Imaging NOTES

Winter 2013
Vol. 28 >> No. 1

EARTH REMOTE SENSING FOR SECURITY, ENERGY AND THE ENVIRONMENT

Announcing the
LMA
LOCATION MEDIA ALLIANCE

Environmental Intelligence Good for the Economy

Precision Ag

Big Social Data

Better Weather Forecasts

Bathymetric Lidar

INTERGRAPH®

THE FORCE THAT DRIVES SMARTER DECISIONS

Welcome to Intergraph Geospatial 2013

WE ARE UNITED. Whether it's by desktop, server, web, or cloud – our integrated geospatial portfolio delivers what you need, where you need it. Less hassle. Complete workflow. One partner.

WE ARE MODERN. Our fresh and intuitive interfaces and automated technology transform the way you see and share your data. This world has new challenges. Combat them with a smarter design.

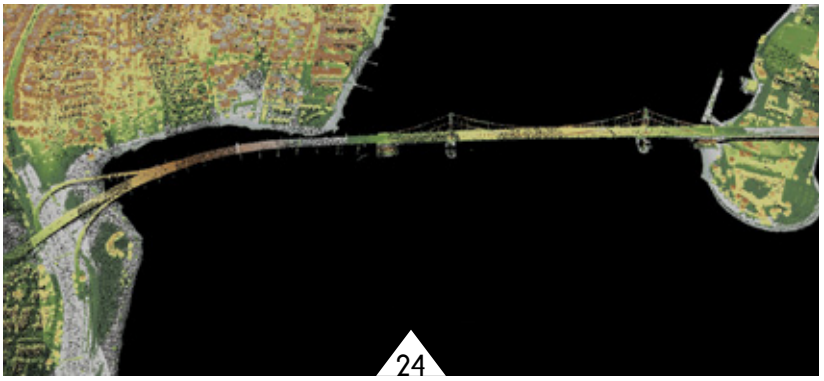
WE ARE DYNAMIC. Leverage our single integrated, dynamic environment for spatial modeling. Our core geospatial tools enable you to exploit the wealth of information found in data from any source.

GEOSPATIAL.INTERGRAPH.COM/2013

TEAM GEO-FORCE

INTERGRAPH GEOSPATIAL 2013
Experience the force that's driving smarter decisions at a road show near you.

PART OF HEXAGON

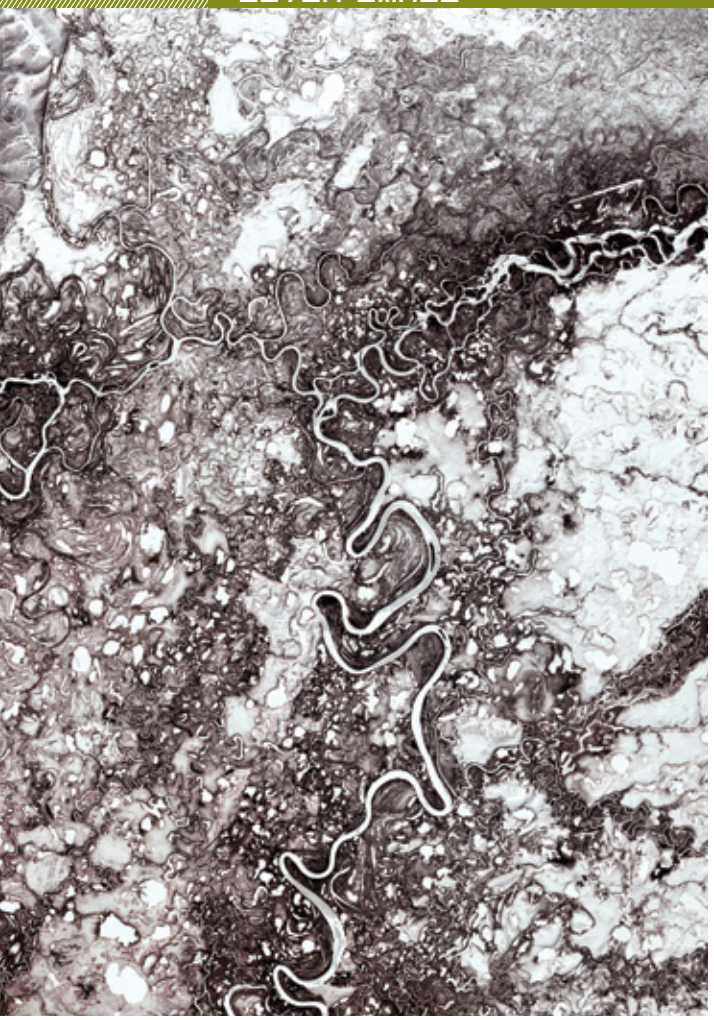


Winter 2013

CONTENTS

Mayn River, Siberia

COVER IMAGE



This image of the Mayn River in Siberia was taken Oct. 1, 2000 by Landsat 7. The image shows the Mayn River with a portion of the Anadyr River, flowing through the far northeastern corner of Siberia.

The Landsat Data Continuity Mission, Landsat 8, is set to launch on Feb. 11, 2013. An Executive Interview with Jenn Sabers begins on page 12. She is Remote Sensing Branch Chief of the Earth Resources Observations and Science (EROS) Center, at the U.S. Geological Survey (USGS).

Imaging NOTES

Winter 2013 / Vol. 28 / No. 1

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 partnerships with Secure World Foundation (www.swfound.org) and Sensors & Systems (www.sensysmag.com).

Imaging Notes is affiliated with the Alliance for Earth Observations, a program of The Institute for Global Environmental Strategies (www.strategies.org).

Editorial Contributions

Imaging Notes welcomes contributions for feature articles. We publish articles on the remote sensing industry, including applications, technology, and business. Please see Contributor's Guidelines on www.imagingnotes.com, and email proposals to editor@imagingnotes.com.

Subscriptions

To subscribe or renew, please go to www.imagingnotes.com, and click on 'subscribe.' If you are a current subscriber, renew by locating your account number on your address label to enter the database and update your subscription. If you cannot go online, you may write to the address below.

IP-S2 HD

LiDAR + IMAGING

MAP EXTRACT DELIVER

Drive route at normal vehicle speeds and collect required data, in one visit, eliminating return trips to the field.

Cost per point is dramatically reduced.

Personnel collect data safely from a vehicle.

Bring the field to the office.

View a powerful 3D high density point cloud with georeferenced images on the PC. Extract features or make measurements from the desktop.

Data judgments are made by the data user.

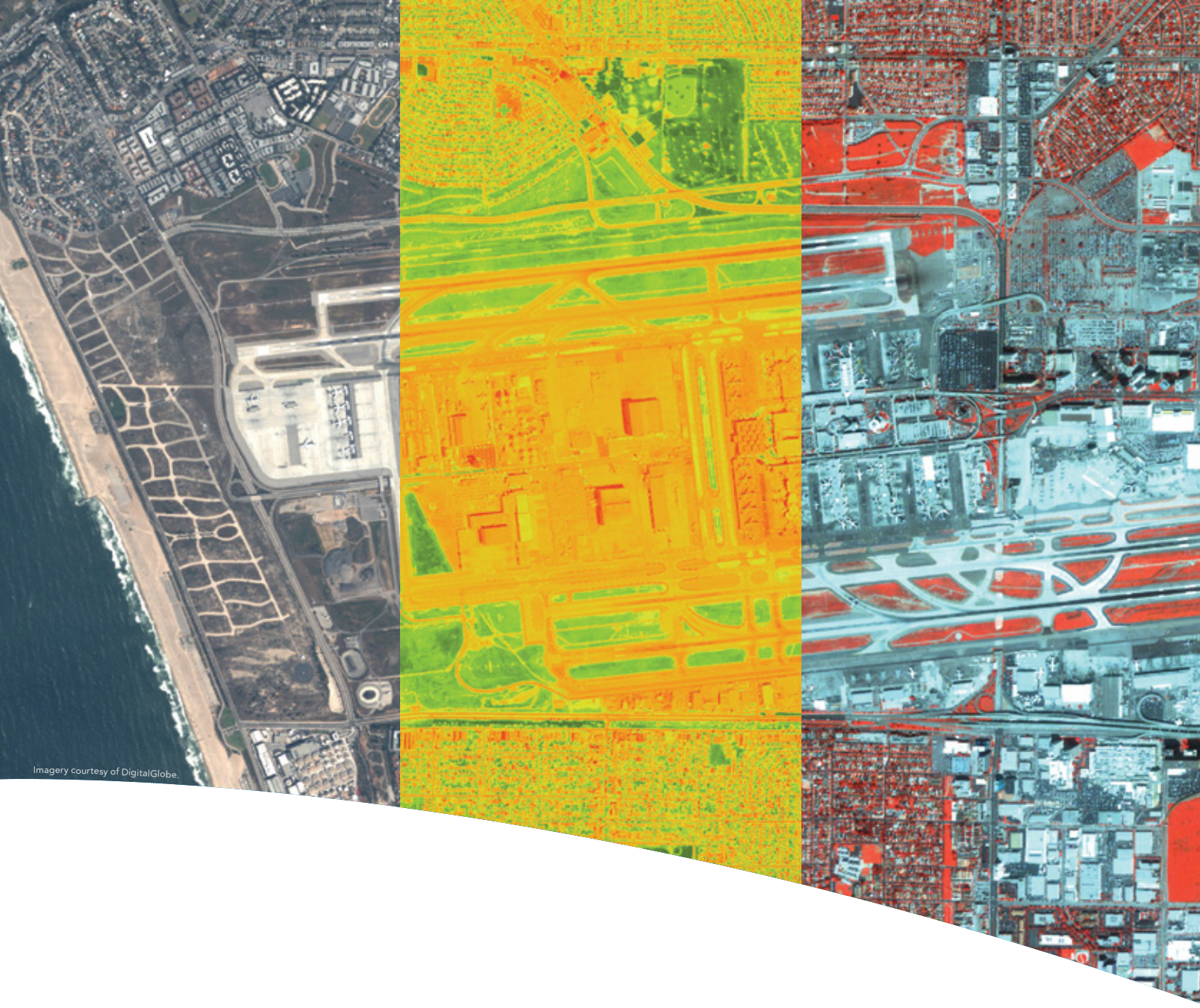
Quickly create and deliver GIS, CAD, point cloud and/or image files.

Revisit the data set to mine data and create additional deliverables at any time.

With this one-source turnkey solution your workflow is as easy as 1-2-3.

topconpositioning.com/MAPPING

TOPCON



Imagine Your Imagery Everywhere

Esri's ArcGIS® simplifies the next generation of imagery management and dissemination through on-the-fly processing, image services, and dynamic mosaicking. With ArcGIS, your imagery is accessible to more people in less time.

Learn more at esri.com/imgnotes

esri®

Announcing the Location Media Alliance

Dear Readers,

Imaging Notes is proud to be a part of the Location Media Alliance (LMA), which includes also *LBx Journal, Sensors & Systems, Informed Infrastructure,* and *Asian Surveying & Mapping*. We offer a combined audience of 59,200 business, technology, and policy professionals. The LMA promotes the power of location analytics and geospatial and remote sensing technologies to improve our world—socially, politically, and economically—with more efficient businesses, smarter built environments, and the better stewardship of our planet's scarce resources.

The LMA will cross-promote and work together in all aspects of our publications, serving distinct user and vendor domains while collectively spanning the full breadth of the geospatial industry and location-based applications. LMA offers an unprecedented coordinated media and advertising distribution platform for optimum market education and brand recognition. Cross-cutting all publications will be quarterly themes, including in the current issues precision agriculture (see page 30). Upcoming themes for all publications are water (Spring), energy (Summer) and security (Fall).

We are celebrating the launch of LMA at the International LiDAR Mapping Forum. Read about bathymetric LiDAR used after Hurricane Sandy on page 24.

DigitalGlobe and GeoEye confirmed the combination of their two companies on Jan. 31, 2013. This begins a new era for imagery, as the combined company will provide a wider variety of earth imagery and geospatial analysis to help customers solve their most complex problems, and to serve better the global market. (See page 11 for more news.) An article about Astrium's offerings will appear in our Spring 2013 issue.

In late January, an important announcement was made at the DGI conference in London by Esri President Jack Dangermond: Esri and DigitalGlobe are expanding their strategic partnership through a collaborative offering of global high-resolution imagery that will be accessible directly from ArcGIS Online as dynamic cloud-based image services. Esri's Director of Imagery Lawrie Jordan noted, "Making recently collected imagery available quickly and simply to millions of GIS users globally is a compelling example of the benefits of leveraging cloud-based GIS as a platform. This is a game-changer for the industry and for our users.

Other exciting developments are occurring under the banner of GeoDesign. At this year's GeoDesign Summit, Bran Ferren of Applied Minds noted that GIS is layers of data at one time, while GeoDesign is a "geo-temporal domain," with temporal compression of data, giving us the ability to tell stories about the past, and future. He says that we must be brave and use GeoDesign to build a "Bill of Rights for the Planet." We can use science combined with engineering and design to rise above the rhetoric and start a public dialog about the subjects that really matter. Watch for articles in the Spring issue.

Finally, not a moment too soon, The Landsat Data Continuity Mission (to be named Landsat 8 after launch) is scheduled for launch Feb. 11, 2013, just after we go to press with this issue. We talk to Jenn Sabers of EROS Center on page 12. This mission is important for the continuity of the nearly 40-year dataset, provided free of charge for users around the world.

Thank you to our long-time strategic partners, Secure World Foundation (read Ray Williamson's column on page 38) and the Alliance for Earth Observations (read the interview with Nancy Colleton on page 20). Thanks also to other long-term Editorial Board members Mark Brender, Anita Burke, Bill Gail and Kevin Pomfret.

Our final board member is Anne Hale Miglarese, who is CEO of newly formed PLANETiQ, a company that will launch a minimum of 12 satellites primarily for weather forecasting, with the vision of having their data available within three minutes! Read more on page 16.

I am more excited than ever to be a part of this industry, as the convergence of cloud computing, Big Data (see article on page 34), standards and crowdsourcing/Community Remote Sensing all come together to bring us closer to the vision of a true "living planet" – a representation of our planet online with real-time data for every part of the world, to be used for the greater good.

It is truly a privilege to be able to report on the trends and new applications that are developing all the time. Thank you for reading. Please email feedback, and keep a close eye on your next issues! We have more exciting news of our own!

Best regards,

Myrna James Yoo
Publisher

LMA
LOCATION MEDIA ALLIANCE

Stay Informed:

on Applications, Technology, Business and Policy

READ THESE PUBLICATIONS

Informed Infrastructure

Informed Infrastructure promotes the combination of sensor inputs, simulation and modeling to tune infrastructure design/build/operation for the greatest efficiency. Areas of coverage include smart grids, water, transportation, facility management, and smart cities. Read daily news updates online, and sign up for the weekly e-newsletter.

www.informedinfrastructure.com

Imaging NOTES

Imaging Notes covers Earth remote sensing for security, energy and the environment with a quarterly print publication and monthly eNews. Reporting is in-depth and exclusive about the uses of imagery and geospatial solutions worldwide.

www.imagingnotes.com

Sensors & Systems

Sensors & Systems provides details on new and existing frameworks of instrumented and interconnected networks and decision support tools to monitor and adapt to global change with daily online news and a weekly newsletter.

www.sensorsandsystems.com

LBx JOURNAL

LBx Journal is location in the language of business – a resource for business professionals who are exploring the location dimensions of business. We connect geospatial technologies with business needs through in-depth reporting and the Location SmartBrief eNewsletter.

www.lbxjournal.com

asm ASIAN SURVEYING & MAPPING

Asian Surveying & Mapping provides news and a weekly e-newsletter focused on geospatial technology applications in Asia-Pacific areas of coverage including surveying, positioning, GIS, and remote sensing tools and case studies.

www.asmmag.com

QUARTERLY LOCATION BUSINESS NEWS REVIEW: HERE ARE THE RECENT
most interesting or important articles according to *Location SmartBrief* readers.

LOCATION ECOSYSTEM

1. **Maps may decide who rules mobile's future** *http://bit.ly/128K4hB* *January 2, 2013*
   Advanced location-based services linked to maps are at the forefront of mobile technology and could play a critical role in which corporate behemoth emerges on top, Rolfe Winkler writes. Apple's disastrous mapping application reinforced Google's sizable lead in the arena, and Google is expected to release a sophisticated predictive tool to provide wireless-device users with information before they even request it.

2. **Why indoor mapping is the next frontier** *http://bit.ly/XRn3c7* *December 12, 2012*
   Indoors is the next mapping frontier for location data, writes Matt Ball. Up-front costs can be high and real-time location tracking can be a challenge, but businesses that take the time and effort will be leaders in indoor marketing. For businesses such as manufacturing plants and hospitals, such maps can improve safety and efficiency.

3. **Geospatial projects found to save time and money** *http://bit.ly/14rlHKL* *January 16, 2013*
   A review of nine geospatial projects by Kim Geomatics revealed that the projects have many benefits, such as cost savings, better market intelligence and increased productivity. Geospatial data can be expensive, however, which might lead to some databases being out of date, but using Web-based databases can help solve that problem, according to Kim Geometrics President Bob Ryerson.

INDUSTRY APPLICATIONS

1. **How location data helped break the Petraeus scandal** *http://bit.ly/YDAxy4* *November 14, 2012*
   Former CIA Director David Petraeus' affair was discovered in part because of location data encoded in a series of alleged harassing e-mails that his mistress sent to another woman. "Email, information-wise, says as much about its sender as its receiver. The messages' metadata told investigators what they needed to know, even if they weren't looking to know it in the first place," this article notes.

2. **Online atlas offers precinct-level view of 2008 election results** *http://bit.ly/WAuC72* *November 7, 2012*
   Researchers at Stanford and Harvard have joined forces to create an online "Election Atlas" giving a precinct-level view of the 2008 election results. The tool lets researchers glean information about the demographic and geographic foundations of President Barack Obama's winning coalition, showing how Obama and John McCain split rural and suburban voters.

3. **Disney introduces bracelet technology to make parks even friendlier** *http://bit.ly/X7t2ZF* *January 9, 2013*
   This spring, Walt Disney World will launch a program that will allow participating customers to bypass entry turnstiles and use rubber bracelets encoded with credit card data to enter and buy items inside the park. The bracelets are part of a vacation management system called MyMagic+, which is part of a larger effort to make the park easier for guests to navigate.

BUSINESS AND STRATEGY PLANNING

1. **Why location data will be a gold mine to marketers in 2013** *http://bit.ly/128K4hB* *January 2, 2013*
   Location-based technology on smartphones will be a boon to marketers in 2013, Neal Leavitt writes. Marketers can target ads and offer instant discounts to customers who "check in" at specific locations. Marketing tech firm Tabbedout caters to users who don't like to broadcast their location by offering applications that allow users to search businesses by ZIP code.

2. **How retailers set prices using customer location data** *http://bit.ly/WAuR1T* *December 26, 2012*
   Some retailers, such as Staples and Office Depot, are using customer location data to set prices when a customer shops online. Prices can be different depending on where a customer lives and how close that location is to a competitor.

3. **How the cloud takes GIS to the next level** *http://bit.ly/14rlHKL* *January 16, 2013*
   Geospatial information systems running in the cloud gives everyone across an organization quick access to location data without worrying about installing software or calling in a GIS professional, Krairop Luanguthai writes. "It provides easy-to-use workflow to enable not only GIS professionals but typical users to convert their own spreadsheet data and create a beautiful map on their own," Luanguthai said.

MONETISING GEOSPATIAL VALUE AND PRACTICES

BRINGING TOGETHER GEOSPATIAL COMMUNITY

Agency9 | ARCADIS | Association of Geographic Information Laboratories for Europe (AGILE) | Astrium | Bentley | Brabant Water | Brazilian Institute of Geography and Statistics (IBGE) | BRGM, France | Cadastre, Land Registry and Mapping Agency | Capgemini | 4C-Grid | Delft University of Technology | Department of Rural Development and Land Reform, South Africa | DigitalGlobe | e-Leaf | Environment Agency Abu Dhabi | Esri | EuroGeographics | European Association of Remote Sensing Companies European Commission | European Environmental Agency | Exelis | GeoBusiness Nederland | Geo-Information Nederland | Geonovum | Google | Group on Earth Observations Heathrow Airport | Hexagon | iCEO/iEEE | Instituto Pereira Passos (IPP) Brazil | International Cartographic Association | ISPRS | King County Municipality | Leibniz Universität Hannover Leica Geosystems | MDA Geospatial Services | Microsoft Bing Maps | Ministry of Lands and Natural Resources, Ghana | Ministry of Municipal and Rural Affairs, Kingdom of Saudi Arabia | Munich Airport | NASA | Open Geospatial Consortium | Oracle | Ordnance Survey of Great Britain | OSGeo | Pitney Bowes Software | Progis | Riegl | Scanex Spectra Energy | Swisstopo | Terrago Technologies | The Joint Research Centre | Topcon | Trimble | UNIGIS, University of Salzburg | University of Wageningen | VALE | World Bank...

TO EXPLORE THE VALUE AND BENEFITS OF GEOSPATIAL TECHNOLOGIES

Monetising Geospatial Value and Practices for Business Enterprises | Monetising Geospatial Value and Practices for National Developmental Goals | Round Table on Geospatial Research and Innovation

FOR POLICY, TECHNOLOGY, AND USER DOMAINS

Land Administration > Public Safety > City Management > Agriculture > Construction & Infrastructure > Mining & Exploration > Capacity Building > Electricity & Gas Water Utility > Cloud Computing > Earth Observation Systems > LiDAR > Open Source > Photogrammetry > Cartography Environment > Asset Management > Gaming and Virtual Reality > Financial Services > 3D > Sensor Web > Big Data > Enterprise GIS > Geospatial Innovations > Airborne Sensors > GI Policy > Spatial Data Infrastructure Crowd Sourcing Vs Field Sourcing > Standards and Interoperability > Spatial Thinking > European Location Framework

FROM ACROSS THE WORLD

Australia | Austria | Bahrain | Belgium | Brazil | Canada | China | Czech Republic | Denmark | Estonia | Ethiopia | Finland | France | Germany | Ghana | Greece | Hungary Iceland | India | Indonesia | Iran | Italy | Japan | Kenya | Korea | Malaysia | Mexico | Nepal | Norway | Poland | Russia | Saudi Arabia | Singapore | South Africa | Sweden Switzerland | Taiwan | Thailand | The Netherlands | Turkey | UAE | United Kingdom | United States of America | Vietnam | Zimbabwe...

WWW.GEOSPATIALWORLDFORUM.ORG

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.sensorsandsystems.com). The stories at the top received the most views for the month. Type in the short URL to access each story or access all here: http://bit.ly/UdsOTO

NOVEMBER	DECEMBER	JANUARY
China Blocks Protection of Antarctica's Waters: Report *http://bit.ly/WkS9cM*	LizardTech Releases Updated GeoViewer Application *http://bit.ly/T7Th75*	DigitalGlobe and GeoEye Complete Combination *http://bit.ly/11o0Jcd*
SAIC Launches GRGlobe *http://bit.ly/Wy6iDi*	Trimble Launches Elite Membership: A Complete Mapping Solution for Outdoor Enthusiasts *http://bit.ly/13UWtoG*	Lockheed Martin Delivers GOES-R Weather Satellite Core Structure for Propulsion System Integration *http://bit.ly/13WABbx*
Envitia Announce the Release of MapLink Pro 7.1 *http://bit.ly/WQwLuz*	Open Spatial Announces the General Availability Release of Enlighten Bi 3.0 *http://bit.ly/VIwtca*	DigitalGlobe Top Satellite Image 2012 - Winner Announced *http://bit.ly/XPSDce*
Trimble Adds Smartphone App to MyTopo Terrain Navigator Pro Software *http://bit.ly/VIu810*	Intergraph Launches Geospatial Portal 2013 *http://bit.ly/13WzxEq*	OpenStreetMap: A Year of Edits 2012 *http://bit.ly/10f0YG1*
Sandy's Devastating Impact to Hudson River Includes Widespread Toxic Spills *http://bit.ly/W9ZL47*	New Release of SuperGIS Engine 3.1 Beta *http://bit.ly/13UX1Lj*	New Norwegian Satellite to Monitor the High North *http://bit.ly/YhY9s4*
BroadMap Releases MapConnect Enterprise 2012.10 with Enhanced Census and Postal Data *http://bit.ly/XuDjPB*	Leica Geosystems Introduces Virtual Vista for Farmers *http://bit.ly/Xrz7kb*	1Spatial & LSI Partnership Awarded Important U.S. Census Bureau Contract *http://bit.ly/11KDHRi*
NASA Maps How Nutrients Affect Plant Productivity *http://bit.ly/XrycAb*	WCS Applauds Dept. of Interior Plan Balancing Conservation and Energy Development in NPR-A *http://bit.ly/VUkj0Q*	USGS Issues an App Development Challenge *http://bit.ly/WyaGCu*
Avenza Releases MAPublisher 9.1 for Adobe Illustrator *http://bit.ly/Wy7F4S*	GeoSpatial Experts Introduces GeoJot+ Subscription to Mobilize Field Teams *http://bit.ly/WkUKDP*	Sherborne Sensors Automates Mineshaft Inspection *http://bit.ly/UdsEf1*
Intergraph Introduces GeoMedia WebMap 2013 *http://bit.ly/YhX8A2*	Mission Accomplished for Landsat 5 *http://bit.ly/10wLEt0*	Pléiades 1B Captures First Images Using e2v Sensors *http://bit.ly/ViwGSf*
Microsoft Announces Release of UltraMap v3.0 *http://bit.ly/Wh5oKC*	European Earth Observation Programme Renamed Copernicus *http://bit.ly/VivQ85*	U.S. Forest Service Forecasts Trends and Challenges for Next 50 Years *http://bit.ly/WQydNi*

COLOR-CODED CATEGORIES:

Corporate News | Product News | Policy/Research | Global Change | Energy | Environment | Food/ Agriculture

Jenn Sabers

Remote Sensing Branch Chief, EROS Data Center, USGS

This interview originally appeared in *Sensors & Systems*. It can be accessed online at www.sensysmag.com/dialog/interviews.

Landsat Poised to Meet Scientific Mission

LAUNCH SCHEDULED FOR FEB. 11, 2013

THE LANDSAT DATA CONTINUITY Mission (ldcm.nasa.gov), a joint project between NASA and the U.S. Geological Survey, is poised to deliver better data to monitor global land-use change with the planned launch of Landsat 8 on Feb. 11, 2013. *Sensors & Systems* (S&S) special correspondent Matteo Luccio spoke with Jenn Sabers, Remote Sensing Branch Chief, Earth Resources Observations and Science (EROS) Data Center, U.S. Geological Survey (USGS), about the upcoming Landsat mission, the technology, and the important role of meeting the scientific mission.

S&S *What intellectual and academic path brought you to this job?*
SABERS I began in mathematics, here in South Dakota. I was familiar with the EROS Center and visited EROS in college, as part of a math club. I remained in mathematics and got my Master's Degree from the University of South Dakota. I wanted to come to EROS because I was very interested in its mission of understanding the changing Earth and what it did with its data in studying Earth resources. I originally came to EROS to work on the data processing side and programmed mathematical equations to process Earth imagery. Then, I got more and more into the satellite missions and now head up the preparation for participation by the USGS in the Landsat Data Continuity Mission (LDCM).

▶ **FIGURE 1.** *This image shows Guinea-Bissau, a small country in West Africa. Complex patterns can be seen in the shallow waters along its coastline, where silt carried by the Geba and other rivers washes out into the Atlantic Ocean. Image taken Dec. 1, 2000, by Landsat 7.*

S&S *For what aspects of the mission are you responsible?*
SABERS It is important to understand that Landsat is a joint program managed by both USGS and NASA. It is a great partnership that has existed for the 40 years of the Landsat program. NASA is primarily responsible for building and launching the satellite and USGS is responsible for the ground aspects, which include flying and operating the satellite and receiving, processing, archiving, and distributing the data. So, here at EROS, we are ensuring that all the systems are in place to perform all of those tasks.

S&S *And you head all of that?*
SABERS Yes. We have more than a dozen government staff who oversee our technical services contract, as well as other contractors for other portions of the mission.

S&S *Who at NASA do you work with the most closely?*
SABERS We work closely with several folks at NASA. We work mainly with Ken Schwer, LDCM Project Manager at NASA's Goddard Space Flight Center in Greenbelt, Maryland. So, for developing the ground system, we tend to work through Ken at the overall LDCM mission manager level.

We also work with Jim Irons, who is the Landsat Scientist at NASA Goddard. We work extremely closely with the science community, because we want to insure that the mission meets the science requirements and needs to the maximum extent possible. Our Chief Scientist here at EROS is

"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."

Dr. Tom Loveland, who was instrumental in establishing the first Landsat Science Team, which he co-chairs. A new Landsat Science Team was recently selected and announced.

S&S *How does Landsat 8 differ from previous Landsat satellites?*
SABERS There are a number of significant improvements. The operational land imager (OLI) is a push-broom system, which is an enhancement from our prior instrument. It has two new spectral bands: a blue, visible channel, which is specifically designed for water resources and coastal zone investigation, and a new infrared band that we use for detecting cirrus clouds. Those are both significant improvements.

Also, the quality of the data has increased, and we expect to see significant improvement in our ability to detect changes on the Earth's surface. Another improvement is that we plan to collect at least 400 scenes a day, which is a significant improvement over the current Landsat mission. Not only will the data we get be of higher quality and more spectral depth, but we will get much more coverage of the entire Earth.

S&S *What is your perspective on consistency vs. improvements with regards to Landsat products?*
SABERS With the Landsat products, there is a fine balance between consistency and improvements. Since Landsat has been around for more than 40 years, we are the leading resource in being able to do long-term Earth studies. It is essential to maintain that consistency, so that we can continue that longest global data record of the Earth. So, consistency in areas such as spatial resolution, calibration, and spectral characterization is extremely important. However, we do want to take advantage of advancements in engineering and remote sensing, to try to ensure that we're getting the best data and the most data as cost-effectively as possible for the users and the government.

S&S *Will UAS (unmanned aerial systems) and/or microsats change the role of Landsat?*
SABERS The National Research Council hosted a workshop earlier this year, on behalf of the USGS, to get a sense of the current state of smallsat technologies and how they can be utilized for future Landsat missions. We want to ensure that Landsat is operational and that we have a solid path forward. We want to take advantage of new technologies, but we need to assure that they are proven and can maintain our long-term data records and that we can maintain that consistency. We definitely want to keep monitoring the technology and, when the time is right and we have confidence in it, take advantage of it.

The approach has not yet been decided for any mission past LDCM. However, we want to take advantage of any sort of future technology, as long as we can ensure that we can get the global coverage and the type of imagery that we need to satisfy our user needs. There is also potential for UAS and microsat technology for augmenting Landsat's capabilities.

S&S *What has been the biggest change in Landsat during the life of the program?*
SABERS It is the free archive of Landsat data. It became freely available several years ago and that has revolutionized the way that scientists study land change across the entire planet. It has increased the types of studies that are done and the number of uses of Landsat data. One area in which we've seen a large increase in monitoring is evapotranspiration. The western states, in dealing with water rights, have used Landsat data heavily over the past few years and I think that it is due to the fact that it became freely available and so the number of applications of the data has grown.

THERE ARE A NUMBER OF SIGNIFICANT IMPROVEMENTS. THE OPERATIONAL LAND IMAGER (OLI) IS A PUSH-BROOM SYSTEM, AND IT HAS TWO NEW SPECTRAL BANDS: A BLUE, VISIBLE CHANNEL, WHICH IS SPECIFICALLY DESIGNED FOR WATER RESOURCES AND COASTAL ZONE INVESTIGATION, AND A NEW INFRARED BAND THAT WE USE FOR DETECTING CIRRUS CLOUDS.

S&S *Do you have any final comments?*
SABERS Landsat is the most comprehensive record of the global landmass ever assembled. The Landsat archive, going back to 1972 and continuing into the future with LDCM, provides an unprecedented record of the status of the Earth's natural resources and human activity. The Landsat program's success is largely due to the great partnership between NASA and the USGS. I hope that we can build on that for future missions.

asprs THE IMAGING & GEOSPATIAL INFORMATION SOCIETY

Confluence by the Bay — A Gathering of Geospatial Insights

ASPRS 2013 Annual Conference

March 24–28, 2013

Baltimore Marriott Waterfront Hotel

Baltimore, Maryland

www.asprs.org/Conferences/Baltimore2013

The ASPRS Annual Conference returns to Baltimore, Maryland March 24–28, 2013. The conference theme: **Confluence by the Bay — A Gathering of Geospatial Insights**, refers to the "coming together" of researchers and practitioners for the purpose of open dialogue with respect to the most recent advances in geospatial analysis. The term "confluence" also has meaning in the assessment of the three earth's spheres (hydrologic, terrestrial, and atmospheric) via remote sensing; very apropos for our conference location on the eastern seaboard of the United States. Year 2013 promises to be an encouraging period due to the successful launch (scheduled for February 2012 – fingers crossed!) of the LDCM Earth observing satellite. We anticipate first look imagery from Landsat 8 will be presented at our meeting.

Follow Us

#ASPRS13A @ASPRSorg

EXECUTIVE INTERVIEW

Anne Hale Miglarese

CEO of PLANETiQ

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

PLANETiQ

A NEW SERVICE MODEL PLANNED FOR EARTH MONITORING

THE RECENT IMPACT OF SUPERSTORM Sandy speaks to a need for greater weather monitoring, particularly in light of an aging constellation of satellites. This coupled with the budgetary constraints on federal agencies provides an opening for private industry to fill in the gaps. PLANETiQ is a new, privately funded start-up company that plans to launch a constellation of microsatellites to provide real-time data about our atmosphere and planet. *Sensors & Systems* (S&S) editor Matt Ball spoke with Anne Hale Miglarese, CEO of PLANETiQ, about the company's plans and approach.

S&S *How did PLANETiQ get started?*

MIGLARESE In 2006, there was a mission called Cosmic, which was a collaboration between the Taiwanese space agency (NSPO) and UCAR (University Corporation for Atmospheric Research) in the U.S. to fly an experimental constellation of six satellites; they were launched in 2006. The technology is GPS-RO with the RO standing for radio occultation.

The Cosmic program, which was experimental by design, has been wildly successful with many of the forecast agencies around the world seeing a dramatic improvement in their weather forecasts, to the extent that several national weather forecast agencies around the globe now have GPS-RO data in their operational forecast models. This has been a significant gate to cross from a technical validation standpoint. However, the Cosmic-1 constellation is degrading rapidly. There are only four out of six satellites that are operational now, and the life expectancy of the remaining is dropping dramatically.

The follow-on mission that was to be Cosmic-2 has run into a whole host of issues. Part of the burning platform are the severe issues that have been encountered by NOAA and the U.S. Air Force in flying their weather missions, including program cancellations that we've seen for both. They have much larger issues to approach right now in dealing with the basic data that they need. GPS-RO data does not immediately replace any of the traditional data required, but it improves the impact of that data and the forecast significantly for extreme events. You can see where this is of great interest to forecast agencies.

Broad Reach Engineering built the original GPS-RO instrument for the Cosmic mission and gratefully are one of PLANETiQ's financial investors. There's been a good deal of talk for seven or eight years about commercializing GPS-RO data. I think the science community is on the verge of embracing commercial organizational efforts to supply this data. They understand how important it is, as well as the limitations that so many countries around the world face in funding a full-scale mission for GPS-RO data.

Within that environment, Chris McCormick, founder of Broad Reach, has brought together two additional firms, Moog and Millennium Engineering and Integration, to provide the seed capital for PLANETiQ. We are putting together the business plan to raise the capital required to make this a reality.

S&S *Is it a phased approach with a constellation of satellites to span the globe?*

"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."

power grid operators. If we get a solid constellation of 12, and particularly if we can take it to 24, there will be a dramatic increase in the ability to monitor and forecast space weather.

That clearly is a product that we'd like to offer the community. The effectual primary parameters of data that come off of this sensor are temperature and pressure, and secondary data include water vapor, wind speed and wind direction. This is vector-based data, from the atmosphere back to the spacecraft in low Earth orbit. It's not big data, but a profile for multiple points with X, Y and Z coordinates. That raw data is ingested in forecast models to then make a forecast.

There is four trillion dollars in weather risk impacting the economy every year. There are a whole host of applications, with every citizen, society and business interested in weather. Globally, society is very interested in climate change. Another very important variable of this data is the ability to improve climate models over time.

SEVERAL NATIONAL WEATHER FORECAST AGENCIES AROUND THE GLOBE NOW HAVE GPS-RO DATA IN THEIR OPERATIONAL FORECAST MODELS.

MIGLARESE Ideally our maximum constellation would be 24 satellites. Right now, we're looking at 12, and we'll need approximately $125 million for that. Each satellite is about 75 kg, with launches of four at a time in three consecutive years. The 12 satellites will provide excellent data across the globe.

S&S *You mentioned the weather forecast measurement as the primary market. Are there other areas of measurement and monitoring that you can monetize?*

MIGLARESE The ionospheric space weather measurements are of huge interest to the United States Air Force as well as a large number of commercial organizations that operate satellites in space, the airlines, and

S&S *Are you planning to provide a service?*

MIGLARESE We will be a data provider, not a service provider. We will have professional expertise necessary to support our customers as they ingest the data, but we will not offer services. There are many highly qualified government agencies and private weather companies across the globe, and we look to them as our customers.

S&S *So, the opportunity is clearly a business opportunity, but is it also tied into policy?*

MIGLARESE I think there are many interesting policy questions here, most of which parallel the policy issues that have played out in the satellite imagery business. I'm grateful to have spent decades in the imagery world to have learned some of those lessons.

Our customers in the United States will be organizations like NOAA, the United States Air Force, which I've met with several times already, the United States Navy, and the National Science Foundation. I would see NOAA as holding a license to distribute the data throughout the federal civilian government. The Air Force will hopefully buy a license for the DOD efforts, the National Science Foundation could distribute the data to all of their principle investigators who are engaged in research related to weather and climate variability.

If you look at the other governments around the world, I see very similar customers in those organizations. In France for instance – their weather organization, their Air Force, and their climate research organization. Those are the type of government customers we're looking at.

As far as commercial customers, those very high-end weather forecast companies that generate tailored forecasts for their commercial customers, and their customer base may be the Future's Market, commercial airlines,

shipping or the derivatives market. There are a few handful or more of those companies in the United States and around the globe, and we see those as potential customers. We want to focus on what we believe we can do well, and that is to provide the data.

S&S *With this Summer's drought, I remember reading about analysts in the Future's Market getting out of their offices to visit fields and verify more directly, which speaks to a need for more granular data. Do you have experience with the Future's Market?*

MIGLARESE Not yet. I've been on the job about three months now, and I'm employee number one. We're working with lawyers to set up all the corporate documents and things of that nature. I recently traveled to Boulder for a science meeting where many of the GPS-RO scientists from around the world gathered for their annual conference.

Something worth mentioning is that one of the reasons we have Landsat today is based on the Future's Market. The first large-scale commercial Earth observation mission was the LACIE Project. It was a study done in the early to mid-1970s to look at crop forecasts locally for the Future's Market, and it is still an application of Landsat data today.

S&S *Is the future maybe a living model, with direct updates from multiple systems?*

MIGLARESE Maybe. This data will be delivered via an Inmarsat terminal, and will be available within three minutes of taking the observation. I think another interesting policy implication, where your question is leaning, is that in the imagery world we are dealing with commercial industry providing data to the government where traditionally governments owned their own data.

There was NextView and then EnhancedView, and there's certainly a lot of activity around that right now. The intelligence community has been grappling with this for a whole host of reasons for twenty years. I've spent a decade working for NOAA, and working on many of these imagery issues. In an ideal world, government might have all the resources necessary to collect all the data possible, and to distribute it. But, I just don't see that happening; I don't believe that is the model of the future.

> THERE IS FOUR TRILLION DOLLARS IN WEATHER RISK IMPACTING THE ECONOMY EVERY YEAR. THERE ARE A WHOLE HOST OF APPLICATIONS, WITH EVERY CITIZEN, SOCIETY AND BUSINESS INTERESTED IN WEATHER.

NOAA, like the National Geospatial-Intelligence Agency (NGA), is grappling with the cultural and policy issue of identifying the highest priority targets where they will absolutely collect their own data, and where they will partner with the commercial sector to acquire data. You're familiar with NextView and EnhancedView, and I anticipate the same sort of evolution across the U.S. federal civilian government agencies.

S&S *How much of the shift is due to risk and high profile of satellite failure, and the need to cut costs?*

MIGLARESE It is very difficult for a government to build an operational satellite. All of the programmatic reviews that they have to go through, and the requirements analysis, tends to lead to mission creep. Regardless of who you are, whether you are NOAA or another agency, that happens and when it happens you add a tremendous amount of cost.

We are very focused on providing GPS-RO data on a 75-kilogram satellite that we can build, launch and insure for $5 million per satellite. That's an efficiency that I just don't believe it is possible to achieve in government, given all the things that a government has to do to oversee the citizens' and taxpayer investment. At that level of accountability and complexity, it becomes very expensive.

S&S *The $125 million figure for this global constellation seems small, certainly when compared with government programs. The ability to launch four satellites at once also sounds compelling. Are these costs and efficiencies only possible with recent advancements?*

MIGLARESE I think the timing is right with the commercialization, and I think society is encouraging that. The reason that I embrace this challenge is that I'm really passionate about what the data can do to improve the forecast around the globe, and to give us better science about what is going on with our climate. Regardless of what your personal beliefs may be about what is changing the climate, the climate is changing. We need to do a much better job of trying to understand that and to mitigate those changes. It's so much fun to be working on an issue that is so important to society.

S&S *There have been a number of mandates to spur action, with such things as carbon markets to factor in the economic impacts of greenhouse gas emissions, as well as the economic benefits of carbon sinks. Are mandates a necessity to spur the next level of awareness?*

MIGLARESE I think there are a couple of issues. There is the general commercialization of space with this administration. You just have to look at the Space Shuttle program, and what's happened there. I don't think anyone would have thought that commercialization was possible six years ago.

There are also all the financial issues that our country has to face in the next ten years, and how those changes will impact the budgets of the Air Force, NOAA, and NASA. We need to consider the appropriate roles of government, as you look at efficiencies that can be garnered in the private sector, but where the data can also contribute to a public cause.

> THIS DATA WILL BE DELIVERED VIA AN INMARSAT TERMINAL, AND WILL BE AVAILABLE WITHIN THREE MINUTES OF TAKING THE OBSERVATION.

The important thing is that citizens get an accurate forecast and can get out of harm's way, and that we understand the impacts of weather on climate and ecosystem services. There is a part of that mission that is inherently governmental, but does it have to be as a supplier of data? Those are huge policy questions that I think will be addressed in the next couple of years.

Every citizen, government and business wants better weather data. Forecast agencies across the globe have done a fabulous job of improving the forecast over the last ten years, and I think this data can help them even more.

S&S *The latest stumbles of the GOES-13 weather satellite speak to a greater redundancy. Has that spurred you on, and helped the cause?*

MIGLARESE They did a great job of moving that spare satellite into action. Imagine what would have happened if that spare wasn't there. Those satellites are multi-billion dollar satellites, and they are very important to have. We aren't talking about multi-billion dollar satellites; we're talking about $5 million satellites, with a constellation that is going to cost $125 million that provides a dramatic improvement on the forecast when assimilated with the other data. «

EXECUTIVE INTERVIEW

Nancy Colleton

President, Institute for Global Environmental Strategies

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

Environmental Intelligence Important for the Economy

THE CASE FOR ENVIRONMENTAL MONITORING

DURING THE DEBATES OF THE RECENT presidential race, both candidates avoided the polarizing issue of climate change, although there was certainly some mention during both campaigns. Now that the Obama administration will continue, many are asking what steps will be taken, particularly in light of the historic east coast storms. *Sensors & Systems* (S&S) editor Matt Ball recently spoke with Nancy Colleton, president of the Institute for Global Environmental Strategies and co-founder of the Alliance for Earth Observations, about a recent column that she wrote on the next administration's priorities and the need to foster Earth observation's connection between the economy and the environment.

S&S *The Alliance for Earth Observations has provided a nice platform for policy discussion in Washington. How will the Alliance contribute in the future?*

COLLETON One of the things that the Alliance can do is to help provide the connection between industry and the federal government. If you're a private sector company and you have a new idea, or a different way of doing things, I think it's really hard to understand where those entry points might be. There are some barriers of course on the federal side that prohibit engagement with a number of companies in some ways. We're hoping that we can provide a solution to that, become a conduit for new ideas, and connect those ideas to federal agencies.

S&S *Your recent column [http://wapo.st/116wwny], discusses the Earth observation gaps that we face. It's coming to a head isn't it?*

COLLETON There was a piece recently in *Federal Computer Week* where they were talking with David Powner [director of IT management issues for the Government Accountability Office (GAO)], who has done many studies on satellite weather coverage, and he's quoted as saying that there will probably be a 17-month gap. NOAA issued a request for public comment this week seeking ideas on "contingency options" in the event of a gap. So, all signs seem to point to the very unfortunate predicament of a gap in our weather satellite coverage.

S&S *What about our analytical capabilities? Is the U.S. falling behind?*

COLLETON There have been several pieces published in *USA Today*, *The Wall Street Journal*, and other leading publications that talk about how European weather forecasts of Hurricane Sandy came out earlier than the U.S. forecast.

The editorial in *The Wall Street Journal* was by Kerry Emmanuel, professor of atmospheric science at MIT, who talks about why America is falling behind in weather forecasting, identifying the fact that the European model came out first. The U.S. forecast was right on target; it's just wasn't produced as quickly. When you look at this across the whole of U.S. Earth observations, it's really scary, because weather is our most sophisticated area when it comes to observing and producing forecasts. So, if this is where we are with our weather capability as a nation, what does that say about other areas like ocean observation, climate, terrestrial monitoring, and water

"If there is one thing the Obama Administration could do over the next four years to really make a difference, it would be to make environmental information a priority."

WE NEED TO FIND A BETTER WAY TO TIE THIS INFORMATION TO ECONOMIC SECURITY.

availability? How will we ever move towards integrated information that produces environmental intelligence?

S&S *Is there a lack of leadership or is the science community just not being paid attention to?*

COLLETON I do believe there is a lack of leadership. You have these capabilities spread through a number of federal agencies. The U.S. Geological Survey is responsible for the Landsat program; NASA is doing research satellites; NOAA is responsible for the operational weather satellites; the National Science Foundation is funding research, and then you have cubesats, uavs, aircraft, ocean buoys, balloons, stream gauges, and on and on… When you consider our Earth observation capabilities and the number of agencies involved, there's really no one responsible at a high level to look at all these capabilities and to make sure that the United States has a vision and a road map for achieving it. What is different is that we need to find a better way to tie this information to economic security.

If there is one thing the Obama Administration could do over the next four years to really make a difference, it would be to make environmental information a priority – find ways to infuse greater innovation and efficiency, to engage the private sector both as users and providers of information, and to establish a long-term plan.

I think we desperately need to focus on taking that government investment and leveraging it to grow the U.S. economy. That happens two ways: first, all this environmental intelligence that is produced helps us to better manage risk. The second way is in building up the capacity and private enterprise around the government investment. You see that with weather. At The Weather Channel, for example, they don't have their own satellite; they use satellite data from NOAA.

S&S *What are some of the strong economic impacts?*

COLLETON If you just look at it from a natural disaster standpoint the numbers are staggering. Equicat estimates that Hurricane Sandy is resulting in $20 billion in insured losses, and $50 billion in economic losses. Those numbers are likely to rise though, because the power is not back on, some stores are still not open, and there are still transportation issues and structural issues around New York.

Crop losses from the drought are estimated at $25 billion. The drought also has caused low water levels on the Mississippi, which have led to commerce and transportation impacts. *The New York Times* recently reported that $7 billion in products could be stalled in the December-January timeframe if water levels don't increase.

S&S *It's something that was forecast, in terms of long-term warnings, that this level of damage might be possible with a major storm, just like Hurricane Katrina was one of the top ten possible disasters and then it occurred. When is there some liability for not reacting to these long-term forecasts and building in some resilience and adaptability?*

COLLETON I think that's a really important question. A couple of weeks ago I was invited to speak on a satellite colloquium at a law firm. They were asking about some of the legal and regulatory issues coming up. The complexion of our forecasting sources is changing, and with climate change becoming ever more present, there are people who may ask, "why didn't we better prepare?" At some point I think there is going to be some liability somewhere. I'm not sure it will happen any time soon, but I suspect it will happen.

Already there have been shareholders of companies that have been wondering, if the company is damaging the environment (specifically thinking about climate), what's their liability as board members and shareholders? Turning it around, if you have more companies in the weather enterprise

that are issuing forecasts, and there are major business losses related to those forecasts if they are not accurate, what's the liability related to that?

S&S *The models have been very predictive, where the lay of the land in New York City amplifies a storm surge. Why aren't we planning and designing around those eventualities?*

> WHAT THE OPENEIS DOES IS PROVIDE THE MECHANISM FOR WIDER ACCESS TO GOVERNMENT-COLLECTED EARTH OBSERVATIONS.

COLLETON Exactly, and I come back to all of this as environmental intelligence. What can these products tell us about improving our infrastructure as a nation? We put so much money into the economic stimulus, but were we taking climate change into account while we were building those new roads and bridges?

If you look at states like North Carolina where there have been moves, even proposed legislation, not to recognize climate change, one has to ask whether those policy makers are putting their citizens at risk? I always argue that whether you believe in climate change or not, you have to agree with the need for long-term forecasting. We have to improve the capabilities that allow us to look at events like storms and drought in the context of trends.

S&S *It's disconcerting how much climate change has been politicized.*

COLLETON What I try to do is to talk about all of this as environmental intelligence. I look at it in the light of why we need long-term forecasting. If we're going to have 80- or 90-mile-per-hour winds as the new norm, we need to build our houses differently.

The Institute for Business & Home Safety (IBHS) is putting out new standards for how we build based on these trends. At the last Forum on Earth Observations, Carl Hedde, who is head of risk accumulation at Munich Reinsurance, showed video of two houses built similarly, and that have been put in a huge wind tunnel. One of the houses has brackets to hold the roof down, the door opens outward rather than inward, and it has fortified windows and siding. Both houses were built to modern standards, with just $3,000 invested for the fortifications. They did an experiment with Category 3 hurricane winds. The house without the added elements was destroyed. It looked like the Big Bad Wolf had blown it down! [http://www.youtube.com/watch?v=cXF44jBBwxU]

Home builders want to be building good homes, so you do see movement in this sector to better prepare homeowners so that they can withstand more severe weather events. And the companies that insure those homes are providing their customers with reduced rates if houses meet new, safer standards.

S&S *The recent column that you wrote points to the economic impact. Have you had good response to that?*

COLLETON I have had very good feedback, and people have been very appreciative that I made the link with the economic argument. Investment in these systems, and the entire supply chain of environmental information, is directly relevant to our economy. In fact, I did a short piece on The Weather Channel as well.

Earlier this summer we were looking at insured crop losses of $20 billion and now $25 billion. We saw the impact of that globally with the rise in food costs. When you look at the ideas for what the administration could do, there is an effort underway for adopting what is called Open Environmental Information Services (OpenEIS).

This came out of a report produced by the Environmental Information Services Working Group that I co-chair with Walt Dabberdt of Viasala for the NOAA Science Advisory Board. The OpenEIS concept provides the non-federal sector with more access to all of the information that the government has and it also recommends better and earlier engagement with the private sector in algorithm development and other technology areas.

NOAA regularly releases its forecasting and data, but there's a lot of other data that doesn't get released that may be helpful to a particular sector. The OpenEIS concept challenges the federal government to look at ways that we can bring the private sector inside the walls of these data centers with better access to the incredible amount of existing data.

S&S *The computing power, coupled with cloud storage, is really extending the needed tools to the average citizen.*

COLLETON That's true, but if you don't know someone within the community, how do you get access to understand what we really have? What the OpenEIS does is provide the mechanism for wider access to government-collected Earth observations. There are all kinds of data where it is still difficult to get access.

S&S *There seems to be a bit of backlash for the fact that climate change wasn't mentioned at all during the recent presidential debates. There is a lot of hope now that it will become a focus area.*

> WHETHER YOU BELIEVE IN CLIMATE CHANGE OR NOT, YOU HAVE TO AGREE WITH THE NEED FOR LONG-TERM FORECASTING. WE HAVE TO IMPROVE THE CAPABILITIES THAT ALLOW US TO LOOK AT EVENTS LIKE STORMS AND DROUGHT IN THE CONTEXT OF TRENDS.

COLLETON Hopefully, we can rise above the political division in this country and address the significant topic of climate change because it is related to so many other important topics such as water availability, the health of our coastal regions, agriculture and more.

S&S *I really appreciate your approach, and this idea of the E-Q-Tel project (that would establish an E-Q-Tel organization based on the successful In-Q-Tel model to help accelerate Earth-related technologies that advance environmental intelligence, recommended by Colleton in her* Washington Post *article) that would team the government with industry to put the United States back into a leadership role in terms of both Earth observation capacity as well as analysis.*

COLLETON You know all of our issues aren't technical or financial. A lot of them are process-oriented, and I think we need a new way of doing business that gives the country the ability to develop these technologies on a faster track. That's what the In-Q-Tel model does for the intelligence sector and the E-Q-Tel model could do for our civil environmental information sector. We don't have this on the civil side, and we need it.

S&S *There is so much on the military side that gets classified and hidden behind walls. Is there any hope that some of those barriers will come down, specifically for historical data that could be so helpful for understanding change?*

COLLETON I have absolutely no experience working on the defense side. However, I have learned a great deal from my colleagues in the aerospace field that serve both civil and defense programs. And, one of the key lessons is that data alone will not solve our problems, but analytical tools certainly lead to better intelligence for decision-making, whether on a battlefield or a boardroom.

Look at New York right now: policy makers need that same integrated battle space capability to understand what's happening there, to respond, and to reconstruct. So in addition to data, we should be sharing best practices and new technologies. There has to be a way to bring some of those risk management capabilities to the civil side, and it's not just data.

S&S *Are you optimistic about the next four years?*

COLLETON I am optimistic and certainly energized to keep working to improve our U.S. environmental information capabilities. There has been attention, even prior to Hurricane Sandy, on our weather forecasting capabilities. However, we also need more support for climate, ocean, land, and more atmospheric observations. Space weather is also an important area we should not ignore. Environmental intelligence extends beyond weather and I hope that our national approach includes giving responsibility to someone at a high level to manage these important capabilities in the future.

BATHYMETRIC LIDAR

SANDY'S COASTAL IMPACT

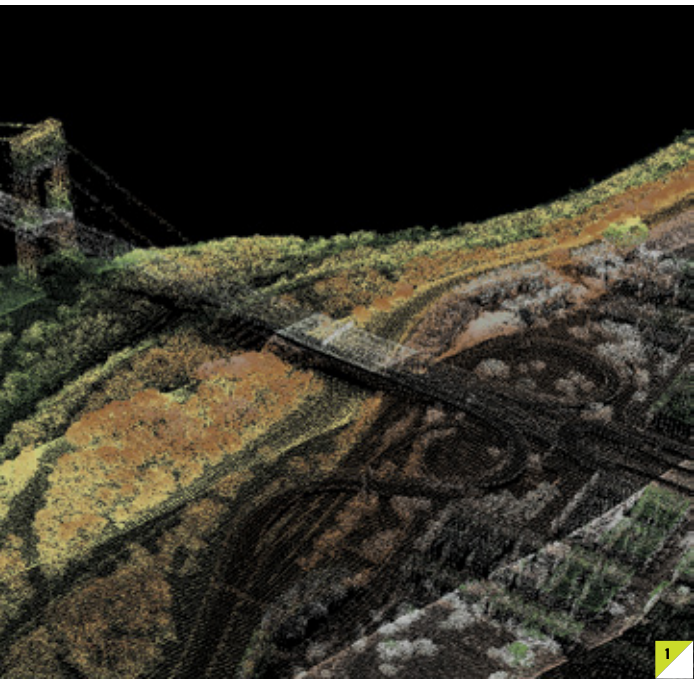
Detailed and accurate charting of the sea bottom along coastlines is vital for environmental monitoring and remediation, shoreline construction, and coastal navigation. Each of these activities requires reliable depth data for planning and management purposes. However, sonar-equipped vessels conducting hydrographic surveys cannot navigate very shallow or rocky coastal areas or narrow inlets with high tidal ranges, and topographic airborne LiDAR mapping (ALM) systems cannot penetrate the water. Airborne LiDAR bathymetry (ALB) fills this gap: as a supplementary survey method, it provides a seamless transition between mapping the land and charting the sea.

EDITOR'S NOTES All images except the last two are of point clouds collected with an Optech CZMIL sensor and are courtesy of JALBTCX and Optech.

MATTEO LUCCIO
Contributing Writer
Pale Blue Dot LLC
Portland, Ore.
www.palebluedotllc.com

Superstorm Sandy — technically, a post-tropical cyclone by the time it made landfall along the coastline of the United States on October 29 — affected 24 states, including the entire Eastern Seaboard from Florida to Maine, causing particularly severe damage in New Jersey and New York. Storm surges, made worse by the full moon, caused high tides to rise about 20 percent higher than normal and wreaked havoc along hundreds of miles of coastline. Its impact included widespread flooding, erosion, and movement of millions of tons of coastal sediments with the extreme power of storm-driven water — thereby actually altering vast stretches of coastline.

In the wake of this devastation, dozens of federal, state, and local agencies, as well as many private companies, contributed to the response. A couple of weeks after the storm, the Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX) of the U.S. Army Corps of Engineers (USACE) flew its Coastal Zone Mapping and Imaging LiDAR (CZMIL)



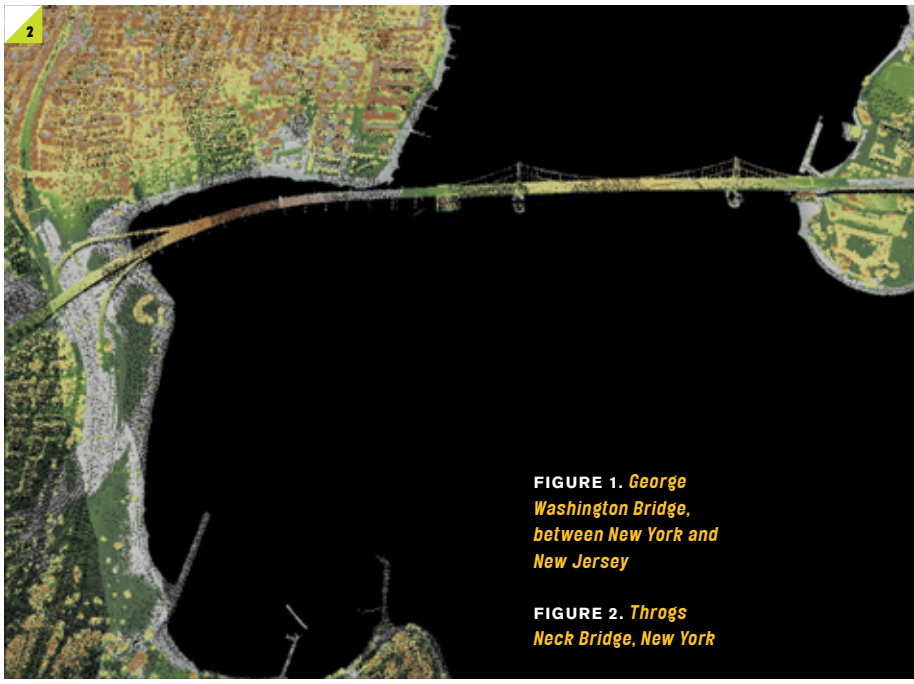


FIGURE 1. *George Washington Bridge, between New York and New Jersey*

FIGURE 2. *Throgs Neck Bridge, New York*

along several stretches of the northeast coast, collecting a consistent data set.

How Bathymetric LiDAR Works

Bathymetry has traditionally been performed using echo sounders (sonars) mounted on ships or boats. The use of multi-beam echo sounders has allowed for highly detailed, accurate seabed charting. While these systems can measure depths even in very shallow water, boats cannot access areas with skerries, shallow reefs, long shallow beaches, large waves, and underwater currents. Furthermore, echo sounder systems are expensive and difficult to deploy at short notice.

ALM systems operated from fixed or rotary wing aircraft, on the other hand, can be deployed at short notice and enable accurate, cost-effective data collection, but use an infrared laser that has poor water penetration capabilities. Therefore, in coastal zones the combination of these two technologies is not always sufficient to create seamless mapping.

ALB systems are also operated from aircraft. However, unlike ALM systems, they transmit two light waves, one in the infrared and one in the green portion of the electromagnetic spectrum, and are capable of separately detecting the returns from each. The infrared band is quickly absorbed and is therefore used to detect the water surface. The green band, which is the optimum color to achieve maximum penetration in shallow water, is used to delineate the sea bottom.

As the pulse of green laser light travels through the water and reflects off the seabed, it is subjected to refraction, scattering, and absorption, which attenuate it and limit the depth of water that it can measure. The greater the water's particle content, the greater the backscattering, up to the point that it becomes impossible to distinguish the backscatter from the bottom return.

Therefore, the maximum depth for ALB is determined by the reflective characteristics of the seabed and by water clarity. Under ideal conditions, the theoretical maximum depth measurement is about 70 meters.

In order to penetrate the denser medium of water and then minimize scattering, LiDAR bathymetry requires much higher power and longer laser pulses than topographic LiDAR. Therefore, bathymetric systems operate at a much slower rate and with much longer pulses than topographic ones. For example, Optech's CZMIL has a measurement rate of 70 kHz when operating in topographic mode but of only 10 kHz when operating in hydrographic mode. This lower pulse frequency reduces the achievable point density.

Even in relatively smooth air, all aircraft are subject to vibrations, sudden loss of attitude, and constant small changes in their pitch, roll and yaw. Therefore, knowing the range to a target is not sufficient to determine its position, which also requires knowledge of the aircraft's exact location and attitude at the time each laser pulse is fired. Differential GPS provides the former and an inertial measurement unit (IMU) provides the latter.

ALB systems make it possible to survey in a single scan features and constructions both above and below the waterline. Typically, digital images are recorded at the same time, enabling their visual analysis and use with digital terrain models.

The Mission

JALBTCX is a joint center of government agencies working together to advance LiDAR bathymetry and

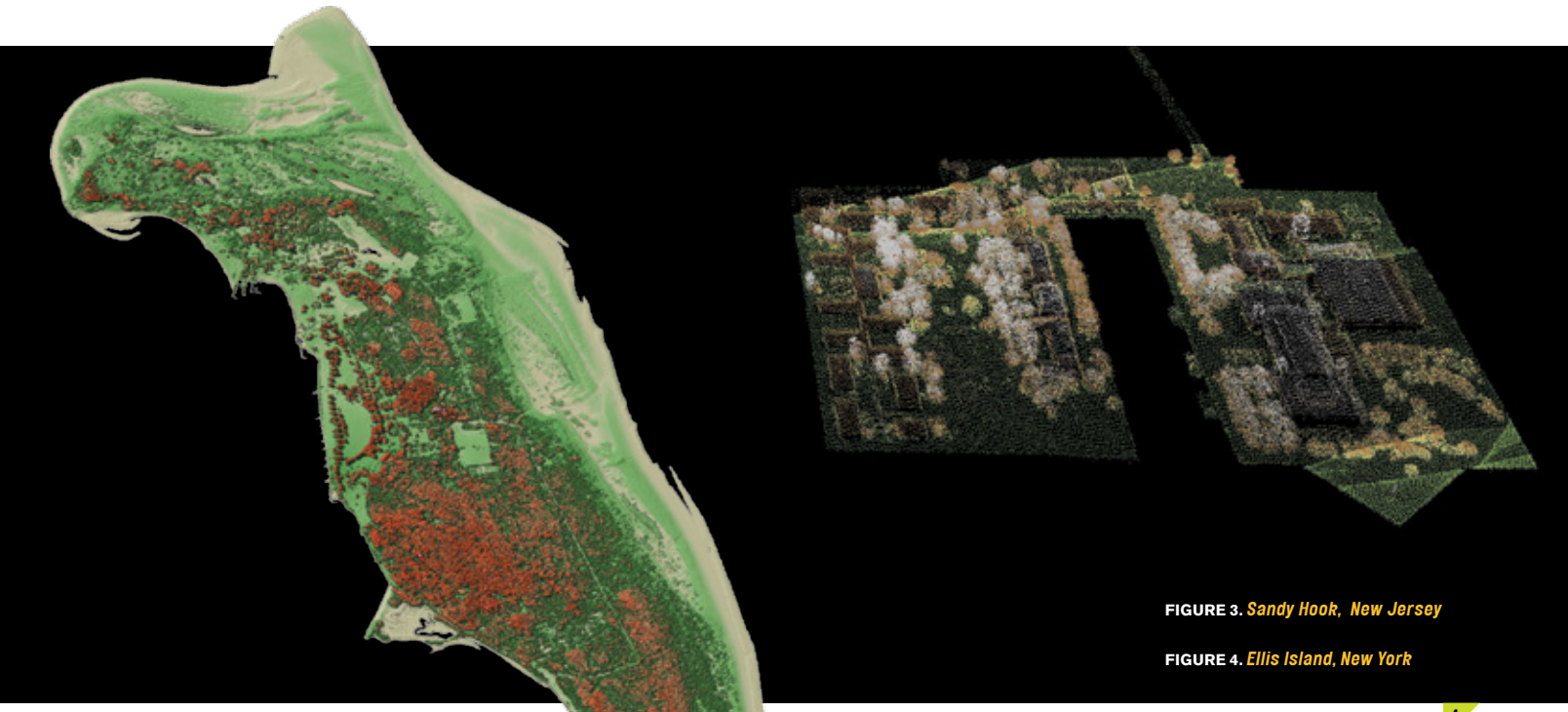


FIGURE 3. *Sandy Hook, New Jersey*

FIGURE 4. *Ellis Island, New York*

4

complementary technologies for coastal mapping, explains Jennifer Wozencraft, the center's director. It is made up of USACE, the U.S. Naval Oceanographic Office, the Remote Sensing Division of the National Geodetic Survey of the National Oceanographic and Atmospheric Administration (NOAA), and the U.S. Geological Survey's Coastal and Marine Geology Program. "We own and operate, through contract, LiDAR bathymetry and airborne remote sensing sensors for coastal mapping for the USACE and the Navy, and then with the other agencies we do research and development to advance hardware and software and to demonstrate the different applications of the data that we collect," says Wozencraft.

The center funds companies to develop hardware for it — primarily airborne sensors. "It all started with the SHOALS program, back in the late 1980s," Wozencraft recalls, referring to the Scanning Hydrographic Operational Airborne LiDAR Survey. "One of the main goals of that program was to develop a capability that could be commercialized to make it more widely available for the USACE and our other partners."

Immediately following Sandy, JALBTCX was tasked by USACE's North Atlantic Division to collect LiDAR data for the districts that fall within that division's jurisdiction. The center used its own planes to collect the data for the New York District and contracted with private companies to collect data for the New England District, the Philadelphia District, and the Norfolk District.

The flights took place November 11-24, as soon as the center had been able to gather the requirements from the impacted areas. "The primary requirement," says Wozencraft, "was classified topographic LiDAR data as well as bare earth DEMs generated

3

for mapping. There was a coordinated effort in advance of the survey with other agencies to see what everyone else was doing to try to collect a consistent dataset and a vertical accuracy of 12.5 centimeters RMSE (root mean square error). We typically fly about 1,000 meters off shore or to laser extinction, whichever happens first. In this case, I think it was probably less than that, maybe even only 250 meters off shore."

JALBTCX flew from its base in New Haven, Connecticut along the New Jersey coast line, the Long Island shoreline, New York's inner harbor, Sandy Hook, Staten Island, and the East River. "Typically, after a storm, you have access issues," Wozencraft explains, "and we did experience those getting the GPS way stations and ground truth locations and such. Ours was the only bathymetric LiDAR that was deployed. We fly lower than everybody else, so we had some air traffic control issues that forced us to fly most of our flights at night, which is different for us. We usually do our work in the summer, when the water is nice and clear. This time, of course, it was much colder than usual. It wasn't particularly a challenge, but different than it usually is, and the wave climate was a little more energetic than it is in the summer."

Normally, JALBTCX collects concurrent RGB and hyperspectral imagery, which it was not able to do in this case due to having to fly at night. Instead, it collected that imagery subsequently, when it was able to fly during the day.

"Another part of the work that JALBTCX did and is currently doing for the North Atlantic Division is volumetric change analysis of beach projects," says Wozencraft. "The main operational program that JALBTCX does for the USACE is called the National Coastal Mapping Program. We collect data around the coast of the United States on a cyclical basis. We had collected data in this area in 2010, so we are comparing all of that data to the post-event data for volumetric change analysis."

The Sensor

The CZMIL ALB sensor that JALBTCX used for its post-Sandy flights was built by Optech Inc., the U.S. subsidiary of the Canadian company Optech Incorporated, for the U.S. Navy, which then loaned it to the center. It is an airborne coastal zone mapping system that produces simultaneous high-resolution 3D data and imagery of the beach and shallow water seafloor, including coastal topography, benthic classification, and water column characterization. According to Optech, CZMIL performs particularly well in shallow, turbid waters. Its bathymetric LiDAR is integrated with a hyperspectral imaging system and a digital metric camera.

The CZMIL requires no ground truthing. "It is connected to a GPS receiver and an IMU," says Max Elbaz, Optech Inc.'s president, "so all collected data is automatically georeferenced and co-registered with initial geometric calibration procedures. When we built the system, before delivery, we compared CZMIL data with ground truth data to characterize the system performance. When these very stringent specifications are being met, the data is deemed within required accuracies."

According to Elbaz, his company's history in using LiDAR for bathymetry and environmental applications for rapid response and disaster management scenarios began in the 1970s and the company helped pioneer airborne LiDAR throughout the 1980s. "We followed up with the SHOALS LiDAR bathymeter system in the 1990s and after," he says, "adding a camera and a hyperspectral sensor. Then, last year, we introduced the Optech CZMIL, which includes an RGB camera, a hyperspectral sensor, and a topographic LiDAR, as well as the bathymetric LiDAR. To date we have delivered three CZMIL systems: one to the U.S. Army Corps of Engineers (USACE), one to the U.S. Navy, and one to the Japanese Coast Guard."

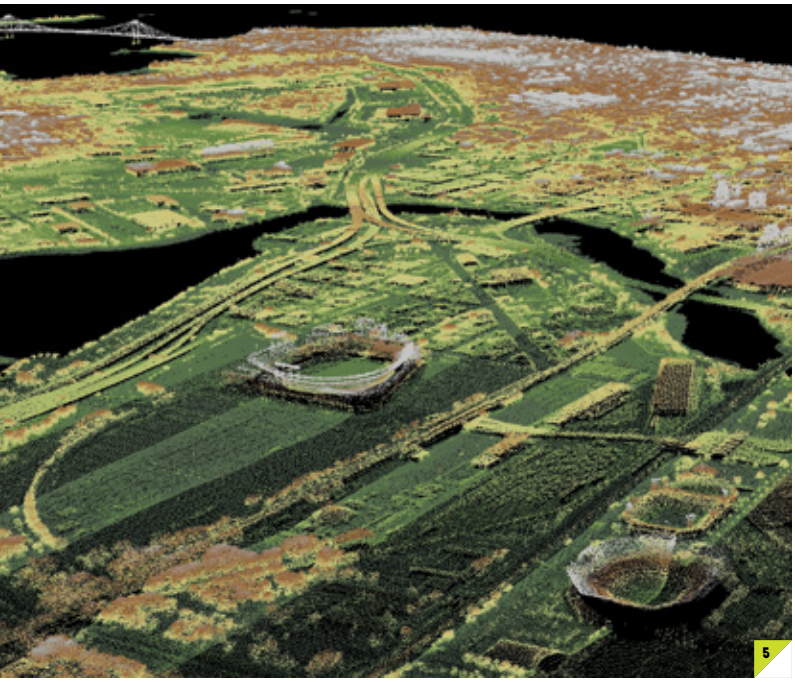
The nominal height of CZMIL operation is 400 meters, Elbaz explains, but JALBTCX flew it mostly at 570 meters to cover a wider area. "They were not interested in surveying deeper water; they wanted to fly only over shallow areas." Because the device is a joint topographic and bathymetric LiDAR system, it can be used to probe land, shallow water, and deep water up to about 50 meters, he points out. "Beyond 50 meters it isn't as essential because you can use sonar on ships."

"Our team in Kiln, Mississippi, where CZMIL was developed and built, supported the mission from data acquisition through to data processing," says Elbaz. "However, we did not send personnel out; instead we supported the mission remotely, using CZMIL's Web monitoring and diagnostic tools. It's a new system on an important mission, so our team made sure USACE had all the support it needed."

The Data

To process the data from its post-Sandy mission, USACE used Optech's HydroFusion post-processing software suite, which handles data from all three CZMIL sensors, from mission planning to the fused LiDAR and imagery data set. "It's a single user interface that replaces the seven to eight different pieces of software that our customers previously used to get to the same level," says Elbaz. HydroFusion handles mission planning, georeferencing of topographic and bathymetric LiDAR data and of hyperspectral and digital camera image data, image mosaic processing, the generation of LiDAR sea floor reflectance data, the extraction of sea floor spectral data using data fusion techniques, classification of the sea floor, and extraction of the shoreline, explains Joong Yong Park, Optech Inc.'s Software Development Manager, who manages a group for post-processing software and algorithms development.

"Once the data are downloaded, several steps of processing are required to extract interesting points from the



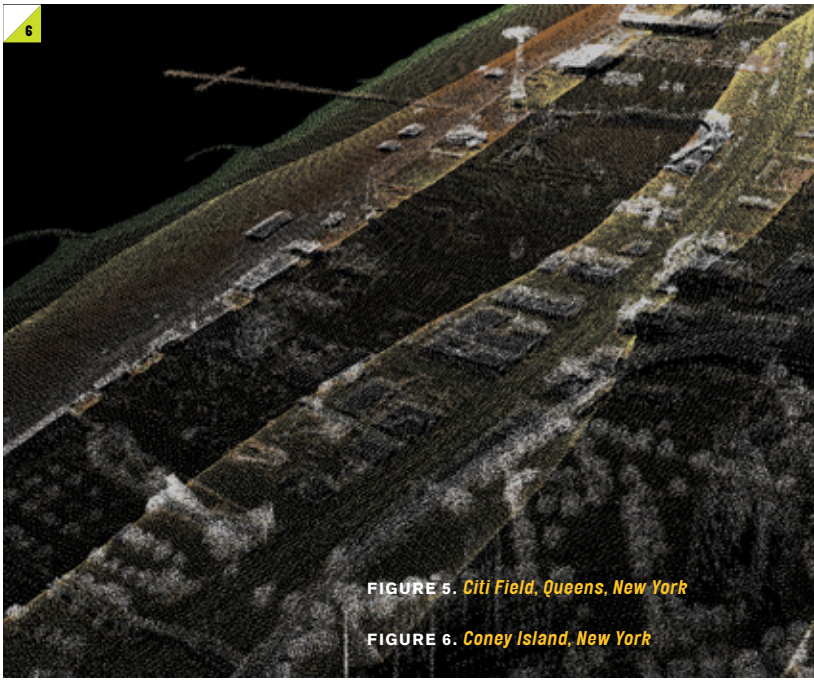


FIGURE 5. *Citi Field, Queens, New York*

FIGURE 6. *Coney Island, New York*

waveform," says Park. The process involves filtering the input waveform, converting the optical signal to an electric signal, detecting the peaks or half peaks in LiDAR wave format at the water surface and the sea floor, and georeferencing the data to compute the coordinates at the water surface and the sea floor in ellipsoid height.

Unlike in the typical TIM-based processing used for topographic LiDAR, Park explains, bathymetric LiDAR requires waveform processing for each point in order to extract the time and position at the water surface and the sea floor. "Since the CZMIL is a bathymetric LiDAR system, even though it has 70 kHz topo/shallow returns, all point clouds were processed by waveform analysis techniques. Therefore CZMIL point clouds are from multiple returns from one waveform, up to 31 returns. Optech and JALBTCX worked very closely to keep the CZMIL system in operation and to resolve data processing problems on a daily base."

The Future

The key recent advance in LiDAR bathymetry has been the development of new 'shallow water' high-resolution sensors, according to Edwin Danson, a Chartered Surveyor and Past-President and Fellow of the Chartered Institution of Civil Engineering Surveyors in the United Kingdom. "This technology," he says, "offers significant advantages and matches well with the commercial transition zone between traditional vessel-based swathe systems and airborne. In my opinion, this holds a more interesting future for the technique."

Wozencraft sees a couple of paths for developments looking forward. "At JALBTCX," she says, "we are focusing on a comprehensive system for coastal mapping that includes LiDAR bathymetry, topography, aerial photography, and hyperspectral imagery, along with exploitation software that allows us to generate products beyond point clouds, such as land cover and sea floor classifications. This information, with the point cloud elevation data, enables us to begin to truly characterize the coastal zone in terms of both geomorphology and environmental resources." In industry, she adds, "there is a push for smaller bathymetric LiDAR sensors that work well in water that is shallow (less than 10 meters) and very clear, to make for more cost-effective surveys of clear water beaches, coral reefs, and clear, shallow rivers and streams."

"In the future," Wozencraft predicts, "we'll continue to see advancements in data fusion and exploitation to really take advantage of all the information contained in the LiDAR returns and imagery data. The JALBTCX and industry efforts will focus a lot in the near term on data processing strategies for these new systems as we begin to understand the new data better."

"Bathymetric LiDAR systems are not only for bathymetry anymore," Park points out. "Using an optical signal from a laser through a water column now makes sea floor reflectance imagery available for environmental monitoring. LiDAR system data will be fused with data from other sensors and used for oceanographic and environmental monitoring. The main interest area for bathymetry will shift to shallow and turbid water near coastlines. The system will be lighter and smaller for small aircraft and UAS, with an advanced laser and digitizer."

ArcGIS Also Used for Analysis

DATA ACQUIRED USING USACE'S COASTAL ZONE MAPPING AND IMAGING LIDAR (CZMIL) was also analyzed in ESRI ArcGIS to lend insight into storm-driven coastal geomorphology change, and to produce information products critical to USACE emergency response requirements. In the past, workflows for vector, lidar, and imagery have been collected on a project-by-project basis. ArcGIS enables users such as USACE to manage these massive collections of data for more than one purpose and extend the content into 3D. These 3D models, lidar, and imagery can be cataloged and distributed for access in multiple collections as either raster data, raw elevation data, or Esri webscenes. If data is not necessary, it can be easily filtered out for a clean representation. By managing massive 3D models and point clouds with ArcGIS, data can be more easily visualized and analyzed.

FIGURE 7. *This is the bridge at Mantoloking (CR-528) in New Jersey. Barnegal Bay is to the West, and the Atlantic Ocean is to the East. This strip of land including the beach is barely 1000 ft wide. Image from the Esri ArcGIS Online base map, before Superstorm Sandy.*

FIGURE 8. *The same area after Superstorm Sandy, from NOAA Aerial Image Service, hosted by the Esri Disaster Response Team on ArcGIS Online.*

If Old McDonald had a farm today, he could manage it from his laptop computer and map it with an application on his handheld device. When he is out in the field, his tractor's guidance system could know its position to within less than an inch, turning his planters and sprayers on and off accordingly. A boom height control system would make sure that his sprayer did not hit the ground and a yield monitor on his combine would measure the exact volume of his harvest, in real time. Soil moisture sensors networked via cellular modems, soil density sensors on his planters, and infrared crop health sensors on his tractor would gather a wealth of data that his agronomist would use to prepare a prescription map for the next season.

In a few years, that data stream would also include aerial imagery collected by his unmanned aerial vehicle (UAV) and his tractor would also be running unmanned as a robot in the field. If a chick, duck, turkey, pig, cow, cat, mule, dog, turtle, or farm hand got in its way, the tractor's radar collision avoidance system would recognize it and stop.

The most widely used term to describe this complex suite of technologies is precision agriculture, and the uptake is exploding. Most new tractors and implements are sold with factory-installed global navigation satellite system (GNSS, which includes the better-known GPS) receivers and a variety of sensors. Reversing a long-standing trend, kids who were born and raised on farms are now returning there after college, because the work is much more intellectually challenging and less manual labor-intensive than it used to be.

EDITOR'S NOTES This feature is one of three in publications of the Location Media Alliance that tackle different applications of geospatial technology to improve agricultural efficiency. This feature shares high-tech tools that farmers now use in precision farming. Learn about the precision tools being applied along the full plant lifecycle in *Precision Agriculture: Sensors Drive Agricultural Efficiency* (http://bit.ly/WerP76) by Matteo Luccio in *Sensors & Systems*. Gain insight on how farmers and suppliers are now able to track individual plants back to the field for greater food safety in *LBx Journal* (www.lbxjournal.com). Also, the application of mapping for agricultural gleaning from fruit trees in urban yards is covered in *Informed Infrastructure* (http://bit.ly/UBEtfd).

MATTEO LUCCIO
Contributing Writer
Pale Blue Dot LLC
Portland, Ore.
www.palebluedotllc.com

FIGURE 3. *A Kinze Autonomous Harvest System consists of a tractor, grain cart and combine. Image courtesy of Kinze.*

Precision A

Agriculture

SENSORS DRIVE AGRICULTURAL EFFICIENCY

Addressing Variability

Soil characteristics — including the amount of phosphorus, potassium, calcium, and magnesium — often vary significantly from one area of a field to another. The practice of variable rate takes this variability into account to reduce inputs of water, seed, fertilizers, and fuel as well as to increase yields by dividing fields into sectors and prescribing rates for each one. Fertilizer dealers, seed salesmen, and crop consultants analyze farm data and advise farmers on these rates. However, farmers can also create prescription maps themselves, by uploading soil type data, historical yield data, and aerial imagery into farm management software on their computers. They can then upload those maps to their tractors' guidance systems, which use them to vary the rates depending on location, with wireless networks creating a farm-wide system.

Precision also plays with environmental impacts, such as reducing water use or the amount of farm chemicals in water. "To be more efficient with our water and to stop flushing out so much nitrogen through the soil into the water table," says Chris Gallo, a Precision Agriculture Specialist at Simplot, "many farmers are switching from flood irrigation to drip irrigation and micro-sprinklers."

By managing their fields based on soil properties and putting fertilizer where it needs to go, farmers can better manage their nutrients. By setting up "exclusion zones," farmers are also able to cut off the spray of fertilizer automatically before it reaches a critical distance from a water supply. "That has saved many farmers from litigation and fines," says Mike Martinez, a market manager at Trimble Agriculture.

Another benefit of precision agriculture is that it enables farmers to avoid gaps and overlaps when planting. "We are able to geospatially sense where we have already applied fertilizer and planted. That way the system cuts the supply at those points, so that you don't waste inputs," says Martinez.

Standard Equipment

Just as car buyers today expect Bluetooth integration and XM satellite Sirius radio, farmers expect new tractors to come with guidance. Case IH tractors, sprayers, and combines are sold with a factory-installed Glonass-enabled GNSS receiver, a display, and a controller, which consists of acceler-

▲ **FIGURE 1.** *Case IH AFS Pro 700, courtesy of Case IH.*

▲ **FIGURE 2.** *Image courtesy of Kinze.*

ometers and gyroscopes that compensate for uneven terrain.

"Just as you pay for different levels of XM radio in your vehicle, you pay to unlock different levels of positioning accuracy," says Trevor Mecham, America's marketing manager for Case IH, Advanced Farming Systems. "You can get free WAAS corrections or pay for DGPS accuracy that gets you plus or minus a couple of inches pass-to-pass," he points out, referring to the Federal Aviation Administration's Wide Area Augmentation System and the U.S. Coast Guard's Differential Global Positioning System. "If you need year-after-year repeatability for controlled traffic farming, so that you can do the side dressing and strip till applications, you need RTK," which stands for real-time kinematic satellite navigation. See ***Figure 1***.

Likewise, John Deere sells its tractors and combines with an integrated guidance system. "The sensors on the combines are already factory-installed for yield mapping and harvest documentation," says Cole Murray, product manager for the company's Intelligent Solutions Group (ISG). "We also have some add-on opportunities: for example, by adding a GPS receiver to a sprayer you can do swath control."

John Deere owns NavCom, which designs and builds GNSS receivers and writes software. It also owns a differential corrections network, the StarFire network, which works worldwide.

Kinze manufactures planters and grain carts that quantify planting and harvesting. "We've added scales to these carts, so as farmers unload the grain from the combine into the cart, they can use it to record how much grain they are getting out in the field," says Rhett Schildroth, one of the company's product managers.

"When they are planting, farmers care about three things: how deep they plant that seed into the soil, getting good seed-to-soil contact, and the spacing between the seeds," Schildroth explains. "So, we've added sensors in order to make sure that we can gauge each of those things and then also control it on the go, so that they can vary it throughout the field." See ***Figures 2-3*** (on previous page).

Analyzing the Data

Various services analyze farm data and generate prescription maps. Fertilizer dealers, crop consultants and agronomists take the data, analyze it, and help the farmers make decisions.

Nick Achen, an agricultural engineer, and his brother, a farmer, co-founded and co-own www.easyfarmmaps.com. "We identified a need in our community to be able to process all this data that farmers collect in the field," he says. "There is software for sale that is expensive and complicated, so many farmers don't know how to use it or don't want to learn to use these systems. So we set up a Web site to take those files, then process them into readable maps." See ***Figures 4-5***.

AgJunction, a Web-based agronomy system operated by Hemisphere GPS, allows users to import soil test data and the locations of the soil samples, as well as data from John Deere, Raven, Trimble and other systems, and generate prescription maps. Its customers are primarily agriculture retailers, such as independent chemical fertilizer retailers or cooperatives.

According to John Lueger, director of Product Management at Hemisphere GPS, "A retailer could use our system to send a prescription map directly to one of our terminals on a tractor or a sprayer and then the farmer, when he has completed that job, can send that data back to the retailer and automatically archive it for historical purposes." See ***Figure 6***.

Other options and approaches from the different manufacturers take a similar approach. Raven Industries has a product called Slingshot that records what you are doing with various datasets and synchs to cloud-based software. Trimble's Connected Farm wirelessly extracts the data from the growers' applications throughout the seasons and consolidates it. Across the board, manufacturers assert that these technologies pay for themselves in about a season of use.

Sensors

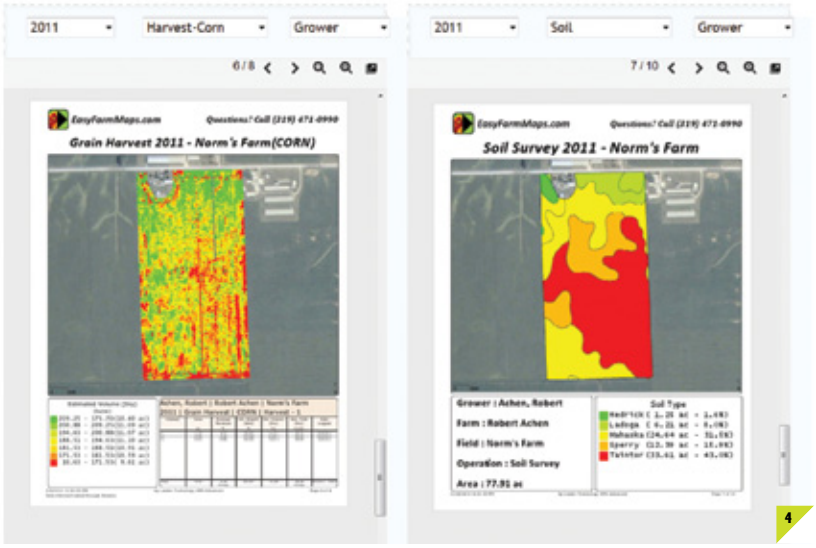
Almost every piece of agricultural equipment has sensors and controls these days. Sprayers now have sensors that sense whether plants are nutrient-deprived or not, and sensors dragged across the field show the textural variation in the soil.

"We use load cells on grain carts, magnetic flux sensors to sense when

▶ **FIGURE 4.** *Dual Map View of grain harvest and soil survey of the same plot of land, courtesy of www.easyfarmmaps.com.*

▶ **FIGURE 5.** *Reports such as condensed farm report, yield vs. soil type, yield vs. seed variety, and yield vs. population can be viewed, courtesy of www.easyfarmmaps.com.*

▼ **FIGURE 6.** *GPS image courtesy of Hemisphere GPS.*



power take-off (PTO) shafts are turning and grain is unloaded, infrared sensors to count the seed as it goes down the seed tube, load cells on planters to understand the down force required to plant the seeds, and GPS receivers for positioning," says Schildroth.

The use of soil moisture sensors, networked using cellular modems, is growing very rapidly. "When I was on our family farm, in the early 90s, the task I disliked the most was to go in the fields and read soil moisture content meters," says Mecham. "Corporate family farms can have as many as 35,000 acres and one person doing just that all day. So, this is extremely important, especially in areas where you have to pump the water from deep well systems. Now farmers can receive that information via e-mail or text messages."

"Our basic guidance system will come standard with a series of inertial sensors that provide feedback to the guidance system on the tilt of the field or the vehicle's pitch, roll, yaw, or heading," says Martinez. "Combines have optical sensors that record the volume that is passing through their grain elevator, as well as moisture sensors. So, in real time, we know the volume and we know the moisture content of that crop being harvested."

Sensors are now being used to control the height of spray booms, which can be up to 120 feet across. "So, as they are traveling at high speeds across the field, if you don't have a perfectly flat field, you are going to hit that boom on the ground," Martinez points out. "It is no longer feasible for the driver to control the height of his boom fast enough. So, we just announced a system that uses ultrasonic sensors to sense, very quickly, the profile of the ground so that it can then, via hydraulics, move the boom up and down as needed."

Trimble's GreenSeeker sensor is a localized, real-time sensor that is mounted right to the spraying vehicle. It uses an optical sensor and a few different light bands to measure the health of the crop in real-time.

"Immediately, as the sprayer is traveling and recording this data, it is creating a prescription to also then apply nitrogen in the right amount needed in that particular portion of the field," Martinez explains. The company's WeedSeeker spot spray system uses advanced optics to sense whether a weed is present and signals a spray nozzle to deliver a precise amount of chemical — spraying only the weed and not the bare ground.

Future

Future developments in precision agriculture include autonomous farm vehicles, the use of imagery from UAVs, and telemetry — wirelessly transmitting back to the office data on crop health, soil characteristics, and yield, as well as on the status of the farm machines, which will allow farmers to improve planning for vehicle servicing and maintenance, says Swain. Sensors that can analyze and manage soil compaction are also in the future, according to Achen.

Currently, growers get feature unlock codes from their dealer. "In the future," says Mecham, "we would like dealers to be able to send them directly to the devices on the vehicles, via modem, to allow customers to try new features. Our customers are demanding that level of simplicity." «

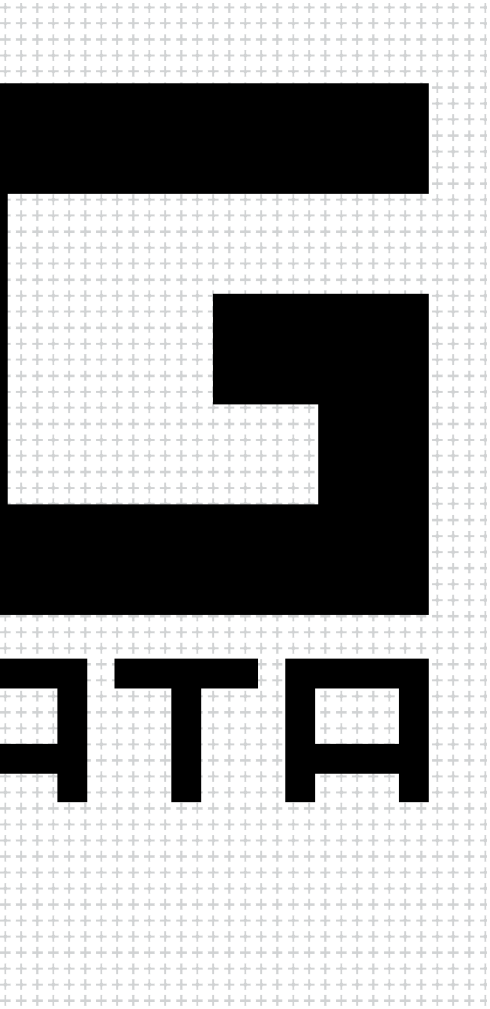
SOCIAL GI

...THE LONG TAIL OF SCIENCE DATA

RICHARD HEIMANN
Analytics Coordinator
Data Tactics Corportation
McLean, Va.
www.data-tactics-corp.com

THE 20TH CENTURY was seminal for the natural sciences, with discoveries such as penicillin (Fleming, 1945), the polio vaccine (Salk, 1952), the double helix structure of DNA (Watson & Crick, 1953), and the first complete DNA sequence of an organism (Sanger et al., 1977), all of which advanced human understanding and human welfare. The advent of the OpenWeb and a seemingly endless amount of new science data have the potential to do for the computational social sciences in the 21st century what other measurement tools did for the natural sciences of the 20th century – advancing further human understanding and human welfare. Big Data will be central to that pursuit.

"Data is the new oil" is a phrase coined by Clive Humby and embraced by the World Economic Forum in 2011 as it considered data as an economic asset like oil. Every day, we create 2.5 quintillion bytes of data – so much that 90% of the data in the world today has been created in the last two years alone. (IBM) These data come from everywhere: hard sensors used to gather information, the social web, transaction records, and cell phone GPS signals, to name a few. The amount of such data is big and by every account growing exponentially. These facts, however, give no hint to where the largest growth is, or comparatively speaking, where the greatest rewards lie for researchers. It is difficult to believe that data are increasing uniformly.



Despite the remarkable growth of data, the description of Big Data still seems rather empty. The description of the distribution of the 90% outgrowth of Big Data would more accurately define what Big Data is and, more importantly, how it is different from traditional science data. If, for example, the data explosion is normally distributed, then perhaps Big Data will have less impact than expected for the social sciences. This would result from the fact that the tails are closer to the average than what would be true under a power law distribution. If this is the case, Big Data isn't special or is not as special as suspected, and is less "oil" than it is an average economic asset.

The Long Tail of Science Data

A distribution is said to have a long tail if a larger share of population or use rests within its tail than would under a normal distribution. A signature quality of a power law is the long tail and the large number of occurrences far from the head or central part of a distribution. The long tail has gained popularity in describing a retailing strategy of selling a large number of unique items with relatively small quantities. The Long Tail (Anderson, 2004) encourages entertainment to "forget squeezing millions from a few megahits at the top of the charts." Anderson quite successfully foretells that "the future of entertainment is in the millions of niche markets at the shallow end of the bit stream." This principle explains why Netflix beat out Blockbuster, and how Amazon has been so successful, with stock prices increasing from $40 in late 2004 to nearly $240 in late 2012.

The long tail of science data follows the power law distribution. The National Science Foundation has shown its grants in dollar amounts to follow the power law – empirical support for the long tail of science data. The tail has many heterogeneous datasets; these data are small, often individually curated and unmaintained. As a result, the data are discontiguous from other research efforts and discontinuous over space and time. See Figures 1-2.

Intelligence data too are often collected in a manner that is limited in scope and almost never preserves any semblance of external validity. These data are often collected for small projects and are often forgotten and not maintained. The poor curation of these data leads to their inevitable misplacement – dark data, or data that are suspected to exist or ought to exist, but are difficult or impossible to find. The problem of dark data is real and prevalent in the tail. The utter lack of central management of data in the tail invariably leads these data to be forgotten. The long tail is an intractably large management problem and an analytical one as well. The central curation of data in the head ensures maintenance, unlike data in the tail.

Professor and mathematician Richard Hamming's prominent words during a speech titled "You and Your Research" encourage researchers to ask, "What are the important problems in my field?" Understanding the long tail of science data may suggest where computational social scientists will have the greatest impact and contribute the greatest social good.

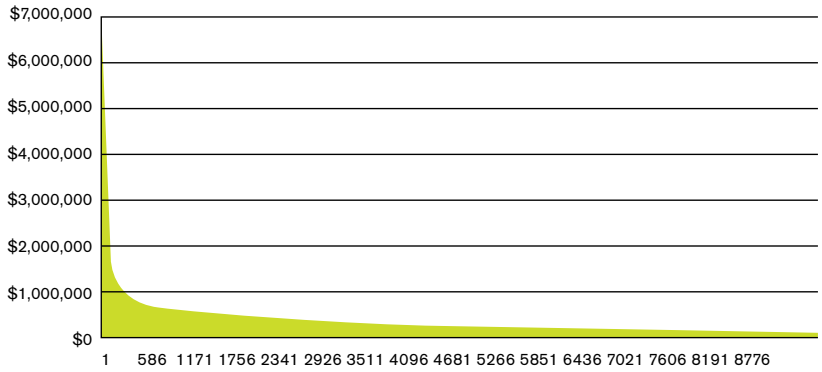
The head of the distribution is where large, homogenous datasets reside and perhaps where the greatest impact is on human understanding and human welfare. The high volume of data produces coincident datasets in time and space – unintentionally producing binding research across social science disciplines, even producing binding research between the natural and social sciences. Their coincident nature makes them ideal for cross-correlation and multivariate analysis.

Open Innovation initiatives hold certain promise for sharing risk and rewards. "Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas." (Chesbrough, 2003) Designing binding research across social science disciplines and between the natural and social sciences will require shared laboratories provided by the head of the long tail, and shared interest in socially critical problems.

Big Social Data

There is no argument that Big Data has spurred technological innovation, the result of which has lowered processing cost on data and consequently has had a social impact. Businesses especially are using Big Data to answer questions that five years ago were not answerable. A recent study (Brynjolfsson, 2011) found that technology investments of 179 large publicly traded firms that adopted data-driven decision making have output and productivity that is five to six percent higher than what would be expected

1



Power Law	80%	20%
Number of Grants	7,478	1,859
Dollar Amount	$938,548,595	$1,199,088,125
Total Grants (NSF07)	9,347 (Count)	$2,137,636,716 (Amount)

2

given their other investments and information technology usage.

Big Data advancements have included better targeted Web ads by the likes of Google and Facebook, as well as better recommendation systems by Netflix and Amazon. The use of data on the part of these and similarly savvy data-driven companies has seemingly had a positive, unilateral impact on operations, offering supporting evidence for a data-driven approach.

The social turn in Big Data, however, promises the marked improvement of policy and governance decisions affecting the lives of everyone. Big Social Data makes great effort to disspell a number of enduring malpositions of Big Data. The contributions on the part of several socially conscious data scientists are ultimately highlighting the differences between the demands on data and analysis on the part of private industry and the demands on data and analysis on the part of security, governance, and policy – foreign or domestic.

Lieutenant General Michael Flynn (Director of the Defense Intelligence Agency, 2012) recently noted that focuses on the precursors of war are needed – what he calls "left of boom." When speaking of national security, he notes that one thing needed in greater frequency is the engagement of populations before starting a counterinsurgency campaign. He notes that there have been 32 major insurgencies since 1960, and in 22 of these cases the insurgent forces were the victors. Irregular warfare is the template for future battlefields; U.S. interests are best served by preventive measures that ensure these wars are never fought.

Ethnic tension is frequently a part of the developing world, a world often in the greatest need of aid or humanitarian assistance, and the frontlines of current or perhaps future engagements. These areas have also seen some significant, if not dramatic, increases in data. Flynn cautiously accounts for potential social ills facing the industrialized world as well. Big Social Data is a potential that is largely untapped and will allow decision makers to track progress, better understand and improve social conditions of local populations, and understand where existing policies require adjustment.

Big Data, Small Theory

The typical state-centric analysis that seeks to determine how states can or do maintain stability must also develop a sensory capability to better detect the precursors to political change, a social radar of sorts with a level of granularity that enables policy leaders to make informed decisions that maximize national influence left of boom. (Flynn, 2012)

The Failed States Index (Foreign Policy, 2012) claims that 108 of the 178 countries evaluated are in high warning of failing. Assuming the remaining unmeasured countries (18) are "stable," then Foreign Policy estimates 55% of the world's countries to be in serious danger of failing. Many of these countries are important pivots in foreign policy, currently receiving aid and/or simply in close proximity to the United States, (see Figure 3) either geographically or economically.

The Failed States Index provides annual snapshots of a state at a national level. It turns out that states fail for a variety of reasons, shaped in innumerable ways, many of which are not violence. Violence, as it is, may result from the failure of the state, what Thomas Hobbes called the "state of nature." Flynn's idea of left of boom is an acknowledgement of the "state of nature" and a plea for better data analysis. State failures are not

without disharmonies of local communities or without heterogeneous castings of ethnicities, economies, and other human characteristics of the landscape.

Geographers already know stationarity is a tenuous claim due to heteroscedasticity in the response and spatial heterogeneity in the control. Analytical pursuits seeking nomothetic laws quickly sacrifice internal validity. At times, the reaction on the part of human geographers is to treat every observation as a special case. This is extreme heterogeneity with multiple equilibrium – one process for every observation over space.

Analyses of this nature prove to be overly descriptive and quite idiographic, ultimately lacking any external validity, which is the hope of making generalizations to other places or times of interest. By clutching complexity, the computational social sciences can blend these two contrasting outlooks.

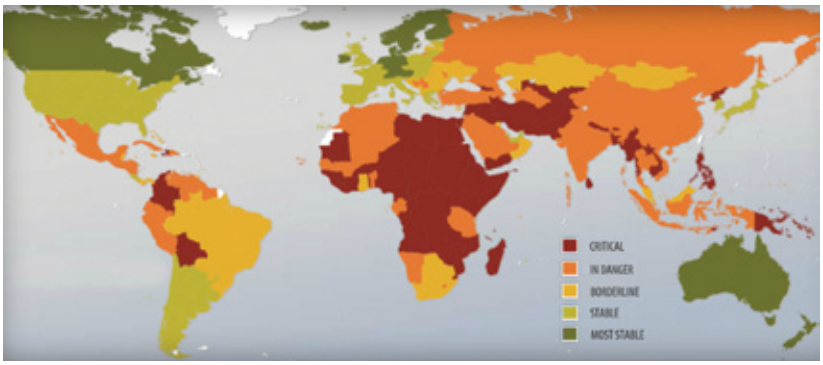
Peter Norvig, Director of Research at Google Inc., (2009) writes in "The Unreasonable Effectiveness of Data" about seizing complexity. He draws direct comparison to Eugene Wigner's article, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences" (1960) and acknowledges that sciences that involve humans rather than elementary particles have proven resistant to elegant mathematics. Norvig continues, "(We) should stop acting as if our goal is to author extremely elegant theories, and instead embrace complexity and make use of the best ally we have: the unreasonable effectiveness of data."

Italian scientist Galileo's experiment of dropping two balls of different masses from the Leaning Tower of Pisa demonstrated that their time of decent was independent of their mass. Wigner explains how this result is true everywhere, was always true, and will always be true. It is valid no matter whether it rains or not, whether the experiment is carried out in the Far East, Near East, or Northeast D.C., no matter whether the person is a man or a woman, rich or poor, Muslim or Catholic. This invariance property of physics is well recognized, and without invariance principles, physics would not be possible.

Social phenomena are not invariant however. As Gelfand and others (Velupillai, Poli, Norvig) noted, there is only one thing more unreasonable than the unreasonable effectiveness of mathematics in physics, and that is the unreasonable ineffectiveness of mathematics in other sciences, including the humanities. While serial and spatial autocorrelation exist, so do temporal and spatial heterogeneity and, ultimately, uncontrolled variance. Exploiting the complexity of data in the head of the distribution holds certain promise, rather than creating models to decisively model all of human behavior.

Big Social Data's goal is to learn about social systems at a speed commensurate with decision making and at a spatial support commensurate with policy development and assessment. Small theory is one framework to operate within. These small theories are not small in significance but locally calibrated to the populations they measure. They are based on empirical observation and are expected to be generally true and sufficient to be useful norms.

The social turn in big data mimics similar social turns in the Department of Defense and the U.S. Intelligence Community. One ought to wonder what U.S. Government engagements would look like if Big Social Data could improve decision making or intelligence analysis by a mere five to six percent, as industry has done for output and production. Big Social Data has untapped potential, as Anyon (1982) envisioned, for social sciences to study socially critical problems.



◀ **FIGURE 1.** *The Long Tail of data*

◀ **FIGURE 2.** *Power Law Distribution example, similar to The Long Tail*

▲ **FIGURE 3.** *Failed States Index,* Foreign Policy *magazine, 2012*

CITATIONS

- Anderson, C. (2004). Wired 12.10: The Long Tail. wired.com. Retrieved December 30, 2012, from http://www.wired.com/wired/archive/12.10/tail.html
- Anyon, Jean. (1982). "Adequate Social Science, Curriculum Investigation, and Theory." Theory Into Practice. Vol. 21, Number 1, 1982: 34-38.
- Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in Numbers: How Does Data-Driven Decision Making Affect Firm Performance? SSRN Electronic Journal. doi:10.2139/ssrn.1819486
- Chesbrough, H. W. (2006). Open Innovation: The New Imperative for Creating And Profiting from Technology. Harvard Business School Press.
- Failed States Index. (n.d.). Retrieved from http://www.foreignpolicy.com/failed_states_index_2012_interactive
- Halevy, A., Norvig, P., & Pereira, F. (2009). The Unreasonable Effectiveness of Data. Intelligent Systems, IEEE, 24(2), 8-12.
- NSI, A., OSD, M. Flynn., H., Casebeer, B., Chapman, M., & Rice, C. et al (2012). National Security Challenges: Insights from Social, Neurobiological, and Complexity Sciences. DTIC Document, (July).
- Long Tail. (n.d) In Wikipedia. Retrieved December 30, 2012, from http://en.wikipedia.org/wiki/Long_tail

The Next 15–20 Years

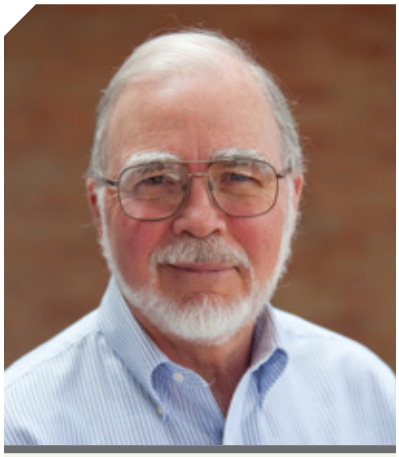
SECURE WORLD FOUNDATION FORUM

This past December, the National Intelligence Council, an element of the Department of National Intelligence (DNI), issued *Global Trends 2030*, a voluminous report assessing the state of the world and trends from a geopolitical perspective. The DNI oversees and coordinates the work of the Central Intelligence Agency, the National Security Agency, and other entities charged with collecting and interpreting information that might affect U.S. national security.

Global Trends 2030 (http://www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends) is well worth reading, not only to bring us up to speed regarding the interplay of the various geopolitical influences that affect the United States and the rest of the world, but also to explore the possible futures that we all might encounter. Although the report does not mention the use of Earth observations (EO), remote sensing or other geospatial technologies, many of the concerns it raises can be addressed in part through the use of data provided by space systems.

The report is notable for its methodology. Before starting on *Global Trends 2030*, the authors commissioned a review of its four earlier global trends studies to "highlight any persistent blind spots and biases as well as distinctive strengths," which they then used in designing this study. After completing the first draft, they actively sought feedback and criticism of it from non-U.S. interlocutors around the globe, researchers and analysts who provided a broader perspective on worldwide trends than could have been possible without it. The report's authors also created a public blog, accessible worldwide, that invited additional feedback and inputs on the report's major themes. Many of the concerns of experts in other countries about the initial draft are reproduced in a section devoted to the responses received.

The report has three major sections:



RAY A. WILLIAMSON, PHD, is editor of *Imaging Notes* and Senior Advisor to the Secure World Foundation, an organization devoted to the promotion of cooperative approaches to space security (www.swfound.org).

a. **Megatrends – four broad trends they considered as especially important today;**
b. **Game-Changers – elements of the world's political, economic, technological, and social fabric that could affect the trends in major ways;**
c. **and a Set of Potential Worlds – alternative futures that could result from the dynamic interaction among elements of the first two sections.**

The report and the methodology used to create it are designed "to stimulate thinking about the rapid and vast geopolitical changes characterizing the world today and possible global trajectories during the next 15-20 years." This report certainly started me thinking. Among other things, it helped me review just how many of the worldwide challenges we face that can be met with more effective use of space technologies, particularly geospatial ones. Unfortunately, the world community falls far short in using space systems effectively to tackle these challenges, many of which could improve the chances of reaching sustainable Earth environments.

Among the report's broad conclusions is the likelihood that as a result of increased population and the growth of the middle class in developing countries, demand for food and clean water resources will increase, potentially leading to regional scarcities that engender or exacerbate conflict. As readers of this magazine are well aware, climate change will likely have a major impact on humankind's ability to meet these resource needs, especially in developing countries.

That line of thinking led me to focus on two other security-related reports that have appeared in the past year and a half, both issued by the Center for a New American Security (CNAS). The first saw the light of day in July 2011 (see *Imaging Notes*, Winter 2012). Appropriately titled, *Blinded: The Decline of U.S. Earth Monitoring Capabilities and Its Consequences for National Security* (http://www.cnas.org/blinded), this report laments the steep decline in U.S. environmental monitoring capabilities and urges the U.S. Government to put additional resources toward maintaining and even strengthening the capacity for environmental monitoring. U.S. national security depends on it.

As shown by the surprisingly rapid losses of ice in the Arctic Sea, Greenland, and Antarctica and other dramatic environmental changes over the past few years or so, climate change is occurring at a much faster rate than climate scientists had predicted. Yet our ability to track these and other environmental modifications and to

analyze how they might affect food production or access to water resources in regions around the world is declining as resources for this purpose dry up.

There is a strong disconnect between what the scientific and technical communities are capable of doing and the financial resources available to carry out crucial tasks of environmental monitoring. As the CNAS report documents, these lacks undermine U.S. national security in several important ways. For example, according to a National Academy of Science study released in May 2012 (http://www.nap.edu/catalog.php?record_id=13405), we are faced with a serious gap even in the ability of the National Oceanic and Atmospheric Administration (NOAA) to provide the basic accurate weather forecast services that we depend upon every day in our fast-paced world, even though 95 percent of the data inputs to U.S. meteorological models derive from space-borne platforms devoted to weather monitoring.

The more sophisticated scientific information available from NASA's declining EO research capabilities have helped scientists and policymakers understand better how and at what rates the world's environments are changing. They have provided the basic data for developing environmental trend models. Yet nearly all of the rich collection of environmental research satellites that NASA lofted into orbit during the last decade have passed the end of their design lives and many of their instruments will not be replaced with new versions, further reducing our ability to follow environmental trends.

It is necessary to monitor climate change, not only to track it for the scientific knowledge gained but also to provide the information needed for advance warning to populations likely to be affected.

Not all changes in climate are likely to be negative for the affected populations; some will be beneficial. Warming trends, for example, could extend the growing season in northern regions while leading to hotter, drier weather in already parched regions of the U.S. Southwest. For farmers and others whose businesses are weather dependent, it is very important to have advance warning about the impacts of major environmental changes so that they can plan ahead. Space systems can help with those tasks.

Climate change models strongly suggest that storms will become a lot more frequent and more severe. Hence it will be especially important for emergency management officials to use every tool at their disposal to track progress of major storms, to monitor the oceans for the occurrence of tsunamis, and to track deformations of Earth's surface in earthquake zones. Satellite systems are particularly good at those tasks. *Sentries in the Sky: Using Space Technologies for Disaster Response*, the latest CNAS report, focuses on space systems and natural disasters (http://www.cnas.org/sentriesinthesky). In it, analyst Will Rogers argues that America could make much better use of space technology to mitigate the damage and destruction of major natural disasters.

This latest CNAS report centers in on the use of space systems to support tsunami detection and prediction, but many of its conclusions can be applied to other natural disasters, from earthquakes, flooding, and hurricanes to long-term drought. Major natural disasters like Hurricane Sandy have garnered a lot of attention because of the tremendous damage and disruption they inflict on people and infrastructure in a short period, but incremental changes in average temperature over a long term can well inflict more economic damage and social disruption. EO satellite systems, because they provide a repeatable, synoptic view of Earth's surface and the atmosphere, are ideal for long-term, regional studies of environmental change.

Altering the current declining course will require not just additional funding, but the development of innovative ways to provide the needed data and the modeling and analytic tools needed to make effective use of the satellite data. *Sentries in the Sky* argues, for example, that modest investments in government and academic research programs could be targeted toward "improving current disaster management tools…that help disseminate information more rapidly to first responders." The report also suggests that the government should explore the feasibility of placing sensors on commercial satellites, such as new communications satellites. Such a practice could reduce costs and spur innovation. It also emphasizes the role that international cooperation can play in easing funding constraints for any one agency or country.

Taken together, these three reports present not only an assessment of the world community and where it might be headed, but also a set of solutions to address several of the most serious challenges we face, based on more effective use of space technologies. Because these challenges are global ones, we should be tackling them together as a global community.

Global Trends 2030 notes that one of the major challenges we face is the question of evolving better governance mechanisms, on all levels, local, country, regional, and international. Organizing more effective governance of space activities, especially for environmental monitoring, could assist that process.

GLOBAL BASEMAP

With Global Basemap, imagery consumption is easy. Global Basemap provides the most accurate and up-to-date imagery available and ensures seamless coverage of every square kilometer of the Earth's landmass. DigitalGlobe is responsible for all processing, updating, and hosting, enabling users to focus on understanding and analyzing their area of interest.

LARGEST ONLINE IMAGE LIBRARY

COMPLETE GLOBAL COVERAGE

DigitalGlobe™

GELORA BUNG KARNO STADIUM, JAKARTA

www.digitalglobe.com/qualitygbm