guarantees freedom to access government information and the KRA has legal authority to ask for any data that has revenue implications. "I have been able to prove to our government that by sharing information amongst the various agencies, we can greatly enhance service delivery to Kenya's taxpayers," says Njuguna. He has written various technical documents and advisory notes to the KRA's senior management meant to convince the government to adopt a geospatial system.



▲ **FIGURE 6.** *Digital GIS data for pilot area within Nairobi City*

He was able to demonstrate his innovative system to review panels both within and outside Kenya and was awarded the first ever Innovation Award by the KRA in December 2011. GEOCRIS then won a Global Innovation Award for Kenya at the Annual Innovation Contest of the Inter-American Center of Tax Administrations. The initiative was cited as one of the three leading innovations undertaken by tax administrations in the previous year.

"Lack of records has been an obvious and endemic problem that has been created intentionally by the rich and mighty, as well as political leaders, in order for them to loot property and avoid paying taxes," says Njuguna. "I am working on this project so that we may enhance revenue collection. However, GEOCRIS is also going to bring sanity to our land administration processes and thus mitigate cases of dubious land dealings by closing the data gaps. Lack of proper land and property records is the main loophole through which the rich steal land from the poor. Of course, we recognize that the rich and mighty are going to resist and they have already started doing so by mounting road blocks to implementation of the system."

Despite this resistance and threats he claims to have received, Njuguna remains undaunted. "They may kill my body but not my soul," he says. "I am humbly requesting the entire GIS fraternity around the globe to assist in starting up a project of tapping talent of other geospatial change agents like myself, who are hidden from the world and are somewhere in Africa and beyond. These agents can play a crucial role in the development of Africa, since only Africans can liberate their continent, although with the support of development partners from all over the world." «

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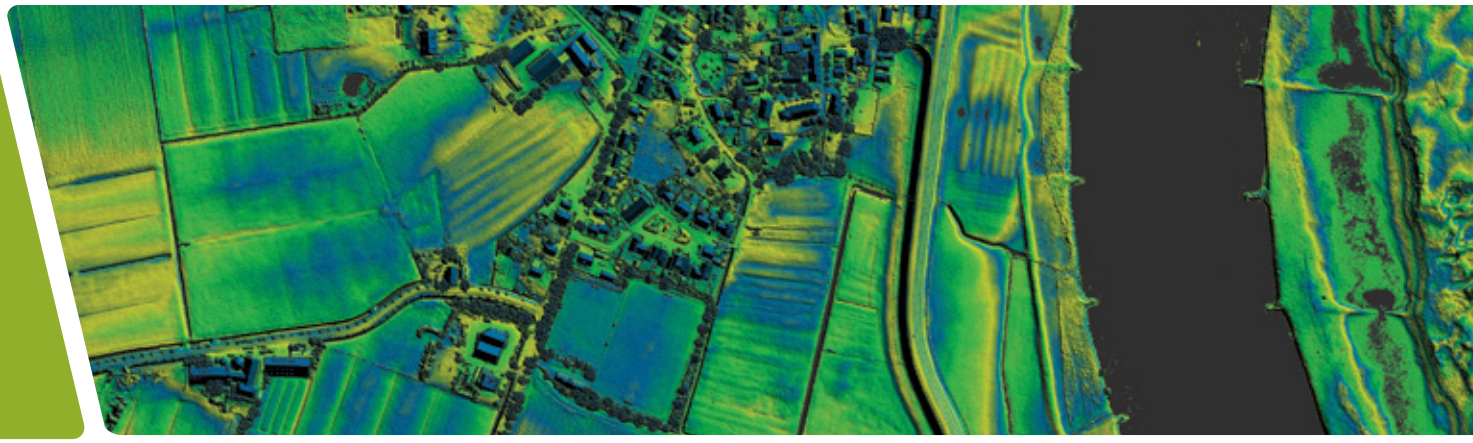

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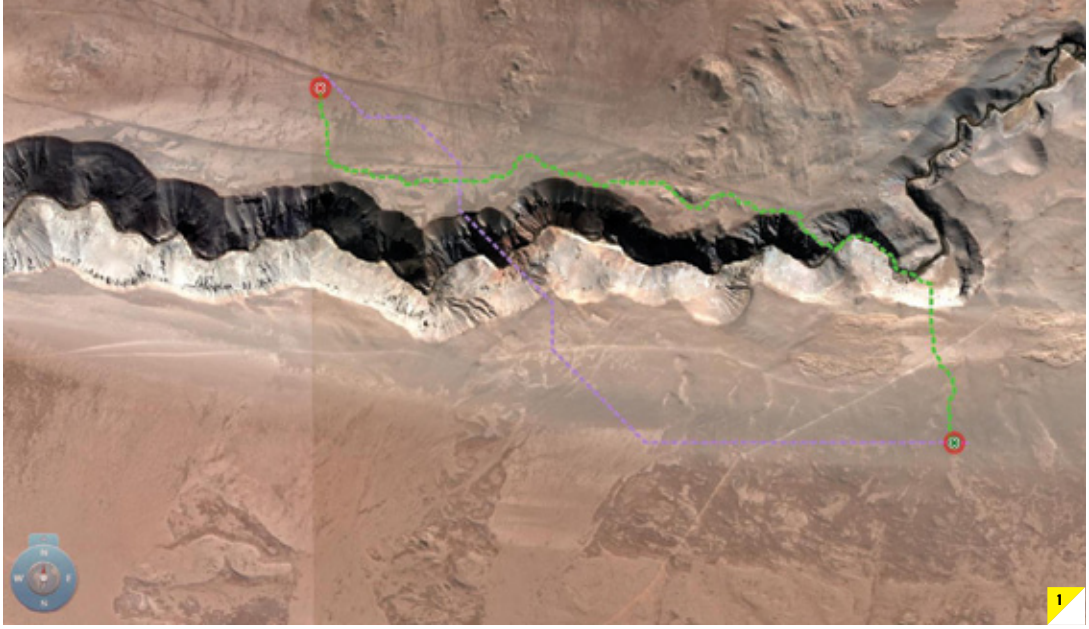

Simplified Elevation Analysis in the Cloud

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Advances in technology, data storage and distribution have allowed analysis of Earth observation data to be placed more firmly in the hands of the decision makers than ever. Satellite elevation data created from stereo imagery can be acquired anywhere in the world; accuracy of data collected is higher than ever; and large datasets can be processed through cloud computing, increasing speed of results.

▲ **FIGURE 1.** *Least-cost-path Analysis DigitalGlobe AES 8-meter Precision digital surface model and CountrySphere imagery in Chile*

Engineers do not have to be geospatial experts to review least-cost-path options for placement of a pipeline. Community participants don't have to understand the science behind line-of-sight analysis to determine the best location for placement of broadband towers to provide coverage in their town. Military personnel can assess the best ground approach en-route utilizing secure Web-based elevation data tools with imagery.

Until recently, the size of higher accuracy elevation data, the expertise required to write algorithms for anal-

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ysis, and the time needed to process these analyses kept the decision maker a step or two away from the information required to move forward. Cloud processing, in conjunction with Web-based geospatial analysis tools, allows development of simple interfaces for users who do not need to own any software or hardware beyond a desktop computer or mobile device with internet access, nor to store and maintain their own data.

The feasibility of this virtual analysis approach has been demonstrated utilizing Esri's (Redlands, Calif.) ArcGIS Server Web interface within the Amazon EC2 Elastic Compute Cloud (Seattle, Wash.), with DigitalGlobe's (Longmont, Colo.) Advanced Elevation Series (AES), alongside other Web services such as satellite imagery, publically available elevation data, and basemap data. A fully cloud-based hardware, software and data service, the application was developed by Idea (Jacksonville, Fl.), applying the "one question, one answer" design methodology coined by Geographic Information Systems (GIS) practice executive Brady Hustad.

The question that stimulated this project was, "What would make it easier for people to use elevation data?" The answer: intuitive Web applications that answer focused questions for specific users where they don't have to concern themselves with the hardware, software and data management. Trusted experts in their organization or in service-providing organizations design deeply analytical but simple-to-use geoprocessing tools based on their users' workflow. They insure that the data accuracy in their system is appropriate for the use, then utilize Web services for high-speed processing of large-scale datasets in the cloud.

"DigitalGlobe's constellation collects over 2.4 million km^2 on a daily basis. The global reach of the constellation has enabled DigitalGlobe to deliver Advanced Elevation Series products on every continent, including Antarctica. As WorldView-1 and WorldView-2 satellites are able to slew 200km in 10 seconds, they are preferred platforms for capturing stereo data – the raw materials needed for development of AES elevation products. And with the expertise in planning and collecting imagery, DigitalGlobe has cultivated and developed expert processing to deliver quickly large expanses of elevation and orthorectified imagery," states Stuart Schwartz, elevation product manager at DigitalGlobe. To further the availability of this type data, users benefit by accessing it as a Web service and integrating it into a meaningful question/answer context.

Higher accuracy means larger data – an increased number of pixels for an area of imagery or elevation data, such as the 2-, 4-, and 8-meter AES digital terrain and digital surface models. In the past, analysis of large datasets was limited to desktop processes, as Web-based tools are limited by bandwidth. Now cloud computing harnesses the capacity of server farms with much greater extensibility than a typical company can justify investing in their own infrastructure, and takes away the heavy lifting from the internet interface for geoprocessing, while quickly returning an answer to the users' queries.

On the ground, users can select a point on the map referencing imagery, choose the accuracy of elevation data if necessary for their application, and execute a process that returns the foot-

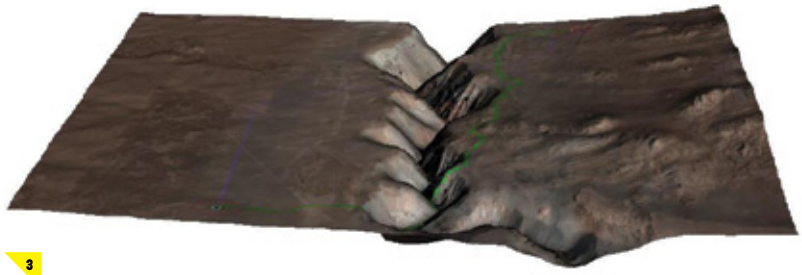
CLOUD PROCESSING, IN CONJUNCTION WITH WEB-BASED GEOSPATIAL ANALYSIS TOOLS, ALLOWS DEVELOPMENT OF SIMPLE INTERFACES FOR USERS WHO DO NOT NEED TO OWN ANY SOFTWARE OR HARDWARE BEYOND A DESKTOP COMPUTER OR MOBILE DEVICE WITH INTERNET ACCESS, NOR TO STORE AND MAINTAIN THEIR OWN DATA.

◀ **FIGURE 2.** *Viewshed Analysis DigitalGlobe AES 4-meter Precision digital surface model and CitySphere imagery of Dunedin, New Zealand*

▼ **FIGURE 3.** *3D View DigitalGlobe AES 8-meter Precision digital surface model and CountrySphere imagery in Chile*

print of coverage generated from a cell tower placed at a certain location, using elevation data in the analysis. More accurate data provides more exact analysis results. Taking this line-of-sight study into a 3D view adds critical information to the decision-making process, such as obstacles which need to be considered that would alter the placement of the towers. See ***Figures 1-3***.

THE QUESTION: "WHAT WOULD MAKE IT EASIER FOR PEOPLE TO USE ELEVATION DATA?" THE ANSWER: INTUITIVE WEB APPLICATIONS THAT ANSWER FOCUSED QUESTIONS FOR SPECIFIC USERS WHERE THEY DON'T HAVE TO CONCERN THEMSELVES WITH THE HARDWARE, SOFTWARE AND DATA MANAGEMENT.



Intuitive Web applications that answer focused questions for specific users have the greatest impact. We've achieved our industry's highest aspiration of increasing the footprint of Earth observation data, when people in any role are using GIS to get their jobs done without being aware of it. Satellite remotely sensed imagery and elevation data are at the foundation of this marriage of technology, science and human decision-making processes.

NOTE: All imagery is courtesy of DigitalGlobe.

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