Imaging NOTES

EARTH REMOTE SENSING
FOR SECURITY
ENERGY AND
THE ENVIRONMENT

Fall 2011
Vol. 26 » No.4

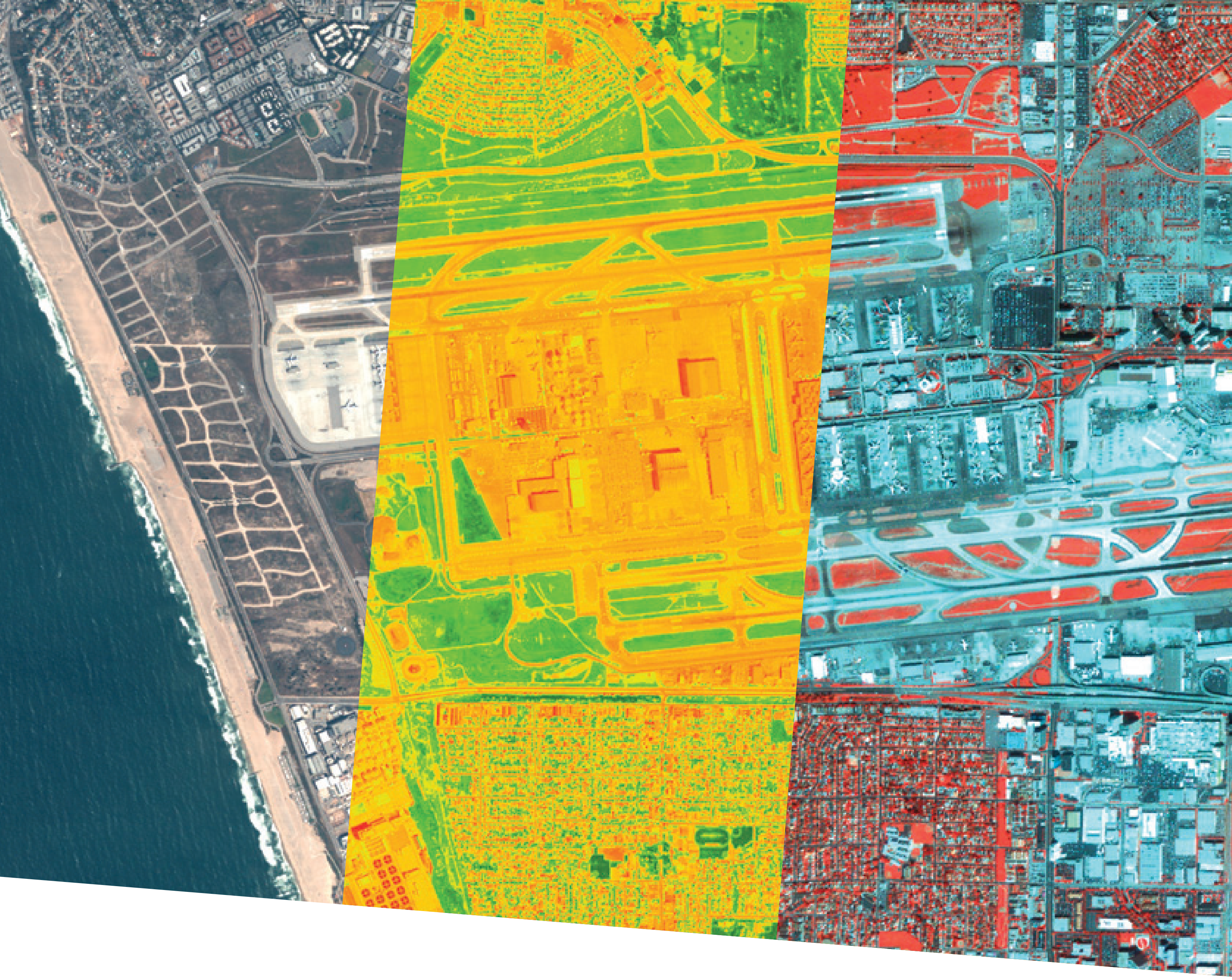
NGA Opens Up

about Software and HumanGeo

RADAR & LIDAR UPDATES

LBx JOURNAL
EDITORIAL SECTION

GEOSPATIAL LAW



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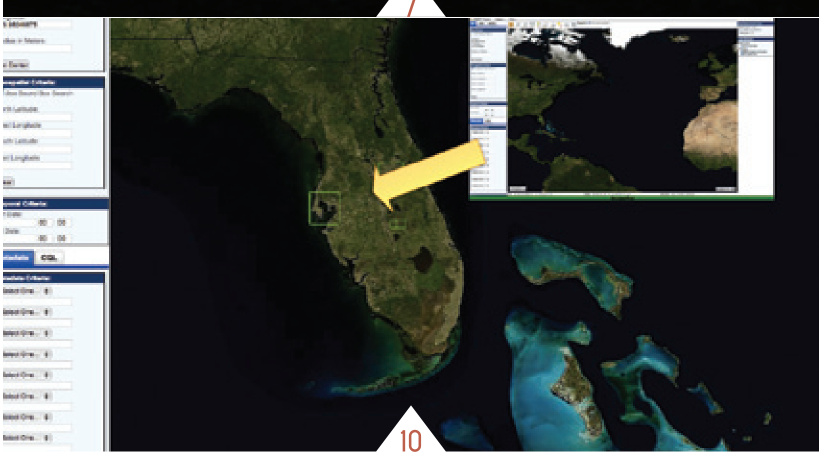

Fall 2011

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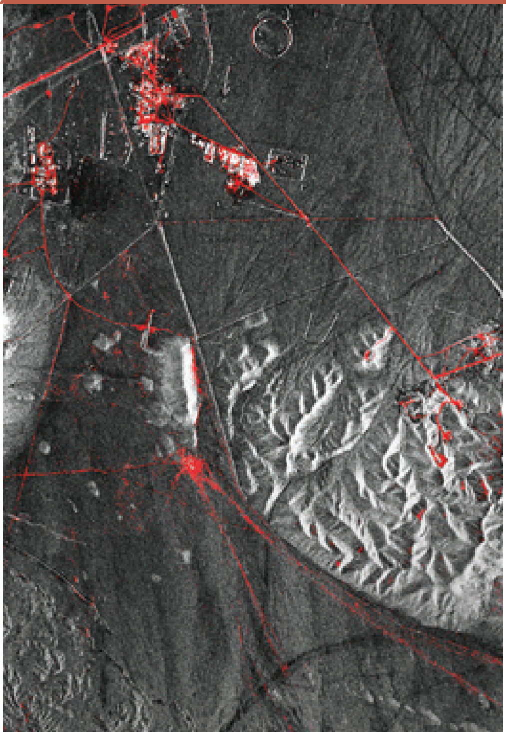

COSMO-SkyMed 1-meter resolution radar image (Spotlight-2 mode) over the nuclear facility of Qom in the Iranian desert shows disturbed terrain. The black and white background image highlights bright industrial structures and buildings. Dark linear features represent dirt roads and a track network around the plant.

When the acquisition of imagery is repeated after a short time, the coherence of the phase signals between the two images provides additional information about the scene. Red tracks are derived from coherence calculated over a time span of eight days. They show where the stable desert terrain was "disturbed" by the passage of vehicles (both on and off-road) and even animals (randomly distributed tracks on the upper right).

Image also appears on page 43, and is courtesy of e-GEOS S.p.A.

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

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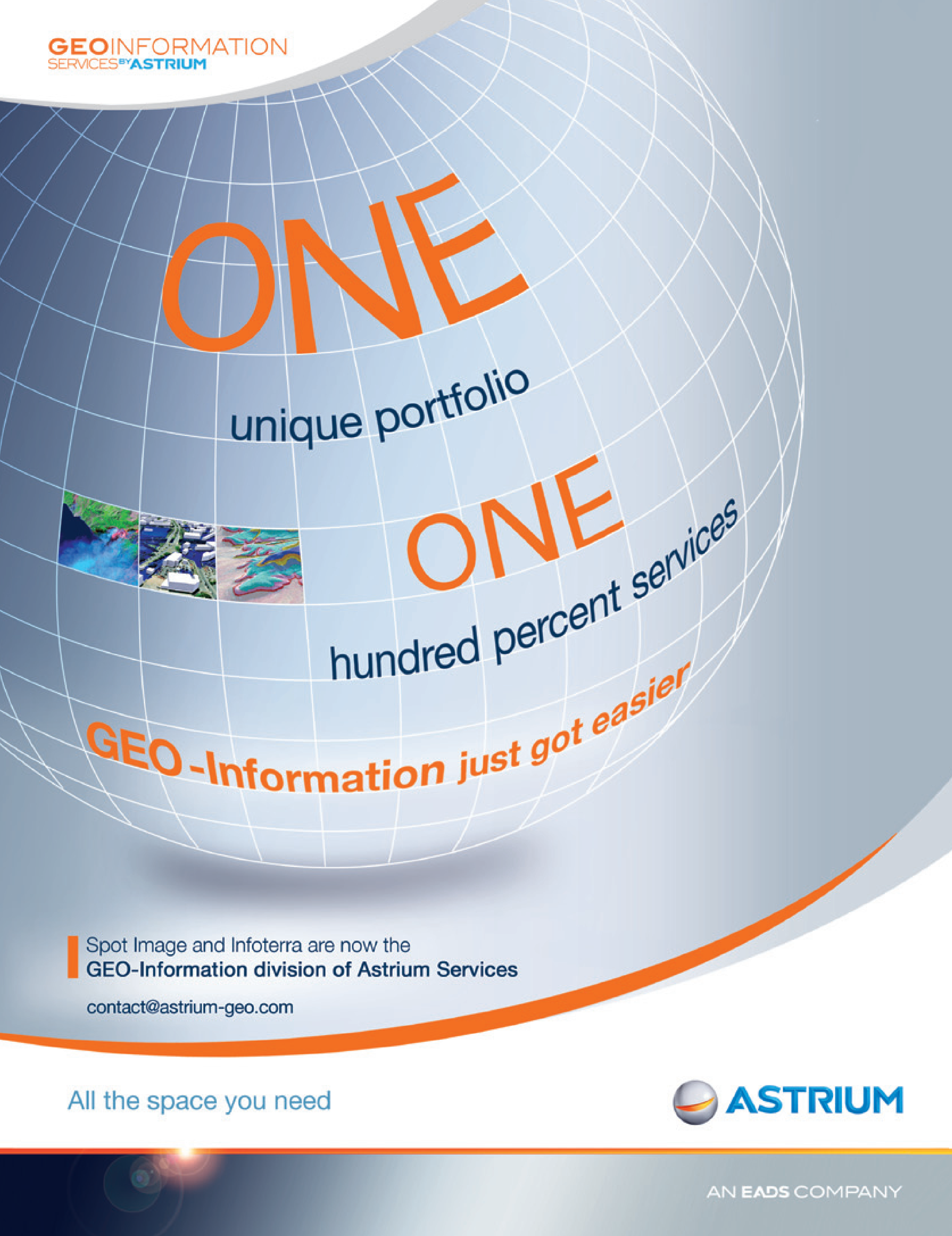
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Big Asteroid Flyby of Earth

OBSERVATION CAMPAIGN SPURRED

Circle the day November 8 on your calendars. One of the largest and potentially most perilous space rocks in the heavens will zoom by Earth. The unique event will become the *object de jour* for an armada of ground observers. An extensive campaign of radar, visual and infrared observations has been ordered to survey the cosmic intruder.

Asteroid 2005 YU55 is a mini-world that's roughly 1,300 feet (400 meters) in diameter. In early November, this asteroid will approach Earth within a scant 0.85 lunar distance. A lunar distance is the distance from the Earth to the Moon or about 240,000 miles.

In many ways, the chunk of rock serves as yet another wake-up call. It is a reminder about life here on our sitting duck of a planet. This will be the closest approach to date by an object this large that we know about in advance.

But don't worry…too much. Although classified as a potentially hazardous object, 2005 YU55 poses no threat of an Earth collision – for at least the next 100 years!

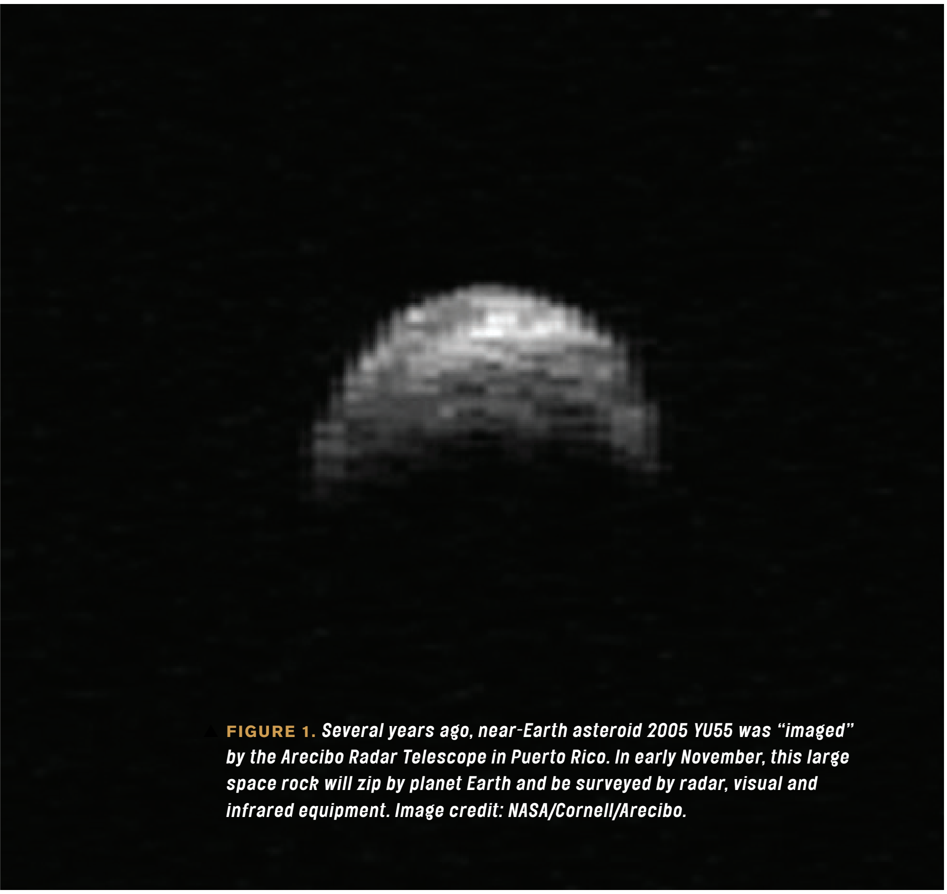


FIGURE 1. *Several years ago, near-Earth asteroid 2005 YU55 was "imaged" by the Arecibo Radar Telescope in Puerto Rico. In early November, this large space rock will zip by planet Earth and be surveyed by radar, visual and infrared equipment. Image credit: NASA/Cornell/Arecibo.*

On-call Observations

The 2005 YU55 is unusual since it is close and big, explains Don Yeomans, Manager of NASA's Near-Earth Object (NEO) Program Office and the Jet Propulsion Laboratory (JPL) in Pasadena, California. "On average, one wouldn't expect an object this big to pass this close but every 30 years."

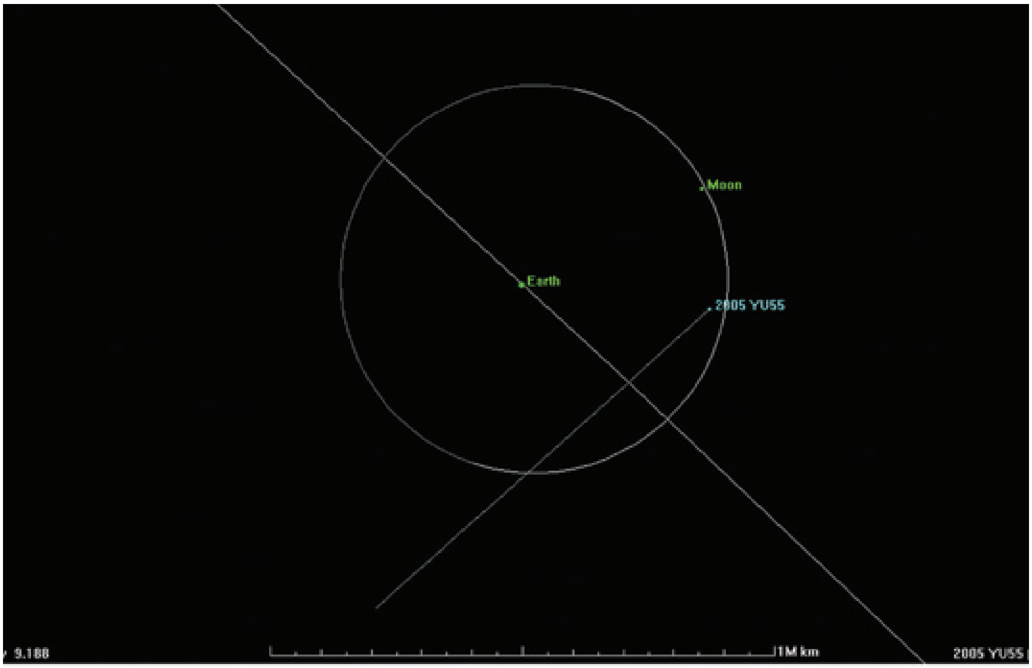
Yeomans told *Imaging Notes* that scientists see a great opportunity coming, given the close flyby. On call are ground-based optical and near-infrared equipment, as well as high-powered radar. Collectively, the observations should paint a fairly complete picture of a large, potentially hazardous asteroid.

The observations should define the object's rotation characteristics, as well as the asteroid's surface roughness and even mineral makeup.

Lance Benner is a research scientist at JPL and a specialist on radar imaging of near-Earth objects. He said radar scanning of the asteroid will be done using the huge Arecibo dish in Puerto Rico and equipment at Goldstone, California. "In a real sense, this will provide imaging resolution comparable to or even better than a spacecraft mission flyby," he points out. "It's a truly extraordinary flyby that we hope will reveal considerably more information than we currently have about this 400-meter sized, round, dark, and mysterious little world."

Using the Goldstone radar operating in a relatively new "chirp" mode, the November radar opportunity could result in a shape model reconstruction of the object with a resolution as fine as 4 meters.

Early on, the asteroid will be too close to the Sun and too faint for optical observers. However, late in the day on November 8 into the following day, the



▲ **FIGURE 2.** *An animation prepared by Jon Giorgini of the Jet Propulsion Laboratory shows the motion of asteroid 2005 YU55 in the vicinity of the Earth and Moon during the flyby. This can be viewed at http://ssd.jpl.nasa.gov/x/jdg/2005yu55/2005_YU55_approach_movie.gif*

object could reach about 11th magnitude for several hours before it fades as its distance from Earth rapidly increases.

But what won't fade is interest in keeping an eye on asteroids that may well have Earth's address on their space routes.

Planetary Defense

The havoc stemming from an NEO plowing into the Earth depends on its size and trajectory. Damage could range from destruction of an area the size of a city, to creation of tsunamis, to the extinction of almost all life on Earth.

In the making is a Planetary Defense strategy, one that includes finding these potentially hazardous objects, predicting their future locations, and providing warning about future impacts with the Earth. It also includes missions to deflect impacting asteroids by changing their orbit, and disaster preparedness, management, and recovery on Earth to mitigate their consequences.

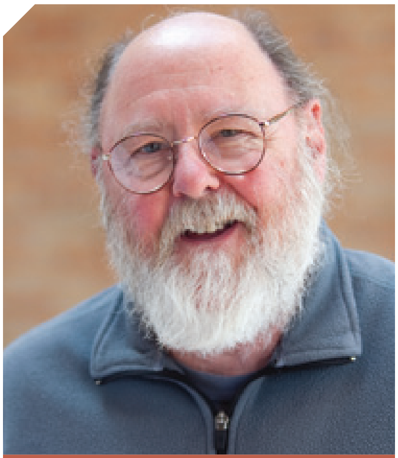
The Secure World Foundation has focused on how the world might organize to meet the challenge of mitigating possible effects of an incoming NEO. Doing so poses significant policy and legal challenges, many of which are common to space situational awareness, data sharing, collective security, and shared decision making.

Hence, the Foundation has partnered with the Association of Space Explorers and other organizations to assist the U.N. Committee on the Peaceful Uses of Outer Space to develop an appropriate international agreement for responding to the NEO threat.

By the way, put in your memory bank the year 2028. That's when asteroid 2001 WN5 will pass to within 0.6 lunar distance!

"There are definitely small near-Earth asteroids in our future, and we must make sure that when we encounter one, it is on our terms, not its," points out David Morrison, Director of the Carl Sagan Center for the Study of Life in the Universe at the SETI Institute in Mountain View, California.

To see an animation prepared by Jon Giorgini of the Jet Propulsion Laboratory that shows the motion of asteroid 2005 YU55 in the vicinity of the Earth and Moon during the flyby, go to http://ssd.jpl.nasa.gov/x/jdg/2005yu55/2005_YU55_approach_movie.gif.



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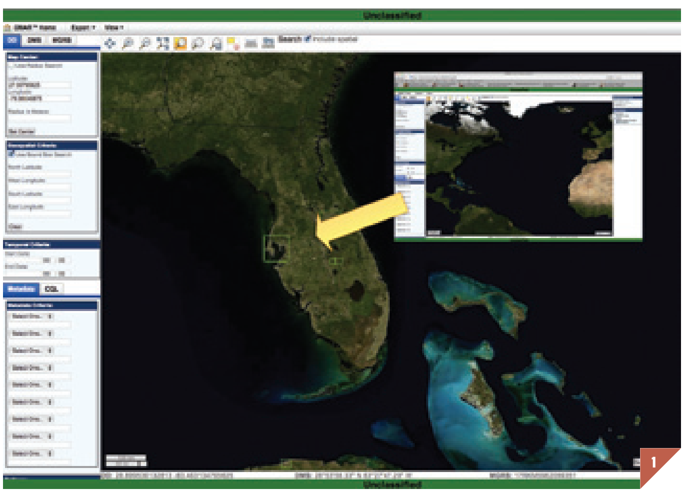
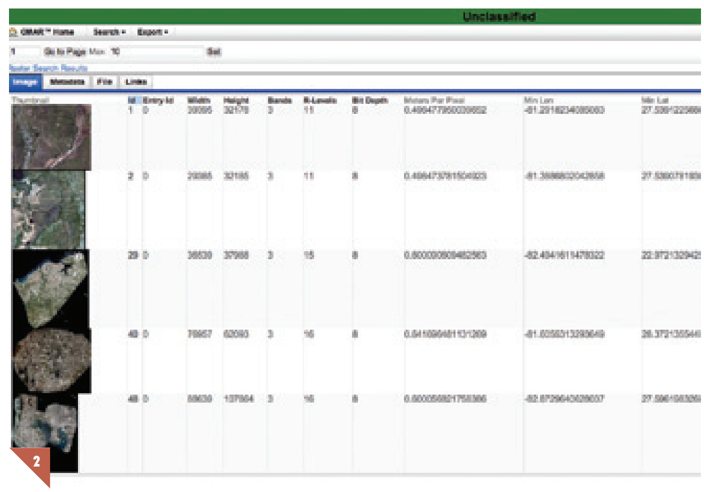
Omar

OPEN SOURCE SOFTWARE FOR GEOINT 3.0



▲ **FIGURE 1.** *A simple Web browser provides the interface to the OMAR system. The map can be panned and zoomed to identify the area of interest. Date, time and other fields can be used to filter the desired search results.*



▲ **FIGURE 2.** *Tabbed pages of metadata and an overview thumbnail are returned from the user's search request.*

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EDITOR'S NOTE: See also related article from The HumanGeo Group by Abe Usher on page 14.

AT THE GEOINT SYMPOSIUM IN 2010, NATIONAL GEOSPATIAL-Intelligence Agency (NGA) Director Letitia Long provided a vision for the future and labeled it GeoInt 3.0. That vision includes remote user access to imagery and products, collaboration, and manipulation of rapidly evolving agile technologies. Omar, from RadiantBlue Technologies, is a web-based processing and distribution solution that addresses many of the GeoInt 3.0 goals.

The solution embodies many of the features and approaches that were eloquently communicated by Director Long. She stated, "I want to put the power of GeoInt directly in the hands of our users."

Today, Omar is deployed on classified networks providing remote access of imagery and video to the warfighter. Ships at sea, rescue missions, numerous patrols, and regular service personnel are routinely reporting how these quick looks have assisted their missions on a daily basis.

The way in which this solution was developed and continues to evolve rapidly is just as interesting as its functionality. OMAR is open source software. It is developed and maintained in an online, distributed, and unclassified environment. The only exceptions are modular classified "plug-ins" that are maintained separately in classified networks. This architecture and approach allows development and integration at "Internet speed."

The rapid evolution of this system is made possible through the use of open source software projects, policies, and procedures led by the Open Source Geospatial (OSGeo) Foundation. OSGeo is the leading organization for open source software projects. OSGeo provides governance, standards, practices, code review, automated testing, and configuration management for leading open source geospatial projects. These services are managed through a stringent incubation process, project steering committees, and community peer pressure. Most projects are commercially backed by companies and consultants. The resulting systems are more efficient, with lower life-cycle costs; just as important, they are extremely agile. There are now hundreds (if not thousands) of companies dependent on OSGeo technologies for the services and value-added products these companies bring to market.

This approach to providing services is in stark contrast to traditional government software procurement and development practices. Existing government procurement practices evolved from large weapons systems and are not appropriate for rapidly evolving commodity technologies. Historically, government acquisition led to pre-defined requirements decomposed into tasks and sub-tasks bound by rigid schedules. Rapid innovation is difficult in that environment.

▲ **FIGURE 3.** *Views are calculated and presented on the fly with full orthorectification and precision terrain correction. Data courtesy of DigitalGlobe Corporation.*

▲ **FIGURE 4.** *The inset shows a resampled area of interest without image enhancements. Simple sharpening and histogram stretch operations can be applied by the user to bring out detail. Linear and area measuring, view export to file, band selection, and output to various streaming protocols are all supported to enhance the user's workflow. Data courtesy of DigitalGlobe Corporation.*

Modern day open source practices and tools provide automated tracking of discrepancies and enhancements, self-documenting code structures, unit testing, continuous builds, and extremely rapid evolution. The Internet and most of the corporate world now run on open source software and have adopted these practices. The need for rapid technical evolution and the pressing need to reduce operating budgets have focused government attention on the open source approach.

Several government agencies are rapidly adopting open source software solutions and practices. As an example, NGA InnoVision (the NGA division tasked with implementing new technologies) recently announced a major initiative for open source software adoption. The primary drivers are total cost of ownership and technical agility. Recently we have seen the open source model applied to hardware design, such as the DARPA vehicleforge.

Companies such as RadiantBlue Technologies provide professional services and support for the resulting systems and bridge the requirements of government acquisitions to the commercial practices, domain expertise, and support of open source business models. These new business models earn revenue by providing value to the customer and flexibility through rapid sub-contracting with other open source companies and consultants.

Open standards and interfaces have allowed these systems to continually integrate and evolve to meet the operational challenges of constantly shifting missions. Significantly, these approaches allow the data to be manipulated and viewed remotely — often avoiding bandwidth limitations and data duplication that are prominent with "push" architectures. The Internet is constantly showing us new business models and ways to collaborate; many of these approaches have been applied in the Omar system.

Key features of the OMAR system are:

- Remote discovery, viewing, and manipulation of imagery and products
- On-the-fly orthorectification, precision terrain correction, and sensor model projection
- Full Motion Video discovery and playback
- ITAR-approved core baseline
- Operation in both classified and unclassified systems
- Standards-based interfaces to external systems and tools
- No software installation needed at the user end
- No licensing fees for the open source software system

The user needs only a web browser and network access to use the system. The design strategy has been to keep the interface simple with only a web browser required on the user's device. All of the advanced processing and storage are managed on the server end where the data reside. This approach works well over long distances with limited bandwidth, providing a simple interface on the user's end and concentrating all of the advanced technology, storage and processing upstream.

The user needs only a web browser and network access to use the system . . . All of the advanced processing and storage are managed on the server end where the data reside. This approach works well over long distances with limited bandwidth, providing a simple interface on the user's end and concentrating all of the advanced technology, storage and processing upstream.

After logging in to the system, the remote user can interactively pan and roam through a reference map of the world to the area of interest. Footprints of available datasets are shown on the map, and results can be filtered based on a wide range of metadata parameters including date, time, sensor, target ID or any arbitrary combination of metadata values.

When the user presses the search button, a results page is returned. The results page includes all of the available datasets that meet the user's criteria. See ***Figure 1***.

An overview thumbnail is included along with a listing of the associated metadata. Tabs can select additional information about the dataset and options for streaming the data. Clicking the thumbnail allows the user to roam and zoom into the image or product at will. Additional controls are available for image adjustment. The user's cursor displays the location readout in a number of formats. See ***Figure 2***.

Many users of the system are using these interfaces to stream OMAR data into Google Earth. The system includes downloadable network links that automatically will fetch the latest data as Google Earth users change their view.

Simple controls for brightness, contrast, and sharpening can be adjusted. The resulting view can be saved locally in a number of formats for use in briefings or as input to other tools. Additionally a number of standard web mapping services allow OMAR views to be fed directly into other applications. Remote viewing and manipulation of National Technical Means (NTM), NGA products, Commercial Imagery, and Motion Imagery Standards Board (MISB)-compliant Full Motion Video (FMV) is provided by the system. NTM imagery is orthorectified and precision terrain corrected on the fly and projected into the web page view with the addition of a software plug-in that is separately maintained in a classified environment.

Once the image is selected, the user can roam and pan at will through the full size remote image. See Figure 3.

Most users are simply looking for reference or recent information in a very small area of interest. The system has exposed simple controls for manipulating the view, reading the coordinates, and taking simple measurements. The user can also save that adjusted view locally in a number of geospatial file formats. The goal was to put the users in charge and give them direct access to their area of interest in the national archives. See ***Figure 4***.

The OMAR system has been deployed on distributed super-computer networks, simple servers, and personal computers. The general concept is to move the software to the data, not the data to the software. Continuing evolution of social networks, standards-based protocols, and online technologies will be integrated into new releases of the system.

In summary, Omar is a demonstration of a new approach of software development and user interaction for everyday government users. The open source software development model and rapid innovation on the Internet lead to technical agility and dramatically lower total cost of ownership for remote manipulation and viewing of remotely sensed data.

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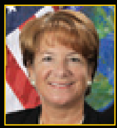

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ISEBOX Fuses Geospatial Data

NEW METHODS OF HUMAN TERRAIN ANALYSIS

Challenges in Today's Technology Landscape

IN TODAY'S COMPLEX ENVIRONMENT, PLANNING FOR FUTURE MILITARY operations requires allocating and moving resources in the geospatial domain. Military planners and intelligence professionals are challenged to make sense out of disparate socio-cultural data, collected for different purposes by a multitude of systems, and at different levels of specificity.

To interpret such data, the military often turns to Geographic Information Systems (GIS) as well as statistical analysis and data mining techniques. However, these solutions have drawbacks. GIS solutions are not built around a user's workflow and typically require that users have a significant understanding of the technology's foundational concepts, including familiarity with the fields of geography, statistics, cartography, and database architecture. Intelligence professionals and military planners also need the technical know-how to phrase questions correctly to get to the answers or results they are searching for based on the differing search query formats and capabilities provided by each tool.

BY ABE USHER, CTO
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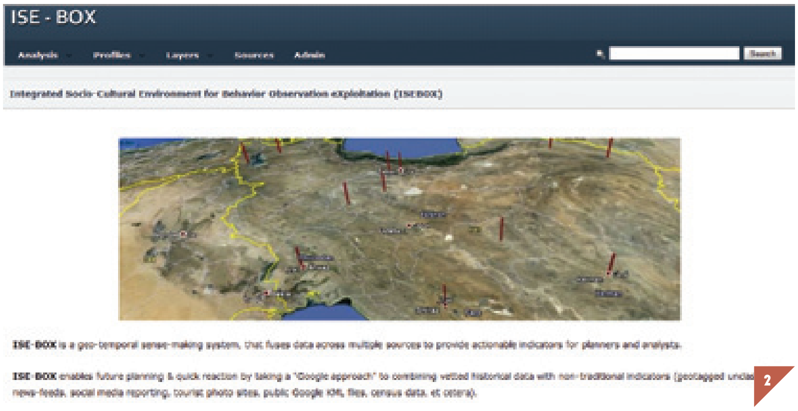
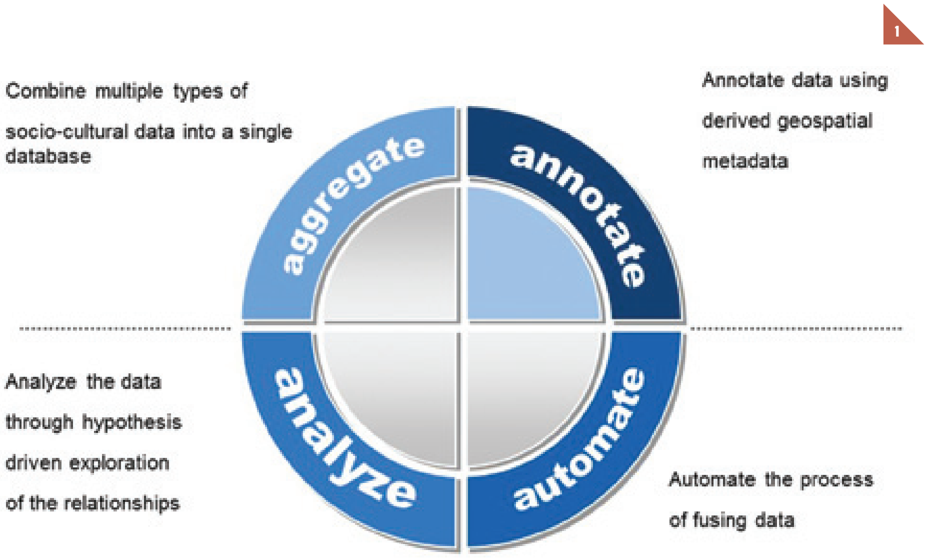
Statistical analysis and data mining are frequently used to predict future activities and events based on indicators (key information about the people and environment). Data mining also helps identify patterns for planners and analysts. There is a significant difference between knowing exactly what you want to look for and allowing patterns to emerge from the data to then analyze.

Such a non-parametric approach of letting the data "be your guide" is particularly powerful when analysts have simple tools that allow them to explore data based on their own expert hypotheses. Although not exact, such models hold enough precision and accuracy to be useful in planning scenarios, but do not provide a complete solution.

New Technology and Methods Are Needed

For all of these technology advances, the Department of Defense (DOD) is still constrained by the variety, quantity, and structure of data it collects. There is a large amount of data being





◀ **FIGURE 1.** *Adding context with the ISEBOX methodology.*

▲ **FIGURE 2.** *ISEBOX (Integrated Socio-Cultural Environment for Behavior Observation eXploitation) methodology adds context. In this image, the boxes and spikes represent areas with a high number of violent events around religious facilities.*

collected, but the process of extracting the relevant data is time consuming. Moreover, the usefulness of the data is dependent upon the users' knowledge, the data they have to work with, and the context from which they view the world.

Jeff Jonas, Chief Scientist of IBM Entity Analytics, notes, "If an organization cannot evaluate how new data points relate to its historical data holding in real time, the organization will miss opportunities for action. However, when the 'data can find the data,' there exists an opportunity for the insight to find the user." To address these data challenges, it is necessary to find ways to collect and fuse non-standard data sources in order to rapidly gain understanding of other regions of the world. When dealing with highly structured, well-formatted data, it is relatively easy to "connect the dots" and understand the associations and relationships between various data elements.

Unfortunately, things are much less clear when examining socio-cultural and behavioral data. Specifically, some types of analyses lend themselves to macro-analyses (e.g., comparing GDP of nations in the world). Other types of analyses require very precise data (e.g., understanding the exact location of a facility

> *Leveraging this real-world example and ISEBOX, the developers replicated and distilled the same analysis of the area of interest in a period of hours, as opposed to weeks, and with a fraction of the resources needed with existing tools and datasets, to discover non-obvious information from open source socio-cultural data.*

that might be a safe house for a terror group).

Analysts are often tempted to interpret the data in terms of man-made boundaries such as provinces, states, or districts, even when such boundaries are often not at a level of geospatial detail required for analysis. This problem is well documented and described as the Modifiable Areal Unit Problem (MAUP), which in essence warns that the unit of analysis selected while performing geospatial analysis has an overwhelming influence on the outcome and accuracy of the analysis (and whether it can be used again in the future).

ISEBOX

To enable the military to fuse together the data at its disposal and make better decisions, faster, the HumanGeo Group developed ISEBOX (Integrated Socio-Cultural Environment for Behavior Observation Exploitation), a geospatial threat-forecasting application that allows data with different spatial resolutions to be intermixed while preserving the original data. See ***Figure 1***. ISEBOX identifies friendly forces, trends, geo-political activity, and threat indicators to provide operations planners with critical access to data required to perform Intelligence Preparation of the Battlefield (IPB). ISEBOX uses variable precision data encodings of location to facilitate non-obvious pattern detection and predictive analysis in the geospatial domain. See ***Figures 2*** and ***3***.

Multi-Precision Data Fusion

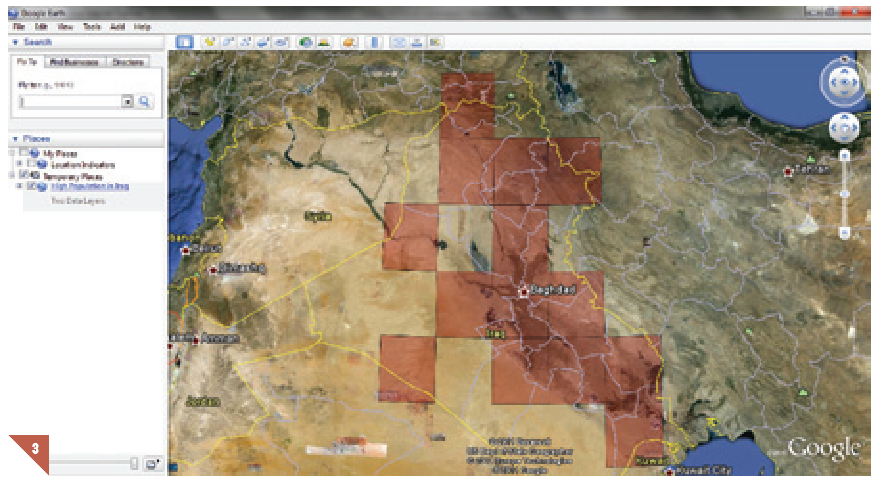
To accomplish this, ISEBOX employs geospatial hashing algorithms to encode data. These mathematical procedures assign unique, compact, and structured indices to any location or time to enable the utilization of data of vastly different geospatial and temporal resolutions. This encoding method enables the combination of datasets to identify regions of threatening characteristics.

Regions are rapidly refined into grid patterns to provide planners, operators, and analysts with geo-rectified collection and analytic start points to address emergent operational analytic requirements. In this way, ISEBOX's innovative capabilities allow decision makers to assess the adequacy of composite datasets to meet operational needs and to conduct effective risk analyses.

ISEBOX's methods of fusing data-based synthetic variables (grids) are a significant departure from legacy geospatial science. "Past strategies for fusing open source data into spatially enabled mission framework have been insufficient. The new innovative methods used for encoding and fusing data in ISEBOX are the future of GEOINT," asserted Chris Tucker, USGIF Board Member.

ISEBOX ingests the widest range of open sources of geospatial data (such as social media, civilian government sources, NGO data, and community-driven data collections) and provides a means of combining the sources to enable analysts to detect non-obvious patterns in the data in order to "tip and cue" planners, collectors, and analysts to points on the ground defined by geography, time, function, and analytic discipline. Many commercial geospatial analysis tools purport to allow geospatial analysts to combine layers of information, assuming those layers of information are accurately registered, and in a common format. However, the typical DOD analyst faces the burden of inferring and conveying the resultant precision and uncertainty of the combined datasets.

During an informal discussion about data fusion, Jeff Jonas from IBM noted, "An organization can only be as smart as the sum of its perceptions. To improve, organizations need more data.



▲ **FIGURE 3.** ***Fusing data layers for better insight: The red boxes show areas with high population density and high violent event rates, fusing two different datasets to see areas of concern quickly.***

The typical DOD analyst currently faces the burden of inferring and conveying the resultant precision and uncertainty of the combined datasets.

Capabilities like ISEBOX that increase observation space by introducing orthogonal data elements will lead to leap-ahead improvements."

Evolution of ISEBOX

In designing and implementing ISEBOX, there were both technical and practical challenges. The team, under the direction of Abe Usher, faced the challenge of applying and adapting hashing algorithms (used in cryptography) to a wide variety of datasets. In addition, the sheer variety of sources, formats, and encodings, and the availability of socio-cultural data presented challenges in finding and ingesting relevant data at the desired levels of granularity.

Operationally, the ISEBOX developers had to contend with overcoming perceptions created by the introduction of so much software for the military over the past ten years. Hundreds of software designs have asserted a unique ability to synthesize data into meaningful products and reports, yet fail to understand the requirements of the end consumers of their information.

Developers have repeatedly claimed the capability of integrating and fusing geospatial data, with most falling far short of their promise to "make sense" of the data for the warfighter. This has led to many analysts and planners pushing back on the introduction of new software tools due to the time and effort required for training and integration of the applications into their often overburdened workflow.

To overcome these preconceptions and prove the value of ISEBOX very quickly, the developers applied ISEBOX to a vignette on threat actor activity to demonstrate the technology could reveal new insights (even just using open source data). Leveraging this real-world example and ISEBOX, the developers replicated and distilled the same analysis of the area of interest in a period of hours, as opposed to weeks, and with a fraction of the resources needed with existing tools and datasets, to discover non-obvious information from open source socio-cultural data. The use of a concrete real-world example helped to prove to analysts, planners, and decision makers that using ISEBOX could help save both time and money while also exposing "weak signals" from a combination of socio-cultural data to identify specific regions of interest/concern.

The Future of Open Source Socio-Cultural Information

Initially developed by Mr. Usher specifically for use by the DOD, The ISEBOX methodology can enhance the ability of planners and leaders in making choices about how and where to allocate resources for the future. It provides operational impact by enabling the incorporation of "near real-time" analytic overlays into plans and forecasting tools along with delivering an inherent ability to assess the uncertainty of the resultant analyses. It also holds promise as a way to combine disparate, weak signals from different sources of socio-cultural data and synthesize them to create a detailed operational picture.

ISEBOX uses variable precision data encodings of location to facilitate non-obvious pattern detection and predictive analysis in the geospatial domain.

ISEBOX introduces a new and unique capability to the nation's geospatial tradecraft by allowing historical and general data for geospatial regions to be integrated with more precise data to address operational requirements while minimizing the potential for over-generalizing or creating a false sense of precision. This capability opens the door to fuse geospatial data with a much broader range of data types in supporting analysis – particularly open source datasets which may have varying temporal and/or geospatial granularity. It enables global scale analyses applying a breadth of sources including community-driven data collections that could not be otherwise integrated. ISEBOX enables the use of open source datasets to identify unique threat patterns that can provide purpose and direction to classified collections. ISEBOX also challenges current classified paradigms and the manner in which the classified sources collect and verify their analysis.

ISEBOX has been nominated by the Office of the Secretary of Defense, the Office of Naval Research, and a DOD Combatant Command for the the USGIF Industry Award for the most innovative geospatial software to be developed in 2011 for DOD. In the award nomination, the government said that the mathematical concept and the team's "understanding of the necessity to harvest open source data for illustrative demonstrations of real-world problems was the best we (they) had seen in the previous decade of attempts."

ISEBOX is currently being deployed by elements of a Combatant Command within the DOD, and it will also be on display at the HumanGeo booth in the New Member Forum (Booth 203) at the GEOINT 2011 Symposium in San Antonio in October. Mr. Usher will also speak at the GEOINT 2011 Symposium on the Enabling Socio-Cultural Technologies Panel hosted by Jeff Jonas from IBM.

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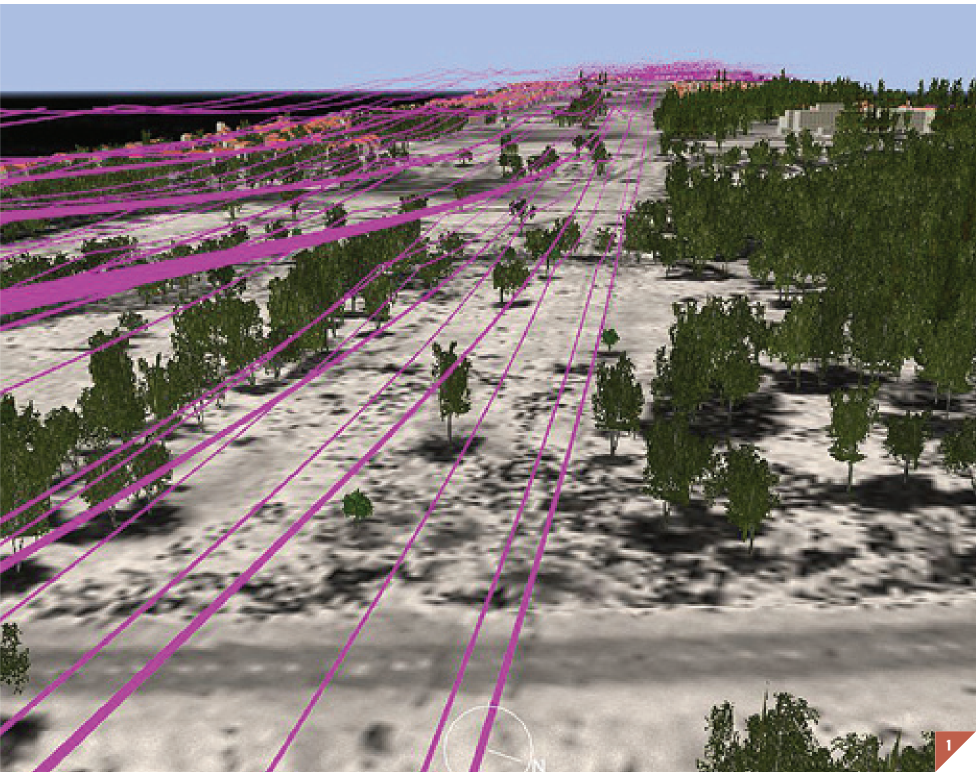

Processing Point Clouds

3D DATA UPDATE

▲ FIGURES 1 & 2. *E3De creates photorealistic 3D representations of LiDAR data. Using E3De, power lines are automatically extracted from LiDAR data with one click. Power line data is then stored as an independent, portable dataset for further analysis in a GIS. Point clouds can not only be represented with RGB values provided in the raw LAS file, but accurate digital ortho-images are also derived with a single click. Using the results from E3De, it is easy to determine where future trouble spots will occur by locating the trees that grow directly under and adjacent to the power lines.*

BY MATTEO LUCCIO
Writer, Portland, Ore.
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EDITOR'S NOTE: This is a preview of the Winter issue, which will be distributed at the International Lidar Mapping Forum. Other lidar processing software and tools, including open source options, will be featured there.

LIKE RASTER AND VECTOR DATA MANY YEARS AGO, 3D CLOUDS OF billions of LiDAR points — which can be colored and very realistic — are an exciting new data type. However, they pose many software challenges, and software vendors are working hard to develop new software to manage, process, visualize, and extract features from point clouds.

The first challenge posed by LiDAR to computer software and hardware is the huge size of the files generated by ever more powerful scanners. Often, the limiting factor is the operating system. For example, the 32-bit operating system can handle only files of up to a few gigabytes, and most systems are not designed for such large datasets. Though software providers have made progress in how they handle the display of point clouds, experts agree that this remains a challenge.

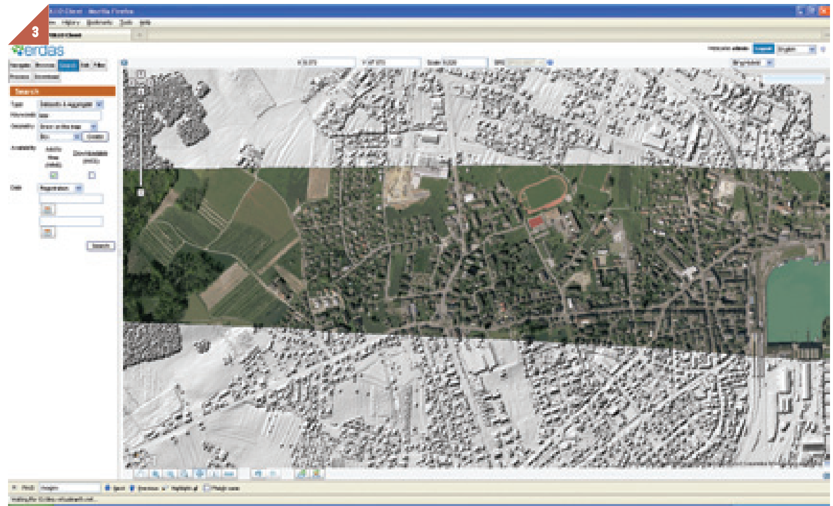
More recently, a new challenge emerged: managing the thousands of files of point cloud data generated by the explosion in the use of terrestrial LiDAR scanners, making these files available to users across an organization, and integrating them across different workflows. The final two challenges are fusing LiDAR point clouds with data from other remote sensing devices and further automating measurements and feature extraction.

Visualizing Lidar Data

Software vendors have taken different approaches to enabling their software to visualize LiDAR data.

People want to visualize LiDAR data as points and they want the ability to do it in 3D, says Brad Skelton, CTO of ERDAS. If you simply load all the points and display them, he explains, you quickly run out of memory. Enabling users to perform the tasks they want to perform with these very large datasets requires indexing the files and providing an efficient paging mechanism.

"The conventional solution," Skelton says, "is to tile LiDAR datasets into smaller pieces that will fit into memory and perform your processing in a piece-wise manner. We are trying not to do piece-wise processing, but instead provide the user with a single, large dataset and continuous experience and still have everything be as fast as it is with the entire dataset in memory at once." The company's competitive advantage, he argues, is going to be its ability to deal with a large dataset, as well as offering both a server product and a suite of desktop products that can deal with LiDAR data. Next year, it will release a new version of its software that will fully support LiDAR as a data type.



▲ **FIGURE 3.** *ERDAS APOLLO Web Client displaying LiDAR and imagery data from the Swiss municipality Romanshorn. The LiDAR data was collected by a Leica ALS50 along with color imagery from a Leica ADS40. Other delivery options of data are by download or delivery via web services into other web client applications. Courtesy of ERDAS.*

> *"We have many tools to make 3D measurements from imagery that can be applied to make 3D measurements from point cloud data," says Zhang of BAE Systems*

Bentley began by embedding point cloud management capability into MicroStation, its CAD 3D editing platform, and ProjectWise Navigator, its tool for collaboration and design review. Because most of the company's industry applications share the same technologies as MicroStation, most of the desktop products that came after MicroStation V8i (SELECTseries 2), released last year, including Bentley Map, OpenPlant, and Bentley Architecture, are able to visualize point clouds. "We bring point clouds inside our engineering tools, whether it is generated by aerial LiDAR or by static or mobile terrestrial scanners," says Benoit Fredericque, a product manager for Bentley. "For us, it is all about our capability to handle huge point clouds properly."

Esri's ArcGIS desktop and server applications, all of which share the same underlying technology, can ingest, process, and display LiDAR data. The trick, explains Clayton Crawford, one of the company's product engineers, is coming up with an efficient I/O stream for moving that data around and accessing it efficiently. "For some applications, working on thinned data is OK, while other applications require full-resolution processing."

"Our next release, ArcGIS 10.1, which is already in beta, adds significant capabilities for LiDAR, including native support for LAS," says Crawford, referring to the industry standard format for LiDAR data. "This means LiDAR data can be managed, viewed, updated, and shared, all while remaining in its native format. We'll be introducing a new data type called a LAS dataset that makes it easy to access your data quickly. You just tell it what LAS files belong to a project and it manages the collection as one dataset for you."

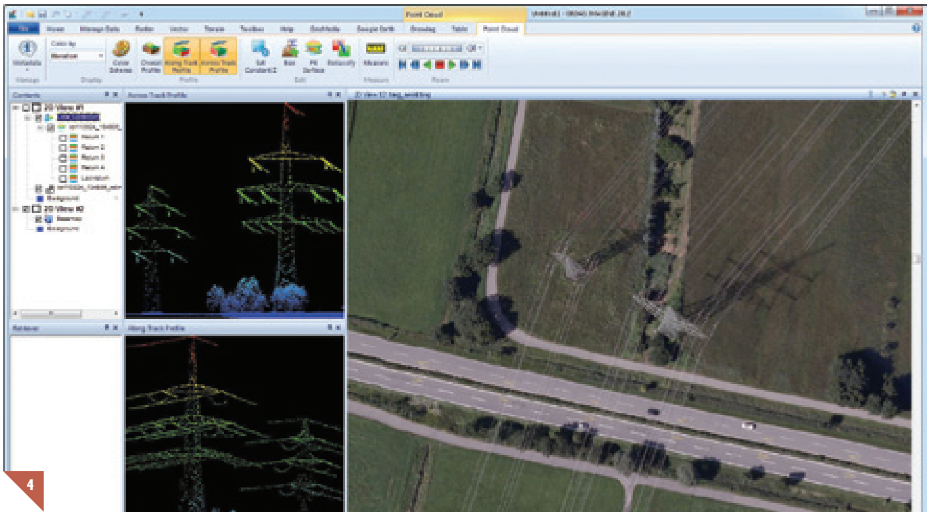
"Our Mosaic dataset, which is used to manage and share imagery," he adds, "is being enhanced to read LAS directly. It will perform fast, on-demand rasterization of LAS points and can handle many LAS files from multiple projects. Through its support of image and elevation services, the Mosaic dataset can also be used to publish LiDAR either in source LAS form or as derivative rasters. It provides a very effective means of managing large collections of LiDAR in a way that's similar to managing lots of imagery."

ITT VIS' flagship image processing and analysis software product, ENVI, can extract elevation and intensity values from LiDAR point clouds. IDL, which is an extensible platform for ENVI and a programming language, gives users API access to LiDAR point cloud data and also has a broad range of tools to visualize LiDAR data and process it volumetrically. The company's latest product, E3De, scheduled for release October 14, is completely specialized for LiDAR data. ITT VIS is initially releasing it as a full stand-alone application, but it will ultimately also serve, optionally, as a module to ENVI, says Peter McIntosh, the company's Manager of Industry Solutions.

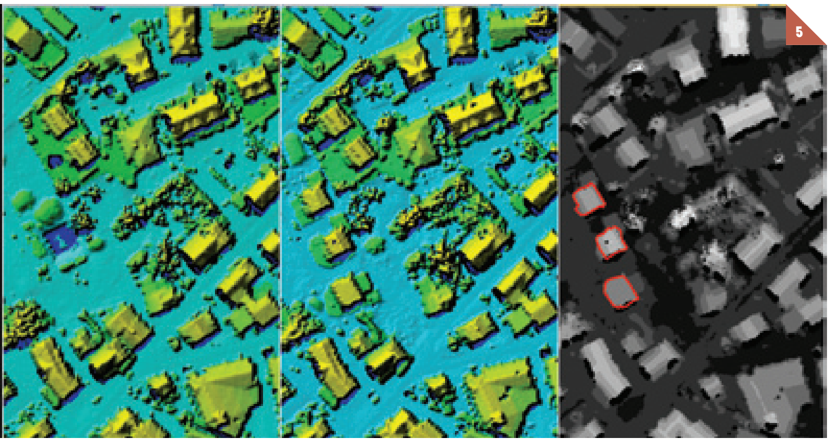
Managing Lidar Data

Bentley is now working on the management of the point cloud on the server side, for which it plans to use Bentley ProjectWise. Meanwhile, on the desktop, it is adding advanced capabilities related to point clouds inside Bentley Descartes, which has been used for more than a decade as a raster editing product that enhances MicroStation workflows. "We are also developing applications to make point cloud data available on iPads and on the Web," says Fredericque. Bentley plans to release in early 2012 ProjectWise V8i (SELECTseries 4), which will provide new capabilities for managing point cloud data.

One of the first ERDAS products to deal with LiDAR data was ERDAS APOLLO, which is the company's enterprise data manager. "A couple of years ago," says Skelton, "we added to ERDAS APOLLO the ability to catalog and manage LiDAR datasets, so that it can discover your LiDAR datasets, extract various pieces of geospatial metadata from them, put them in the catalog, and give you a means of executing spatial and attribute queries to find the datasets that are pertinent to the areas on which you are working."



▲ **FIGURE 4.** *Visualize point clouds across or along track profile view using IMAGINE Point Cloud Tool. Courtesy of ERDAS.*



◀ **FIGURE 5.** *New Building Detection using IMAGINE Objective with multi-date LiDAR data to show the detection of new building activity to determine legality and tax status. The LiDAR is shown as a sun-angle shaded representation at two dates and the IMAGINE Objective results are shown as a vector overlay on the raw height data. Courtesy of ERDAS.*

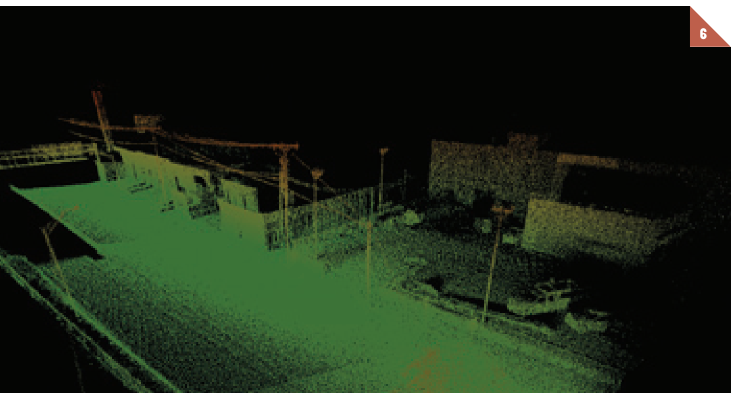
Fusing Data From Lidar and Other Sensors

"We are focusing our energies on integrating LiDAR data with the other modalities," says McIntosh, "to create a holistic and integrated dataset that tells us the volumetric properties that you get from LiDAR, the surface properties that you get from SAR (synthetic aperture radar), and the material properties that you get from optical and hyperspectral. That overall data fusion is the target and the goal for the future. Looking forward, I see the holistic integration of all of the modalities into a unified resource as the biggest challenge with LiDAR."

ITT VIS has worked in the past several years to integrate ENVI with the Esri product line, making image analysis tools available directly from the Arc environment. The road map for E3De, McIntosh says, will include the integration for the GIS user as well. "As with ENVI, it will also have full API programmatic access and extensibility."

BAE Systems is planning to add to future releases of its SOCET GXP the capability to register multiple strips of LIDAR data with each other and LIDAR data with imagery. It is also working to fuse imagery and terrestrial LIDAR data — which, points out Dr. Bingcai Zhang, an Engineering Fellow with BAE Systems, are now denser, less expensive, and more abundant than a few years ago due to advances in ground sensor hardware.

Not surprisingly, Esri is focusing on integrating LiDAR data into GIS, so that it is not being processed in a specialized application but rather in a more general purpose, one for dealing with all kinds of geospatial data. "So we have the integration of the processing, analysis, and display of LiDAR data along with other geospatial data and that brings a lot of power to the end user," says Crawford.



▲ **FIGURE 6.** *Terrestrial point cloud in Phoenix - visualize airborne or terrestrial point clouds in 3D. Courtesy of ERDAS.*

Automatic Feature Extraction

To enable users to get the most out of LiDAR data, software must be able to extract geometries, features, and measurements automatically. For example, it must recognize such 3D objects as houses, trees, and, if the point cloud is sufficiently dense, cars. This is especially valuable for certain industries, such as transportation and building. "We have seen very interesting progress in this automation with aerial LiDAR, but in other areas of the infrastructure world, the level of automation is pretty low," comments Fredericque.

SOCET GXP v4.0, which BAE Systems plans to release in early 2012, will include automatic feature extraction. To increase efficiency and reduce manual entry for end users, the underlying algorithm will automatically compute the dimensional attributes of a 3D object, for about 20 attributes. This capability builds on the company's 16 years of experience in developing photogrammetric algorithms for SOCET SET and SOCET GXP. "We have many tools to make 3D measurements from imagery that can be applied to make 3D measurements from point cloud data," says Zhang. "That is our legacy and our competitive advantage."

ITT VIS is also adding tools that automatically extract information from files of various data types. "We already provide tools for the automatic extraction of building footprints, trees, power lines, etc.," says McIntosh. "We are going to see more and more automated tools that span across industries. So, for example, someone in agriculture will say, 'I want to see crop height for my corn in July,' and it is going to be much more point-and-click, decision-ready information out of these. We are going to see that in forestry, urban planning, etc. — more and more advanced processing. LiDAR brings a whole 3D element into the remote sensing picture, where we can use things like hill shades — slope, aspect, elevation. It just gives us yet another element to discriminate and identify specific features or information that people want."

LPS, ERDAS' photogrammetry software, has a very high resolution terrain extraction component, eATE, which does optical stereo point extraction. It allows users to extract point cloud data at LiDAR densities and output the data as LAS files. Therefore, Skelton points out, in addition to ingesting, processing, and displaying LiDAR data, LPS can also produce LiDAR-like data.

Beyond Automatic Feature Extraction

Many people think of a point cloud only as a kind of intermediate form of data from which to generate geometry. While this is a good application area, Fredericque argues, a point cloud is also very valuable when used 'as is.' "For example," he says, "you can use it as a kind of 3D base map or, in some contexts, as a 3D model. An industrial plant might not have a 3D model; it might just want to replace a piece of equipment. If you consider point clouds only as an intermediate data type, the extraction of all the features becomes a mandatory and demanding process. Another way to address that challenge is to use the point cloud 'as is,' as a background 3D model, and use tools to remove the points that correspond to the piece of equipment that you plan to remove. This way, you can manipulate the point cloud. You can isolate a piece of equipment and replace it with a new one. That kind of workflow and usage is not frequently mentioned or investigated, but I believe it makes a lot of sense."

Clouds of billions of LiDAR points — often colored and very realistic — bring a new 3D element into the remote sensing picture and require new software tools. Software vendors, already challenged by the huge size of the point cloud files created by ever more powerful scanners, are developing new ways to manage the thousands of files generated by the explosion in the use of terrestrial LiDAR scanners, to make them available to users across an organization, and to integrate them into different workflows. They are also embedding point clouds into engineering tools and GIS and developing new ways to automate the extraction of geometries, features, and measurements. The ultimate goal is to fuse volumetric properties derived from LiDAR data, surface properties derived from radar, and material properties derived from optical and hyperspectral data to create a single, integrated dataset.

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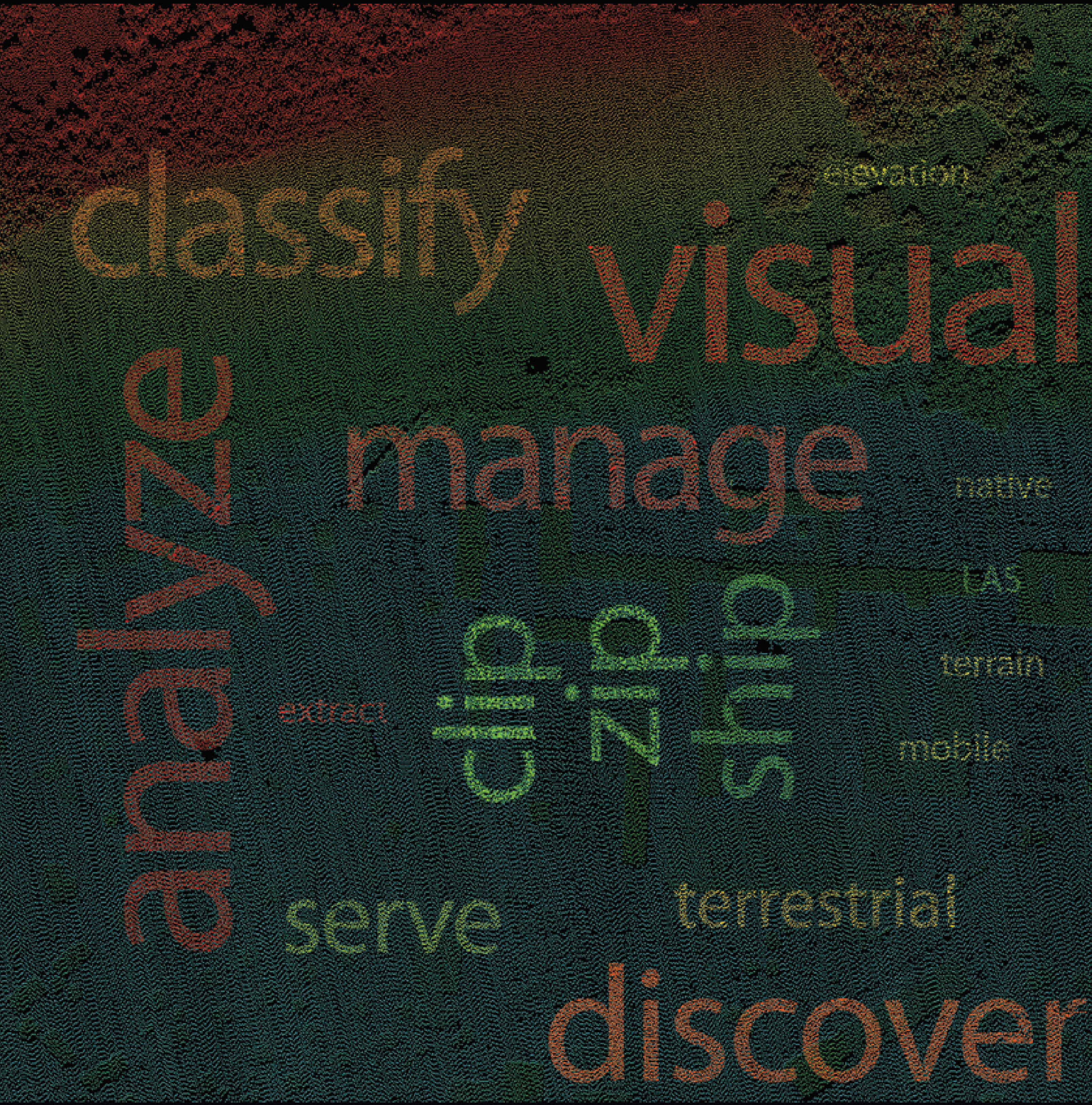

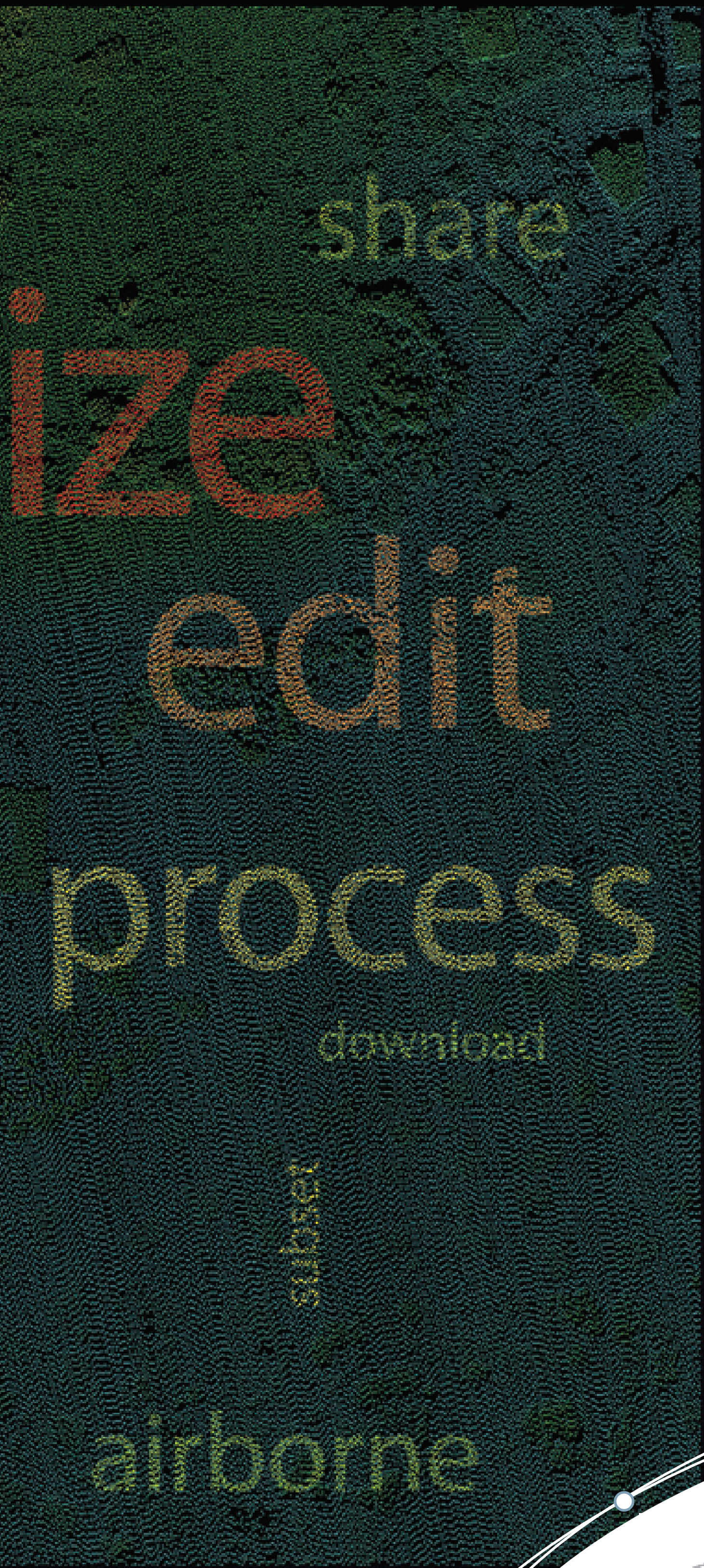

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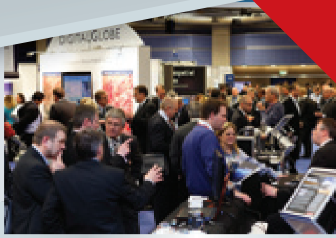

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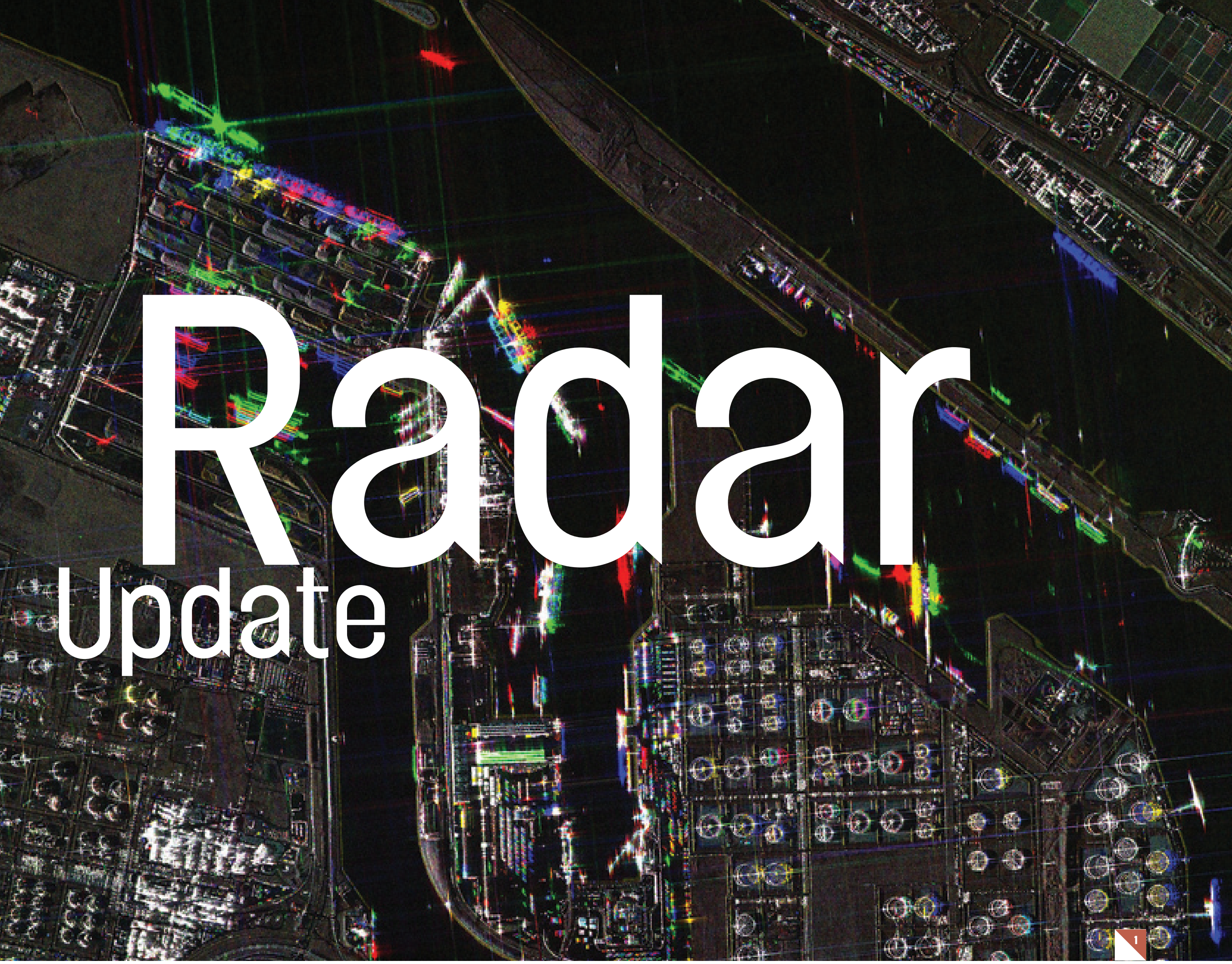
Radar Update



APPLICATIONS ABOUND IN DEFENSE, MARITIME AND ENGINEERING

▲ **FIGURE 1.** *Change Detection Image at Port in Rotterdam, The Netherlands - False color SAR image with 1-m resolution (Spotlight-2 mode) was obtained by combining three observations carried out by different satellites of the COSMO-SkyMed constellation, with red: COSMO 2 on 29/06/2011; green: COSMO 3 on 30/06/2011; blue: COSMO 1 on 07/07/2011. All unchanged features are in black-grey-white color according to their brightness. Colorful features show changes along the time span (9 days) of the observation with ships and boats changing their positions. Faint color variations reveal changes of the content in the fuel tanks in the lower part of the image. Image courtesy of e-Geos.*

WHETHER USED TO VIEW EARTH'S SURFACE THROUGH CLOUDS OR AT NIGHT, TO MEASURE THE thickness of polar ice sheets, to map long-abandoned mines, or to monitor subsidence, synthetic aperture radar (SAR) imaging has become a standard remote sensing tool. While optical satellites have higher resolution, radar imagery is better for change detection. Governments and private companies can use SAR satellites to monitor wide swaths of land or water from relatively low orbits, then

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EDITOR'S NOTE: The Korea Aerospace Research Institute and Fugro declined to be interviewed for this article.

follow up with higher resolution systems to zoom in on, say, an unidentified ship approaching a shore. Capacity continues to grow, as new satellites are launched. The two biggest challenges now for this segment of the geospatial industry are to develop software tuned to the requirements of specific users and to train them in using the data.

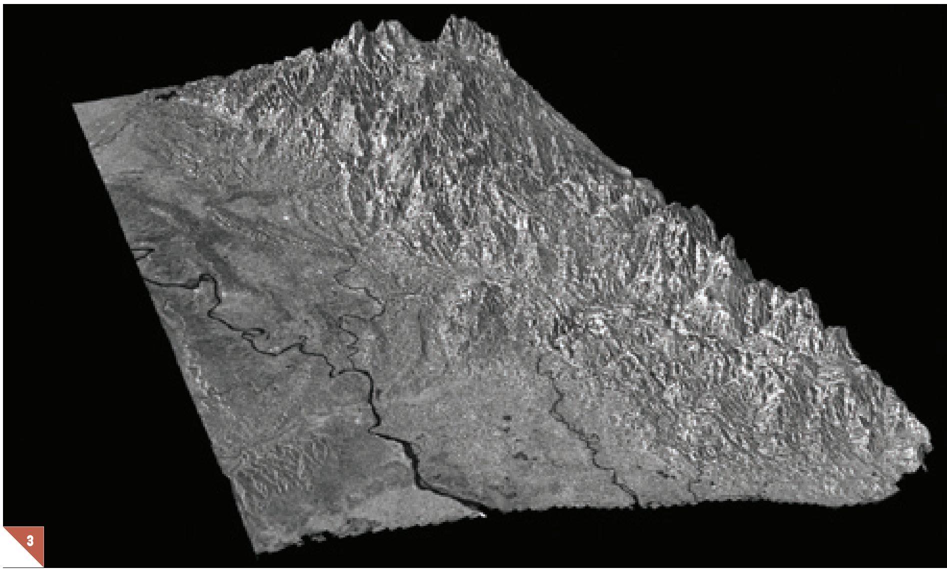
Status and Trends

Radar is a growing market. “From a mostly defense and maritime business,” says Andreas Kern, Director of Business Development and Sales for the European company Astrium GEO-Information Services, which owns TerraSAR-X, “it has grown 20-25 percent per year over the last three years, and the variety of user requests keeps expanding.”

John Hornsby, VP of Geospatial Strategy of the Geospatial Services Division at the Canadian firm MacDonald Dettwiler and Associates Ltd. (MDA) — the commercial provider of RADARSAT-1 data and operator of RADARSAT-2, a SAR imaging satellite that was financed primarily by the Canadian government — has seen his company’s business increase significantly in the past 18 months. For example, he says, Canadian government agencies have dramatically increased utilization for maritime monitoring and surveillance making it a core tool for fulfilling their operational mandates.

“With regards to change detection,” Hornsby says, “clients need the tools to better utilize radar data, and we are developing them. It has been a challenge to develop exploitation systems, because they have to be very tuned to the requirements of specific users. For example, agricultural users need to fully utilize the polarmetric capability of the imagery, which is complex to do – to identify particular crop types. Defense users, on the other hand, are looking more at changes over time and require different techniques to fully exploit the imagery.”

▲ **FIGURE 2.** *MDA’s services for the mining industry identify unstable areas for repositioning of equipment or infrastructure to minimize potential damage and avoid injury. It is also used as a validation mechanism before costly real-time monitoring systems are implemented. This image shows wall integrity, courtesy of MDA Geospatial Services, Inc., 2010.*



▲ **FIGURE 3.** *New RADARSAT-2 imaging modes with wider swaths enable broad-area DEMs to be created using fewer images, reducing the time and cost of production. Courtesy of MDA Geospatial Services, Inc., 2010.*

One indicator of the growing recognition and acceptance of radar imaging is that the National Geospatial-Intelligence Agency (NGA) has put in place contracts with major SAR providers, as it had previously done with optical data providers, so as to have a mechanism to routinely access SAR data. This is one reason Hornsby expects to see an increase in utilization. “We are collaborating with our Italian and German colleagues to build the utilization market,” he says. No commercial U.S. radar system exists currently.

Jack Hild, Vice President for U.S. Defense Strategy at DigitalGlobe, spent 30 years at the NGA, where he was continually in charge of operations in which analysts used radar. While acknowledging that commercial radar technology is very good, he says that he would be surprised to hear that someone had come up with a striking new use for radar imaging recently. “I visited all the major providers within the past few months and did not see anything new,” he says. While radar is “a great supplement” to electro-optical (EO) Earth observation, he points out, it will not replace it. "Radar and EO will continue to grow globally, but I don't see double-digit growth. I do see evolutionary growth, as more nations see the value of remote sensing for security and resource management requirements."

Neither DigitalGlobe nor GeoEye have any radar capabilities on current satellites. "We are looking for a way to establish partnerships with providers of radar data," says Hild. "Depending on the end use and the customer, we may want to do the analysis ourselves, and sometimes we would rely on our partners for some of the advanced processing."

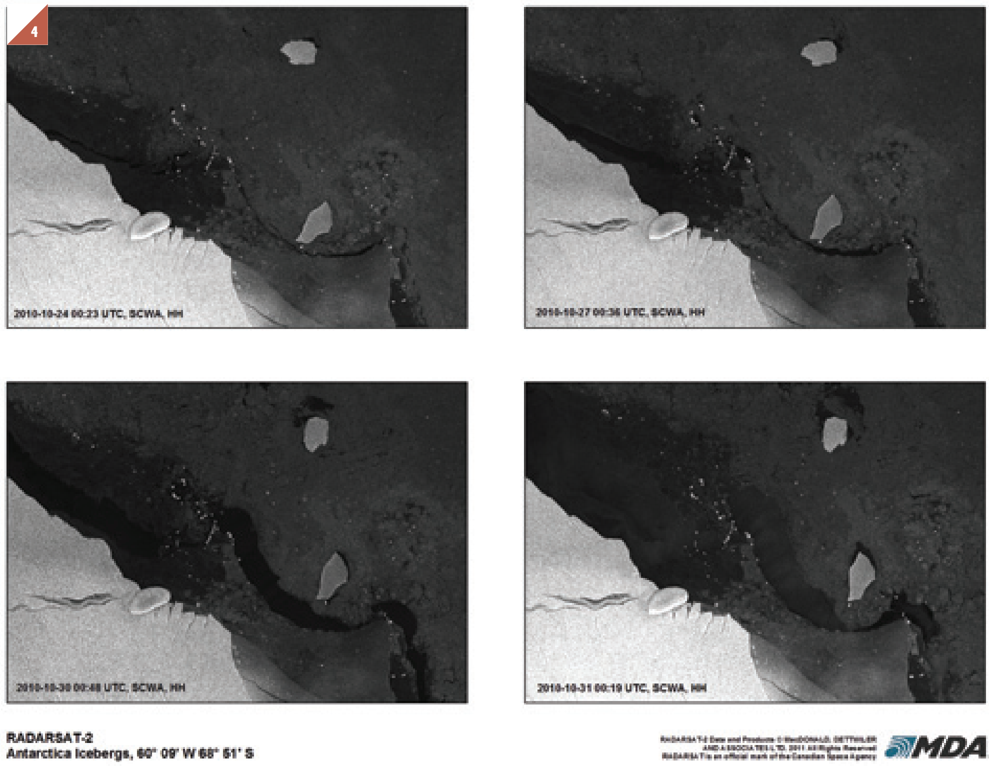
Markets and Applications

Sales of radar data are still mostly business-to-government (B2G) and business-to-business (B2B); however, consumer applications are the next most logical area for growth. "The path for consumer applications is going to be longer," says Kern, "and will require using multi-source data fusion to create derived products and solutions."

Meanwhile, the range of applications for radar imaging is rapidly expanding. "I've seen some great work in using radar to monitor subsidence, in conjunction with autonomous ground sensors," says Hild. "It's also been useful for monitoring ice movements in maritime shipping channels and always has a role to play in weather-related natural disasters, such as Hurricane Irene."

Radar is essential to meet imagery requirements in countries in persistently cloudy areas, he points out. "Clouds happen and you can't always get the picture that you are hoping to get with EO data, but customers more and more have an expectation that they can get imagery at any time. For example, for monitoring ships, they want a guarantee that they will always be able to report whether or not a ship is still docked at port."

One of the most important applications for radar is maritime surveillance — called maritime domain awareness in the United States — which involves monitoring ship traffic over very large areas. The Canadian Department of National Defence (DND) has recently brought into operation two new stations, on Canada's east and west coasts, using radar to produce ship detection within minutes.



▲ **FIGURE 4.** *Icebergs breaking away from the Antarctic Peninsula on four different dates. Courtesy of MDA Geospatial Services, Inc., 2010.*

Hornsby points out, "Building on the strength of the RADARSAT system for maritime monitoring, we are also improving ship detection capability with new operating modes. In this case, new modes have been created which are more effective in identifying vessels. The trade-off is a reduction in appearance of the overall image but for this application, that is not important. The key is getting the ship information." Real operational users such as DND are embracing the capabilities of satellite radar imaging as performance has improved to meet their specific needs.

The key concept is the transition from application to operational service, argues Luca Pietranera, Head of COSMO Product Innovation and Technical Support for the Italian company e-GEOS S.p.A., the commercial provider of COSMO-SkyMed constellation data. This transition means providing the data in near real-time to a user, such as a coast guard. "We can provide a fully integrated system. Within minutes of when a receiving station receives an image from a satellite, we can process it and integrate it into the information system of the end user. We can do this because we have a fully integrated system, and the frequent revisit provided by our constellation is a key factor for the success of the service."

objects that are one meter wide or bigger (i.e. wider than the pixel size). However, if you analyze changes in the phase signal — the first step is coherence analysis — you can see whether a change occurred in objects that are the size of the wavelength (a few centimeters)."

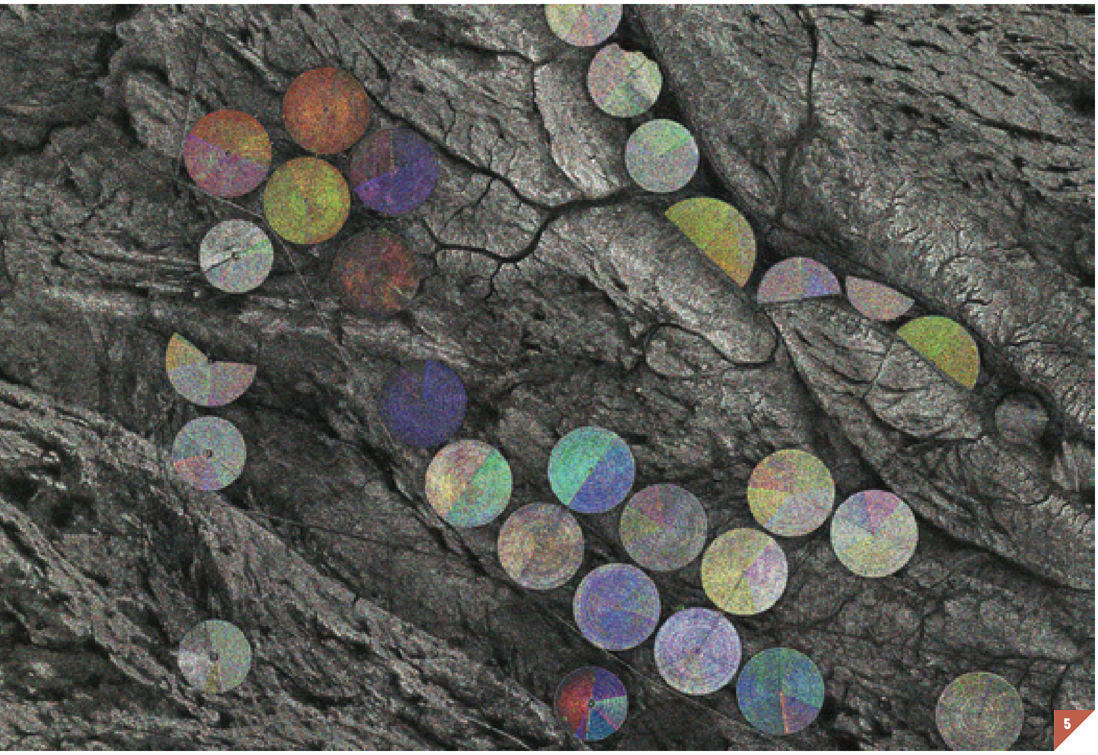
change detection in optical imaging)."

"Interferometric processing techniques, especially when coupled with COSMO-SkyMed's high spatial resolution and frequent revisits," Pietranera says, "can provide significant information for defense and security applications (by detecting disturbances created by human activity, such as the action of wheels on bare terrain), but also to monitor long term land stability (subsidence, landslides, or earthquakes), or even to provide control on agricultural activities."

InSAR is particularly useful in the oil and gas industry (to monitor oil fields), in civil construction (to detect potential sinkholes), and in mining (to monitor subsidence). Regarding the latter, in the eastern United States, active mines are being monitored, and forgotten mines are being detected using GPS.

Astrium's most important vertical markets are defense and the oil and gas industry. In the past year, the company has begun to address the requirements of civil engineers, for example, by using vertical measurements to help operators secure airport safety, and to help large construction projects monitor subsidence. It has also developed methods for collecting from space new ground control points (GCPs), which are needed, for example, to ortho-rectify satellite imagery. "Thanks to the extraordinary accuracy of TerraSAR-X," says Kern, "we can generate GCPs by collecting on specific points and then triangulating with better than 1-meter XYZ. This is especially cost-effective when it is too expensive or dangerous to put people on the ground. Thus, radar complements terrestrial differential GPS, though it will not replace it."

Astrium's data is often used for emergency support, Kern points out. For example, the flood-mapping program it developed with Trimble, which automatically derives flood masks and compares pre- and post-flood data, is



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▲ **FIGURE 5.** *Gawar, Saudi Arabia Center Pivot Cultivation - The multi-temporal image (in false colors) shows center pivot cultivation in the Arabian desert. The three Stripmap mode images (3-m spatial resolution) were collected by different COSMO-SkyMed satellites over one week. Circular cultivated areas show bright colors indicating changes occurring in both terrain and vegetation due to agricultural activity (irrigation, plant growth, ploughing . . .). Image courtesy of e-GEOS.*

Many of these applications are made possible by the use of interferometric SAR (InSAR) and interferometry, the discipline that studies the phase of the SAR signal and its variations. "The phase signal can be regarded as an accurate measurement of the distance between the satellite and the target," explains Pietranera, who develops new fields of application for radar data, mostly by exploiting change detection. "When you compare two images looking just at the backscatter data, you can see changes in

He continued, "Due to the sensitivity of imaging radar to artificial structures and 3D structures with corners, change detection monitoring can be 'focused' on those structures, as illustrated by the image of the port in Rotterdam, The Netherlands. The observations can be repeated very frequently in time and, on top of this, radar wavelengths are not affected by changes in observing conditions (such as atmospheric transmission, presence of haze, which can cause 'spurious effects' when analyzing used by emergency response authorities, currently especially in Asia and South America, but also for insurance claims.

Another key application of radar data, Pietranera points out, is monitoring the polar regions — especially the North Pole, which is becoming more important strategically, creating a big demand for monitoring. As ice melts, new shipping routes are becoming available. The most famous is the Northwest Passage through Canada's polar islands. "These routes are very long and very extended in longitude," he says. "Therefore, it requires a lot of satellite capacity to monitor them and to provide safety information to shipping companies, to national authorities, and to vessels going along the route."

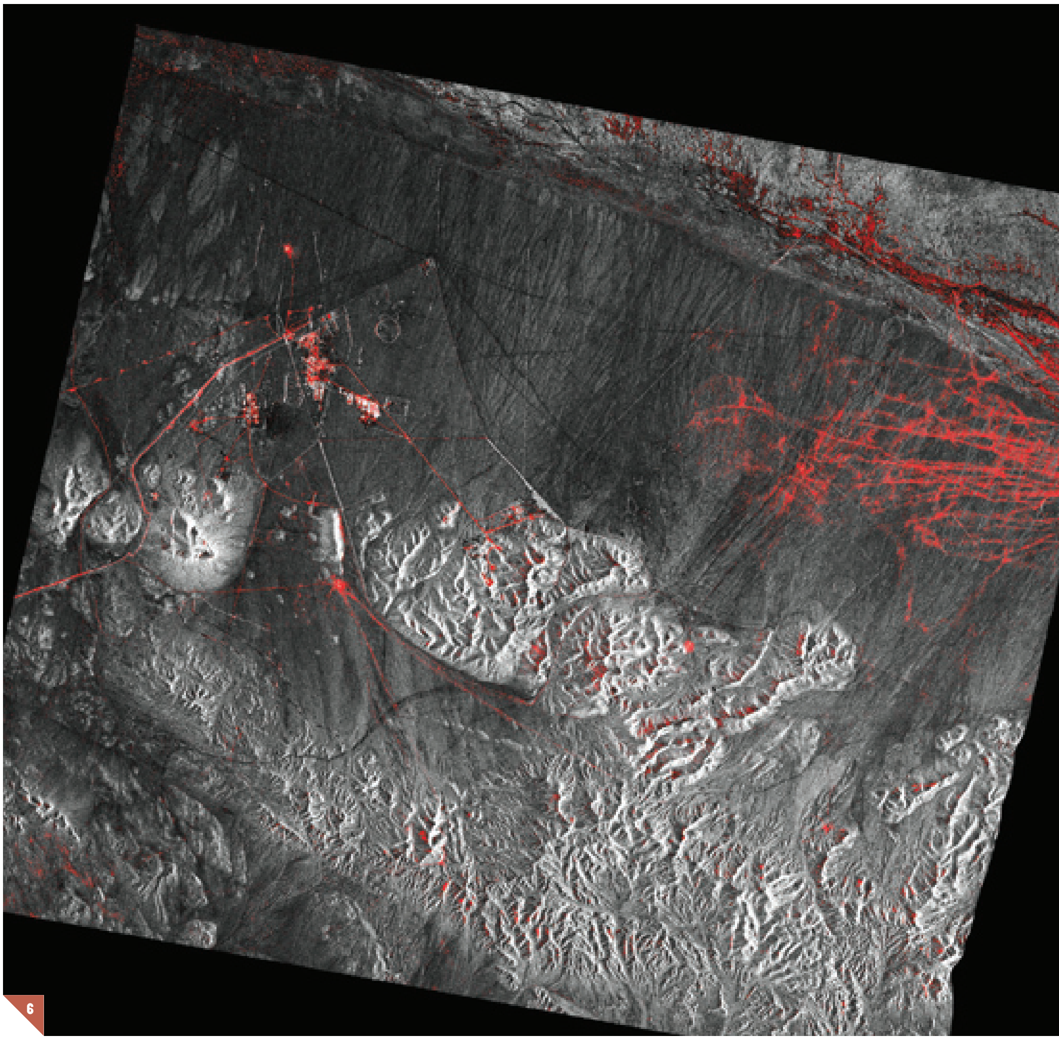
Helping End Users Interpret Radar Data

Radar is becoming mainstream in several communities, such as intelligence, the military, and agriculture. However, according to Pietranera, the organizations that consume the data have many people who are trained to interpret optical data, which is simpler to do, but not enough people trained to interpret radar data. When it comes to the latter, "advanced processing tasks are almost always handed off to specialists, such as image scientists," says Hild.

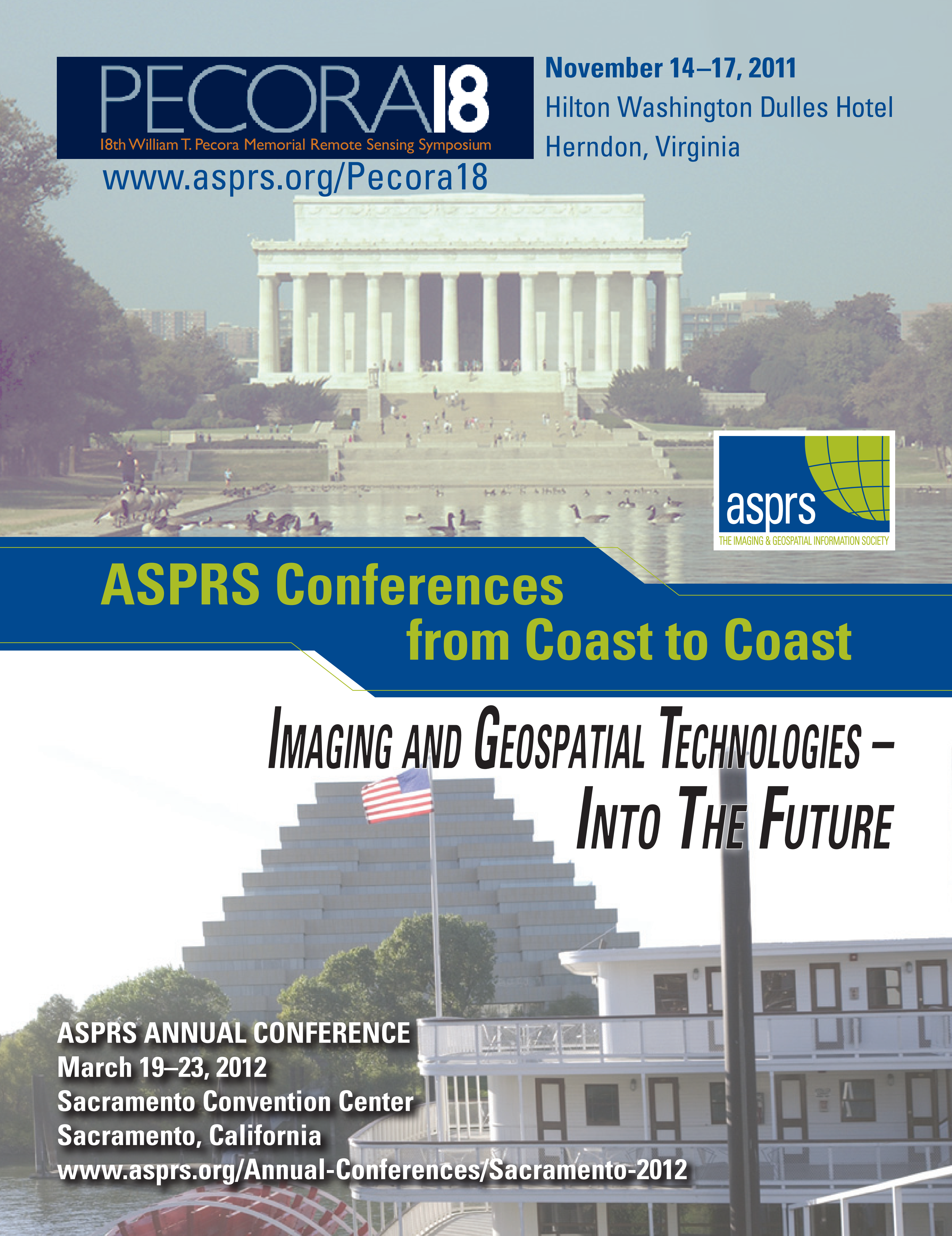
To bring their current and potential customers up to speed, MDA, e-GEOS, and Astrium in May formed a Commercial Synthetic Aperture Radar Satellite Working Group (CSARS WG), under the aegis of the United States Geospatial Intelligence Foundation (USGIF). They are now producing manuals, workshops, and exercises to explain the capabilities and advantages of space-based SAR, as well as to provide hands-on learning and training for users.

"We have recently released an image intelligence manual named TIM — the TerraSAR-X IMINT Manual," says Kern. "It compares the TerraSAR high resolution radar imagery to WorldView high resolution optical imagery to show and explain to image analysts what they are seeing in the radar images and what the key differences are. It is a new teaching and learning tool."

One reason that his company's radar images are more difficult to interpret than those produced by optical satellites, Kern explains, is that they are typically in black and white. To help overcome this problem, Astrium has developed methodologies to provide color radar imagery, not only as multi-temporal imagery but now even with a single data take at full resolution. "As we do not need to use polarizations either, we achieve a top-quality resolution, then we translate speckle into color coding, thereby customizing the radar data to the appearance of the optical image to be overlaid. Color SAR has good poten-



▲ **FIGURE 6.** *Disturbed Terrain Around Qom Plant, Iran - COSMO-SkyMed 1-meter resolution image (Spotlight-2 mode) over the nuclear facility of Qom in Iranian desert. The black and white background image highlights bright industrial structures and buildings. Dark linear features represent dirt roads and track network around the plant. When the acquisition is repeated after a short time, the coherence of the phase signals between the two images provides additional information about the scene. Red tracks are derived from coherence calculated over a time span of eight days. They show where the stable desert terrain was "disturbed" by the passage of vehicles (both on and off-road) and even animals (randomly distributed tracks on the upper right). This image also appears on the front cover, and is courtesy of e-GEOS.*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tial, especially in cloudy areas. You merge whatever optical data is available — which is always best for thematic mapping — with the radar data, and produce colorized thematic layers."

Software Development

Techniques to process radar data — developed by both satellite operators and software companies — are still on the steep slope of the development curve. "We develop many applications for internal company use, as we are a service provider, and offer value-added products and services based on our own developments," says Kern. "Some of these products are based on off-the-shelf software, such as Gamma or Sarscape, which we adapted to use for our change detection and surface motion monitoring services. Sometimes we work with partners, such as Trimble, with whom we developed the Flood Mapper, and sometimes we also make such tools available to our customers, who use them within their own working environments. Additionally, we also support software and application developers, such as ERDAS, with sample data and joint training activities."

New Satellite Launches

Astrium recently launched its second satellite, TanDEM-X, which is now flying in formation and collecting global elevation models. The TanDEM-X mission is currently collecting data for a global homogeneous elevation model of an unprecedented quality, accuracy, and coverage, says Kern, who expects the global dataset to be available in 2014.

The company has recently released its updated GEO Elevation Suite, which includes the radar-based Elevation10 product — globally available regional

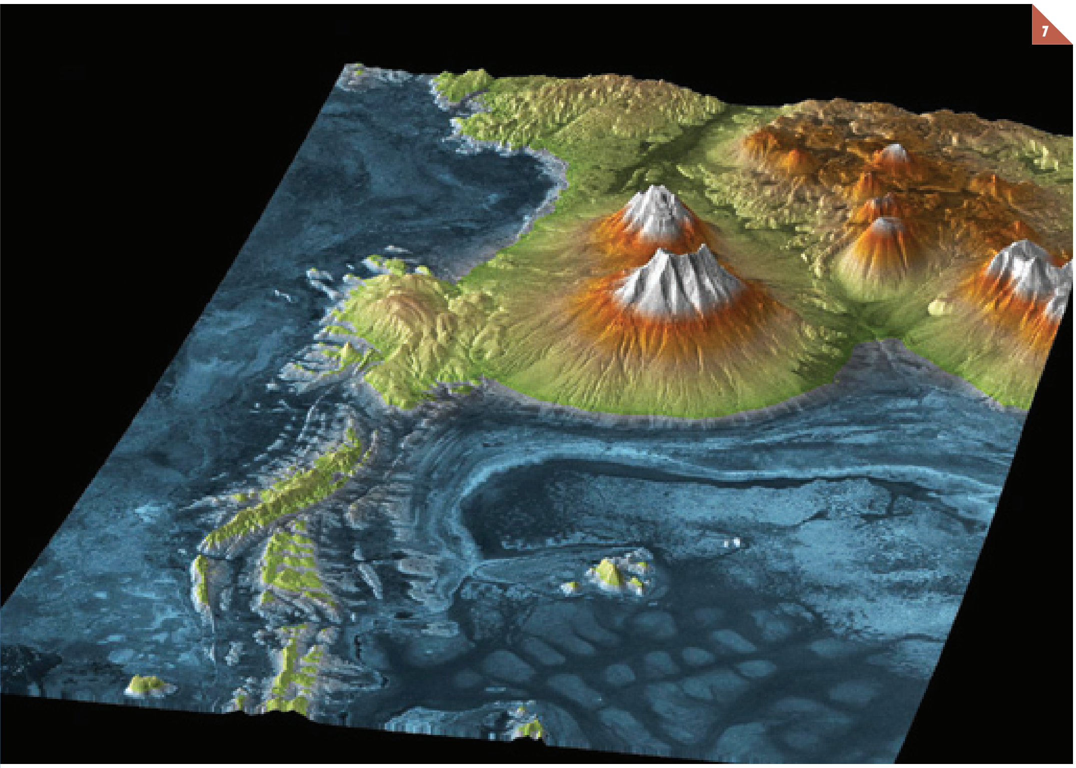
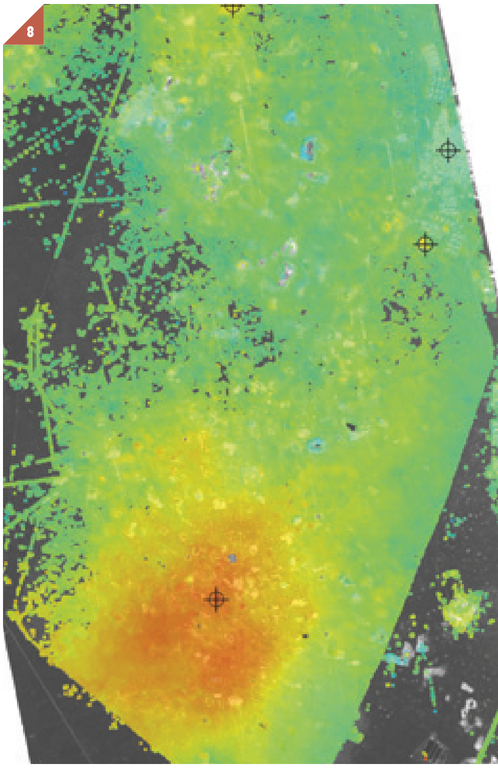


FIGURE 7. *TanDEM-X Digital Elevation Model of Volcano Tunupa and the edges of the salt lake Salar de Uyuni in Bolivia. The blue and dark blue colors mark the salt pan as the area with the lowest elevation level. Courtesy of DLR.*

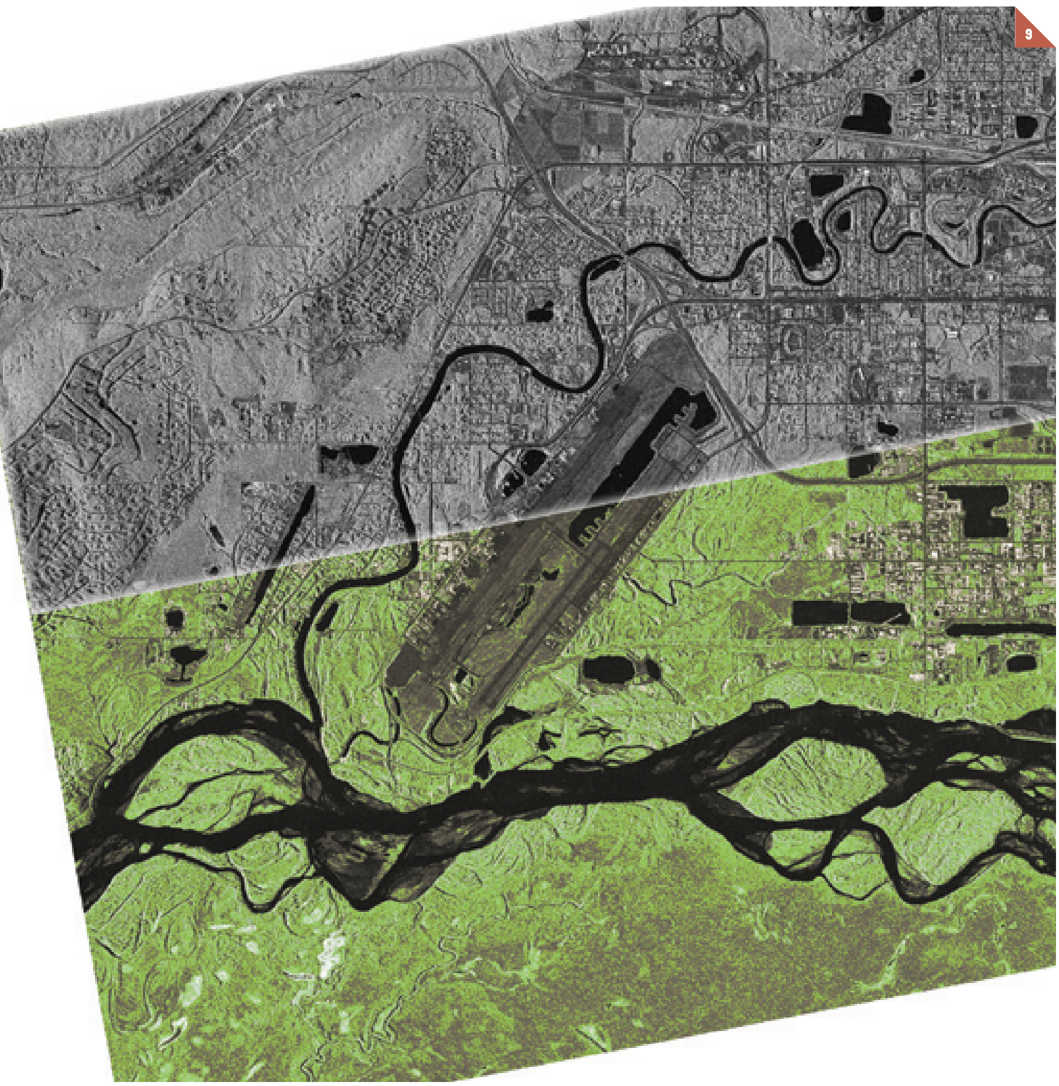


▲ **FIGURE 8.** *TerraSAR-X-based Surface Movement Monitoring of oil production-related surface displacement phenomena in Burghan oilfield in Kuwait, demonstrating significant subsidence of approximately 10mm/year in the main production center visualized by the orange color scale in the graphic. 16 TerraSAR-X StripMap scenes at 3-m ground resolution were selected from an available data stack over the target area covering a time period between January 2008 and February 2011. These datasets were processed using the Small Baseline Subset (SBAS) radar-interferometric approach. Courtesy of Astrium Services / Infoterra GmbH.*

elevation models with up to 5-meter accuracy at 10-meter grid spacing. Astrium also recently began phase A (analysis & assessment) for its follow-on mission, TerraSAR-X2. "We aim to launch it in 2016," Kern says. "It should bring improved collection capabilities, especially resolution down to 25 centimeters."

In November 2010, e-GEOS launched the last of four identical satellites, all of which orbit at an altitude of about 620 kilometers. "We now have the full constellation in orbit and COSMO-SkyMed is at its maximum capacity," says Pietranera. "We can task the satellites separately or use them together to cover large areas faster or to revisit the same locations more frequently. This is very important for many applications, especially those that require analyzing change over time."

Next year, the European Space Agency (ESA) will launch a new mission, Sentinel 2, which will be a continuation of its previous, highly successful ERS and ENVISAT missions. It will use the C band and will have a resolution in the tens of meters. This will be very good for covering large areas, Pietranera points out, though the imagery will not be as fine-grained as that generated by COSMO-SkyMed, which uses the X band and has a resolution of one meter.



▲ **FIGURE 9.** *Subset of a Color SAR image (colorized radar image) of Fairbanks, Alaska, U.S. in comparison to the base TerraSAR-X SpotLight acquisition (1.6-m resolution). Courtesy of Astrium Services/Infoterra GmbH.*

Korea's Multi-Purpose Satellite-5 (KOMPSAT-5), the country's first SAR satellite, will operate in low earth orbit (LEO) and carry an X-band SAR. Built and operated by the Korea Aerospace Research Institute (KARI), its primary mission is to provide high-resolution mode SAR images of 1-meter resolution, standard mode SAR images of 3-meter resolution, and wide-swath mode SAR images of 20-meter resolution. During its five-year mission, it will execute all-weather and all-day observations of the Korean peninsula. The launch, repeatedly delayed, is now scheduled for November 2011 (www.satelliteonthenet.co.uk/index.php/launch-schedule).

Radar imaging satellites — which have lower resolution than optical ones, but are better for change detection — have become a standard tool for intelligence, military, agricultural, and other applications and are essential to meet imagery requirements in persistently cloudy regions. Two European companies recently launched radar satellites and new ones are under development in Europe, Korea, Brazil, and China. Brazil and China are considering the development of a new family of radar satellites to monitor deforestation.

Sales of radar data are still mostly to governments and businesses, but consumer applications are the next area for growth. The two biggest challenges now for this segment of the geospatial industry are to develop software tuned to the requirements of specific users — for example, the different change detection requirements of agricultural and military users — and to train them to interpret radar data, which is harder to interpret than optical data. «

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The Value of Simplifying the Exchange of Geoinformation

By Steven Ramage

Executive Director, Marketing and Communications

Open Geospatial Consortium (OGC)

TRANSPORTATION AND COMMUNICATIONS TECHNOLOGIES have ushered in a new global GeoEconomy, making production networks and trading networks more spatially distributed, dynamic and complex than ever before. Geoinformation adds value in any economy (agricultural, industrial, or information age) because location-based content and services bring buyers and sellers together and help assess costs and risks. Geoinformation is thus, in the GeoEconomy, an increasingly valuable commodity, and is increasingly bought, sold or given away as infrastructure.

In *The Global Shift*, Peter Dicken wrote "The geo-economy...can be pictured as a geographically uneven, highly complex and dynamic web of production networks, economic spaces and places connected together through threads of flows. Once established, a cluster tends to grow through a process of cumulative, self-reinforcing development involving:

- **Attraction of linked activities**
- **Stimulation of entrepreneurship and innovation**
- **Deepening and widening of the local labor market**
- **Economic diversification**
- **Enrichment of the 'industrial atmosphere'**
- **'Thickening' of local institutions**
- **Intensification of the socio-cultural milieu**
- **Enhanced physical infrastructures."**

In this article we invite you to consider that the global GeoEconomy, as well as many valuable non-economic activities, depends on the exchange of geoinformation and that the cost-efficient exchange of geoinformation depends on standards, particularly open standards.

What Is a Geospatial Standard?

Communication means "transmitting or exchanging through a common system of symbols, signs or behavior." Standardization means "agreeing on a common system." Information exchange of any kind depends on information standards such as alphabets, grammars, vocabularies, number systems and digital encodings. Simple verbal geo-communication ("meet me at my house") is easy. Exchanging geoinformation between digital systems (machine to machine) is more complicated.

The complexity of geoinformation exchange becomes apparent when you consider the many different ways we can encode location, measure distance and altitude, image the Earth, describe curves, calculate area, adjust computational errors, name geographic features, etc. (See *Figure 1* for an illustration of geoinformation exchange.) As more devices and digital systems incorporate geospatial information, the absence of a standardized communication language makes interoperability between software and devices a challenging and costly proposition. Some geospatial standards specify whether latitude or longitude must come first, and whether these numbers are to be expressed as floating point numbers or degrees, minutes and seconds. A standard might specify whether a comma or a colon separates the coordinate pairs that define the segments in a line.

With such standards, software developers don't need to reinvent or even fully understand the interfaces and encodings that order this kind of communication. These complex-

Summary

This article discusses the benefits of geospatial standards including:

- Cost savings and cost-effective product and service development
- The ability to share location data across multiple devices and software platforms
- Increasing the value of the location data

ities can be hidden from the user, to focus on the end-user objectives for the use of the geoinformation.

The Value of Sharing Geoinformation

The value of geoinformation is apparent in everyday activities when delivered via location-specific online ads, in-car GPS, Web maps, friend-finder apps on cell phones, 911 emergency location services, "Call Before You Dig" services, etc. The list of familiar and useful applications is long, and many other applications are less familiar but provide value in domains such as infrastructure maintenance, hydrology, urban planning, logistics, fraud management, mobile workforce management, and so on.

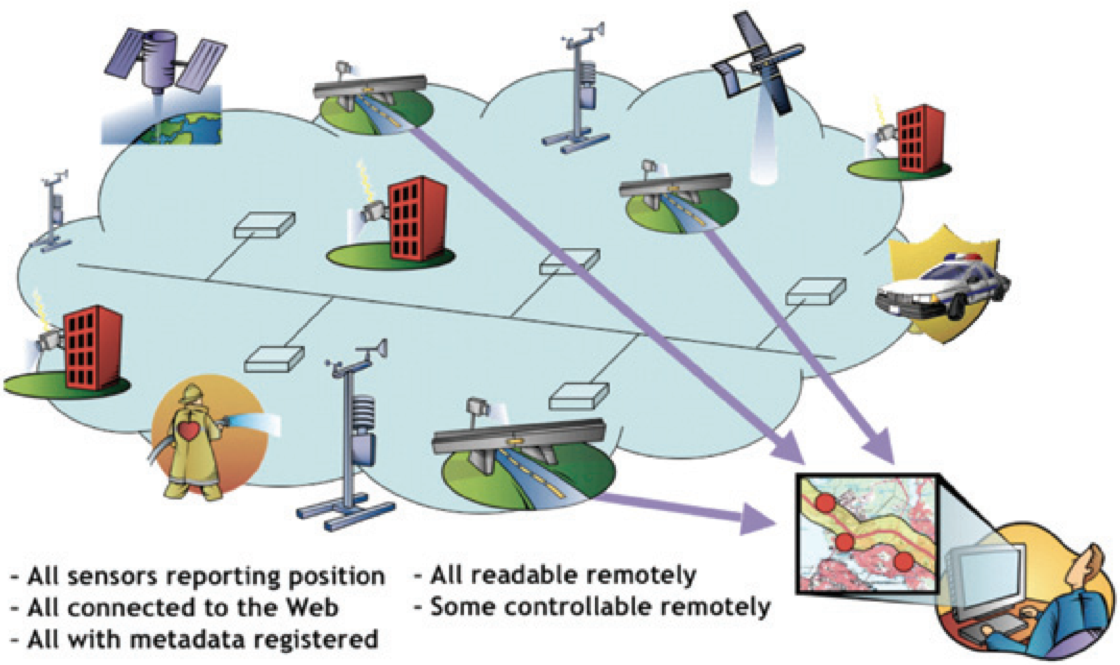
Geoinformation is part of the information that passes between companies and organizations in a value chain. Most providers of geographic information systems, Earth imaging systems, spatial database systems, and some providers of location-based services implement open standards that enable their users to query each others' systems for data and services.

Convergence and Fusion

Open standards enable software to do much of the data management and manipulation that once had to be done manually, and this affects workflows. For example, text, audio and video have converged in Web applications, partly through the Web's open standards. Web mapping represents a convergence of map display technology, mass-market Web server technology, and Web programming technologies, and this comes partly through open standards.

Fusion refers generally to the integration of information. The simplest location services involve merely accessing a simple database of geographic points of interest and their geographic coordinates. More sophisticated services can involve combining – fusing – geographic features from different databases, looking for changes in features, selecting features based on temporal queries, or other operations that may require accessing external data or services.

Mobile devices that increasingly feature sensors represent convergence and fusion. Open standards can support systems that analyze, process and exploit the same or different types of data or products from multiple sensors to improve detection, identification, location, and tracking.



↑ **FIGURE 1.** This chart illustrates the multiple sources of geospatial information and exchange of information that takes place to deliver a geoinformation service to an end user. Courtesy of the Open Geospatial Consortium.

Ironically, people often recognize the value of sharing geoinformation after recognizing the value of geoinformation. Local, subnational and national governments, for example, have information they would like to share, because they would like to avoid redundant data collection and be able to "roll up" data from multiple sources and provide better information to officials and citizens. Users of messaging services and social networking services would like to be able to share location information with others who use different social networking or messaging platforms. For geospatial information to have real value, it must be shared and exchanged.

The Market-building Value of Open Platforms

The Web is perhaps the most dramatic example of open standards supporting market growth, but this phenomenon has been well understood since the advent of commodity nuts and bolts and standard spacing of railroad rails.

Similarly, open geospatial standards increase the value of geospatial data because, for example, they enable any data service that can produce a simple map image to provide that image to any application via a single http request.

Data for selected geographic regions represented in complex Earth images and vector files can likewise be delivered through queries that implement open standards. This applies as well to simple and complex geoprocessing Web services and to geolocated sensors and sensor data stores. Both data and services increase in value with the number of nodes in the world's vast network of servers running applications that implement open geospatial interfaces and encodings.

Not all of the geospatial information products and services provided via the Web depend on open standards, but many do. Google brought KML, the application programming interface for Google Maps and Google Earth, into the OGC to be maintained as an open standard. Michael Weiss-Malik, Google KML product manager, explained, "What OGC brings to the table is...everyone has confidence we won't take advantage of the format or change it in a way that will harm anyone... Governments like to say they can publish to OGC KML instead of Google KML." KML is now implemented in Web mapping applications from other vendors.

Standards for consumer services such as next bus arrival time, wifi hotspot finder or camera location focus on lightweight geospatial standards such as very small profiles of the OGC Geography Markup Language (GML) Encoding Standard. Other examples include the candidate OGC Open GeoSMS encoding standard; GeoPDF (a candidate OGC Best Practice); GeoRSS (which includes a GML option); and GeoJSON, an open format for encoding a variety of geographic data structures that implements the OGC/EPSG's standard way of managing coordinate reference systems.

> "Most providers of geographic information systems, Earth imaging systems, spatial database systems, and some providers of location-based services implement open standards that enable their users to query each others' systems for data and services."

However, some platform and social networking companies seeking to capture and keep users may avoid implementing open geospatial standards in situations where such standards would enable users to exit easily to other websites. At the same time, many social media, crowdsourcing and user-generated content sites chartered to provide societal benefit, such as Ushahidi, InRelief, Sahana and Haiti SDI VGI implement open standards to broaden participation by developers and users.

Open platforms are important as a means of integrating the elements of distributed or federated geospatial data-sharing networks. At all levels of government around the world, officials want to be able to share maps on the Web and deliver data to different systems. They want to have a common language to speak about geospatial data and services, and they want all the systems in a data-sharing network to conform to sometimes complex security rules relating to geospatial data exchange. Standards-based government spatial data infrastructures (SDIs) expand markets for geospatial data, software and services.

SDOs: Finding Value in a Cluster

We live in a highly interconnected world, and inclusive industry standards development organizations (SDOs) that develop and promote open standards provide much of the "glue" that enables the interconnectedness. Standards enable technology convergence and information fusion, and they create a common platform for growth of markets for geospatial data, services and products.

Businesses, government agencies, non-governmental organizations, universities and research institutes participate in SDOs because they want to help shape networks. Members share the cost of developing and maintaining interfaces and encodings. User organizations avoid the costs of custom integration, avoid vendor lock-in, maximize the value of previously purchased software and data, and pool their market power to influence the direction of technology development. Universities and research centers stay at the technology forefront, develop relationships with businesses and government agencies, and advance open source applications.

Where Would the GeoEconomy Be Without Open Standards?

Without geospatial standards of some kind, there could be no communication of geospatial information. Like paved cow paths, or natural languages, many standards are formalizations of common usage. Empires are important drivers for such formalizations. For example, the Prime Meridian passes through the Observatory at Greenwich largely because England had dominated the seas for almost two centuries before the U.S. called for an International Meridian Conference to establish a single global standard. In the digital age, innovation speeds along, constantly creating new and pathless territory for standardization. Companies vie for dominance, hoping to establish their proprietary encodings and interfaces as platforms for further development that they can control and exploit.

With nothing but proprietary standards, geospatial information would certainly flow to support the global GeoEconomy and non-economic activities, and there would be a market in geoinformation. There would still be technology convergence, information fusion and growth of markets for geospatial data, services and products. With open standards, however, there is more competition and more innovation. Users can influence technologies' directions through standards and they can shop in a more bounteous market. Entrepreneurs have more reason to hope, and both new and established businesses have more potential customers. We would still have a geoeconomy without open standards, but it would be more constrained by monopolies. ☒

Improving International Food Security

The Key is Access to Local Information

By Jindra Cekan, Ph.D.

Summary

This article discusses the information, infrastructure and inputs obstacles to improving food security in the developing world, and the promise of enabling access to local information to align production and distribution of food.

AS A PROFESSIONAL IN INTERNATIONAL FOOD SECURITY, I WORK WITH organizations that support people and communities in generating sufficient food production and income to meet their food and other basic needs. Markets, and the information that drives them, are key to international food security.

In 20 years of working in development programs in Africa and elsewhere, I and many others believe that information, infrastructure and inputs are weak links for most smallholder farmers. Many farmers, both female and male, are working 18-hour days with rudimentary tools for small yields, only to have their crops spoil due to lack of access to the best buyers and markets. Access to timely information about a range of topics, from seed production comparisons, to market price differences for goats, to high demand in regional towns, can be key in getting the right products produced and sold at competitive prices. Such access also helps inform food and livestock producers on where food and animals are best sold.

International Food Security Barriers

A West African colleague described the three barriers to international food security as:

1. a lack of information on food availability because many producers are not integrated into the network – their production remains in the local area where food conservation is non-existent;
2. a lack of roads, which blocks global socio-economic development;
3. a lack of food conservation infrastructure that reduces shelf life of food.
4. I would add a lack of knowledge of the best seeds, tools, vaccinations, etc., such as the Google searches and sectoral listserves we take for granted.

According to Yaya Ba, head of capacity building of agricultural enterprises at Burkina Faso's National Agency of Export Promotion, we must develop communication on food availability throughout the country by reinforcing the network. To get there, there is both bad news and good.

The Bad News

Global population will reach 7 billion in the next two years. Food prices and market volatility continue to push deeper into hunger the one billion who are now unable consistently to feed themselves. There are also structural inequities that information, infrastructure and inputs can address. For instance, according to the Population Reference Bureau, the demographics of the developing world indicate that the population there is becoming younger and younger; 50% of many African (and some Asian and Latin American) countries will soon be under the age of 15, but jobs are scarce.

Globally, it is now understood by international development professionals that women produce about half of the world's food but own less than 5% of all property, and widows experience special discrimination, without rights to inherit land. Listen to the Radio Netherlands Interview for more details at www.rnw.nl/africa/radioshow/land-titles-women-too.

Both women and men, especially youth, need control over the land, crops and livestock they manage in order to invest their precious time, energy and resources. Investing in these small-scale subsistence farmers is the critical way to prevent future hunger crises and the political unrest that such crises spark. Geospatial information that links information about their production with demands for the crops and animals produced can be one part of the answer.

The Good News

After the World Bank's 2008 World Development report showed that agriculture was massively under-invested, and after the food price crises of 2008 and 2011 led to violence, donors and private funders began re-investing in farming. According to Secretary of State Hillary Clinton, six of the world's 10 fastest-growing economies in the last decade are in Sub-Saharan Africa. New seed innovations combined with massive infrastructure investments that China has been making across the 'developing' world bode well for production and marketing. A recent UK study showed that improving infrastructure and management of food could eliminate post-harvest loss by 30-40%[1], which is staggering considering that the United Nations Food and Agriculture Organization (FAO) recently said that one-third of the world's food is wasted.

Information is increasingly democratizing progress. While Africa is also the fastest growing market for mobile phones, all 'developing' world continents are growing and represent the majority of 2.4 billion mobile phone users worldwide.

Even in 2007, Kenya was a front-runner in mobile innovation. The Kenya Agricultural Commodity Exchange provided some crop growers with up-to-date commodity information via text message (sms). This technology allowed farmers to access daily fruit and vegetable prices from a dozen markets, which enabled them to skip the hours-long journey to town and instead rely on mobile phones for potential buyers and prices; such innovation has led some to quadruple their earnings. As such coverage spreads, the benefits could multiply and foreign aid could wane.

BIO Jindra Cekan has a Ph.D. in international development from The Fletcher School '94, and 23 years of experience in food security, livelihoods and knowledge management. After overseeing worldwide food programming for Catholic Relief Services and the American Red Cross, she founded her consulting firm (www.cekanconsulting.com) for international development nonprofits. Her clients have included the Bill & Melinda Gates Foundation, Mercy Corps, Lutheran World Relief, World Vision, Save the Children, CARE and others. Jindra has worked in 25 countries including 13 in sub-Saharan Africa, as well as Central America, Central Asia and the Balkans. She believes in the power of organizations to learn from their own best practices, honouring country-national knowledge for sustained impact. Jindra can be reached at jindra@cekanconsulting.com.

New Solutions

A variety of initiatives improve information, inputs and infrastructure, many funded by foundations such as Rockefeller and the Bill and Melinda Gates Foundation and government agencies such as USAID and UK's DIFD. Grants are filling the gaps that keep producers impoverished and agriculture value chains inefficient. For instance, USAID is piloting information communications technologies (ICT) applications that provide market price information to those within agriculture value chains. The U.N. World Food Program's (WFP) Purchase for Progress (Gates-funded) links WFP's demand for food crops (to be reused as food aid) with partners who support farmers to produce food surpluses and sell them at a fair price. By 2013, WFP expects at least half a million smallholder farmers – mostly women – will have increased and improved their agricultural production and earnings. Yet progress is slow in low-literacy contexts and few systematic information-sharing systems exist.

I believe that all of these initiatives could benefit from geospatial market information sharing using simple mobile phones. If buyers knew where village surpluses were, they could consolidate purchases and wholesale them more efficiently. If sellers knew where the highest market prices were (as in the Kenya example above), they could direct their sales there, rather than sell at low profit to local purchasers, and stem losses from overproduction. If local information were more effectively shared and distributed through mobile phones, coupled with better roads, improved seeds, and food drying and canning to stem losses, food security would be dramatically improved across Africa, Asia and Latin America. ☒

FOOTNOTE 1. Watson, Robert. University of East Anglia (U.K.), Highlights from proceedings at the Global Conference on Agriculture, Food Security and Climate Change. November 1, 2010, Volume 184, No. 2.

Law, Regulations, and Best Practices of Location Data

Executive Interview with Kevin Pomfret, Esq., Executive Director, Centre for Spatial Law and Policy

BACKGROUND **Privacy and security are hot topics relative to the use of location data. While there are several bills circulating in Congress, and some initiatives in the Executive Branch, not much has changed in the U.S. over the last five years because the law and policy environment is so much more reactive than proactive in the U.S. Unfortunately, the U.S. is playing catch up with the technologies. Internationally there are more efforts to regulate certain areas and to regulate location privacy. For example, in the past couple of years European privacy regulators have focused on Google Street View, RFID technology and mobile applications. We were pleased to speak with Kevin Pomfret of the Centre for Spatial Law and Policy on his perspective of the legal and policy landscape, the burning issues for providers and users of location, and the future of best practices and guidelines.**

LBX *Is there something particularly special about geodata?*
POMFRET One unique aspect of geodata is that it is so versatile. It can be used for a variety of purposes – both positive and negative – which can create more risks. For example, in an emergency, knowing the exact locations of individuals can save lives; but that same technology could also be used to stalk someone without proper controls. From a consumer perspective, lawmakers are very concerned with the potential of geospatial technology to stalk people.

However, they are struggling with how to define what privacy is from a location perspective. Privacy from a location perspective is not as simple as protecting a social security number or medical records (areas of privacy law that are already protected). For example, what is it that is private relative to location? Is it within a few feet or within a zip code? Is there a temporal component to it? One of the challenges will be defining what location privacy is in the United States.

LBX *Who owns the data of an individual's location?*
POMFRET Some argue that the individual should own the data, determine how it should be used and give consent to how third parties use the data. Others believe that whoever collects the data should own it. However, in either case, the key issue is what right does a third party have to use the data.

LBX *What are the most important concerns for companies that provide location data?*
POMFRET There are three areas of exposure that providers should pay attention to:

- **PRIVACY** **It is not always obvious to a company that a dataset may be subject to privacy concerns because the provider may view the data as innocuous or publicly available. However, companies need to pay attention to the bills currently before Congress because one of the issues being addressed is the privacy implications associated with the aggregation of data and whether individuals can be identified or targeted.**

- **INTELLECTUAL PROPERTY** **Most geospatial data products and services are based on a compilation of various datasets that are subject to different licensing arrangements. Often this is not well understood within an organization beyond a legal department. It is critical that companies understand the restrictions and limitations on their right to use data, and how these impact existing and future products and services.**

- **DATA QUALITY** **In a world where millions of people are accessing location information for a variety of different reasons, providers of location information must recognize that the users of their data or applications are not always experts in geospatial technology.**

Moreover, consumers often receive greater protection under the law than businesses. Businesses will need to consider various scenarios in the design of products and services to mitigate against the consumers' potential misuse.

↑ **KEVIN POMFRET, ESQ.,** Executive Director, Centre for Spatial Law and Policy

LBX *Similarly, what is the most important concern for users of location data?*
POMFRET Business users need to make sure that they have the rights to use the data. This means understanding the rights under the various license agreements under which they received the data and how terms are defined. When combining various databases, the first question a user needs to ask is, "do I have the right to do this under my license agreements?"

Secondly, understanding the allocation of risk in every location information transaction is becoming increasingly important. There is risk associated with usage and data quality. Is the dataset being relied upon complete? Is it sufficient for the intended use of the product or service, especially if the user is reselling it? Usage rights are not fully appreciated in the community right now. There needs to be attention to how the data will be used. For example, if the data is being used for navigation purposes then the provider needs to make sure that the data is not going to be used in a manner that runs afoul of state or national laws. Providers must comply with the laws and make sure that the data is not collected in a way that violates privacy laws.

LBX *How do cloud-based services factor into these considerations?*
POMFRET The cloud complicates things. There is always increased complexity when a third party is involved, such as a provider of cloud services. Whenever there is someone or an organization outside of your control, there is increased complexity and therefore increased risk. Location data is inherently multi-dimensional – which also creates uncertainty.

> "Usage rights are not fully appreciated in the community right now."

LBX *How does the law treat companies and individuals differently when it comes to location data and privacy versus security and confidential information?*
POMFRET The approach to companies and individuals will be different. The concerns about individuals using location data are regarding the ability to track other individuals, especially within a relationship of concern. In other words, from an individual perspective, the greatest concern right now is the ability to use location data to stalk another person. In a business relationship, the concern is the ability to aggregate datasets and make decisions that impact an individual's privacy based on that data – for example, using location information for making decisions on insurance rates or for personalized advertising. The ability to aggregate data with a broader range of datasets, integrate it into multiple applications, and distribute it across multiple technology platforms, subjects the use of the data to greater uncertainty.

LBX *Are there any best practices in the space?*
POMFRET There are a few efforts to develop best practices. For example, CTIA (The Wireless Association) has developed best practices for mobile devices; Australia and New Zealand have developed guidelines for the use of government data. Although these are a couple of examples of best practices for privacy, they are not necessarily complete as they reflect a narrow constituency. Nonetheless, they are starting points and worth reviewing.

LBX *What about best practices on the business side?*
POMFRET It's difficult to comment on that as the business situations vary so much. However, I do believe that we will see geospatial audits in the near future as a means of ensuring compliance with licensing agreements, adequate quality control, ensuring that customers are using the data appropriately, and protecting against foreseeable misuse. My sense is that its use will evolve depending on the company and the importance of the respective issues. For example, it may come from the finance office to make sure that all of the revenue is being collected from customers under license agreements. As location becomes an important component of products and services, best practices and legal frameworks will evolve as companies will require processes to understand all of their location information transactions, potential liability and privacy implications. ☒

Scaling Location Data in Australia and New Zealand

↑ Peter Woodgate

The R&D Behind It

Peter Woodgate, CEO, Cooperative Research Center for Spatial Information

BACKGROUND Australia and New Zealand have developed a forward thinking public-private partnership incubator for spatial information innovation. It's called the Cooperative Research Center for Spatial Information (CRCSI). It is a joint venture of 110 organizations – a combination of private companies, government agencies, and academic institutions with $160 million under investment to solve and commercialize solutions to complex spatial research and development issues. Spatial innovation is critical to Australia and New Zealand's economic, environmental and national security. In addition, one of the largest constellations of Global and Regional Navigation Satellites will in a few short years pass directly overhead. Australia is uniquely positioned to take advantage of the enormous potential of these new and emerging technologies.

Summary

In this interview, Peter Woodgate discusses:

- Australia and New Zealand's $160 million spatial incubator
- The vision for a spatial marketplace
- The role of government, the private sector and academia in collectively developing critical spatial technologies and infrastructure to support a location-referenced world.
- Solving location data challenges at scale

LBX *Tell us a little about CRCSI and why spatial information is so critical to both the public and private sectors in Australia and New Zealand.*

WOODGATE The CRCSI has been set up as a long-term research engine to tackle grand challenges that can only be addressed through the unique cooperation of the private, public and research sectors.

Spatial technologies and the information they generate underpin the Australian economy. Let me give several examples. Firstly, Australia's largest export industry is mining and minerals exploration, which relies heavily on spatial technologies. Secondly, all property transactions rely on detailed data found in cadastre files held by government agencies (these include property boundaries, titles, ownership, land values, parcel, and location data). Thirdly, for a more macro example, Australia is extremely vulnerable to floods, bushfires, and cyclones. Our ability to rapidly respond to these natural disasters impacts the health of the national economy and crucially depends on a range of data from airborne and satellite sources.

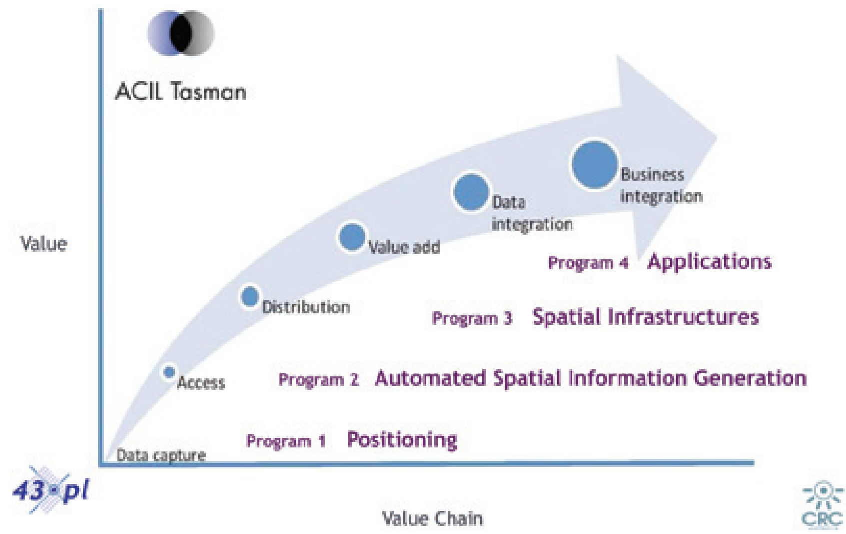
Tens of thousands of spatial datasets exist, especially in the public sector, but relatively few of them are readily available. Through our research projects we intend to revolutionize the availability and therefore value of these data.

Moreover Australia has decided to drive toward the establishment of a National Positioning Infrastructure (NPI) that will deliver 2-cm accurate positioning anywhere outdoors in real-time. This can only be accomplished by taking advantage of the existing GPS system and the new and emerging systems of Galileo (EU), GLONASS (Russia), Compass (China), QZSS (Japan) and IRNSS (India). Australia is uniquely positioned to take advantage of these constellations from a research and development perspective. The CRCSI's research will underpin the NPI vision. Economic modeling that we commissioned suggests that we can add at least $32 billion to the Australian economy over the next 20 years with an NPI.

LBX *What makes the CRCSI unique among technology incubator models around the world?*

WOODGATE Well we are not quite unique. There are similar research centres in Canada (GEOIDE), Korea (KLSG), Mexico (CentroGeo), Sweden (FPX) and Ireland (NCG). What makes these unique is the collaboration they engender between the public, private and research sectors. They all have significant resourcing allowing them to tackle large and complex spatial challenges in a true spirit of inter-sector and inter-disciplinary cooperation.

CRCSI and these five other research centers also have strong education programs that seek to grow the much needed skilled capacity in spatial technology, thinking, and applications of our respective nations.



↑ **FIGURE 1.** This chart illustrates the spatial value chain from data capture to applications and the foundational technologies required to move along the value chain.

While there are many national mandates around the world for the use of spatial/geographic data, there are relatively few committed and coordinated national investment plans incorporating a comprehensive strategic R&D roadmap.

LBX *There's no shortage of seed and venture capital going into location-based technologies, especially on the consumer side. Why is the CRCSI model so critical to market acceleration?*

WOODGATE The CRCSI brings critical mass to the effort to remove barriers to progress and adoption. For example no one organization can create a fully functioning marketplace or a single nationwide, fully integrated positioning infrastructure. It is a complex task establishing and maintaining relationships between 110 organizations, spanning two nations and three sectors (government, private and research). Gaining consensus on the issues that we should tackle together, agreement on the considerable co-investment, explaining the value proposition and sourcing the best researchers represent the keys to success. There are institutional barriers that are being overcome because the partnering organizations have faith in the CRCSI due to its sheer size and reach.

LBX *You mentioned that CRCSI has a well-defined prospective portfolio and tackles complex spatial research problems. What are the top three problems CRCSI seeks to solve and commercialize with its current round of funding?*

WOODGATE The three main focus areas are:

- **Resolving signal processing problems: To deliver the 2-cm positional accuracy I mentioned earlier requires resolving signal processing problems between all of the satellite navigation systems referenced. Especially important is the development of improved integer inference theory that will enable finer accuracy and subsequent integration of these new systems, together with the development of a single network available to all end users to provide this unprecedented accuracy and real-time positioning solution.**
- **Developing a "Spatial Marketplace": Tens of thousands of spatial datasets exist, especially in the public sector, but relatively few of them are readily available. The first problem to solve is to unlock access to the spatial data that resides in government agencies. There are a number of licensing and interoperability issues to resolve, along with identifying the open source platform requirements. Australia and New Zealand have decided to set up a spatial marketplace to facilitate discovery and access to these data and to encourage the development and use of value-added applications and services. The CRCSI's research will help underpin the marketplace. We know that the spatial information industry contributes about $10 billion to Australia's GDP and at least $1 billion to New Zealand's. We expect that the systematic development of the marketplace will add several billion dollars more to this figure.**
- **Enabling data fusion and automated feature extraction of spatially sourced information in five application areas:**

- Agriculture and natural resources affected by climate change
- Defense
- Energy and utilities
- Health
- Sustainable urban planning

LBX *How are the projects for funding evaluated?*

WOODGATE We have a good understanding of the value chain. We have developed a detailed impact analysis that we call a "line of sight" research chain to ensure that the research idea is traced through the entire research chain to the point of utilization and commercialization. All funded projects need to be within the context of that value chain as illustrated in *Figure 1*. Many companies, researchers, and engineers have a lack of understanding of the complete business value chain of these technologies, so this rigorous process is critical to accelerate market growth and realization of spatial information benefits. It significantly aids the understanding of all involved.

> "Tens of thousands of spatial datasets exist, especially in the public sector, but relatively few of them are readily available."

LBX *There's a lot of buzz today around a GeoEconomy; what does that mean to you and how is it related to CRCSI's focus on developing a Spatial Marketplace?*

WOODGATE There are many issues related to a Spatial Marketplace from market regulation to structural constraints on growth to developing viable business models. The industry has been dominated by the public sector in the past, and it's alien for much of the private sector to think about the fundamentals of the creation of a whole marketplace. Trading data and spatial services, in the knowledge working economies of the future is a relatively new concept and is increasingly happening at scales that traditional spatial professionals are unaccustomed to. This is why the CRCSI is so important; it provides some structure and discipline to help explain what all this means and to help all accelerate the rate of take up of spatial technologies and products in existing and new markets.

LBX *Is the main focus of the Spatial Marketplace to unlock government spatial data or all spatial data?*

WOODGATE The focus is on all data from any source; however there is so much information locked up in government agencies that accessing these data is an important first step.

LBX *Can you share your perspective on the variety of geospatial data that resides in the government that is relevant to driving location-based applications?*

WOODGATE The data ranges from the traditional and well-known sources including the cadastre, topography, aerial and satellite imagery, and environmental data, to the new and emerging spatially enabled datasets like health. The pursuit of more accuracy, for example as we drive down to centimeter precision, means codification of more and more new data. In addition, as the supply and demand for data increases with the move to 3D and time-stamped data, spatial data stores will become phenomenally large.

LBX *What is your vision for the Spatial Marketplace? How do you envision it working for spatial stakeholders such as data providers, application providers, data users?*

WOODGATE My vision for the marketplace is focused on simplicity; simplicity of discovery, of access and of use. It will see a single catalogue of dataset descriptions, linked via a federated data model to the datasets themselves. So for example, if an analyst needs to put together a map of agricultural biomass for Australia, instead of toiling across individual data sources, she can search the marketplace and find eight agricultural datasets that when joined together cover the country.

She can then combine these data with the most recent NOAA AVHRR (advanced very high resolution) satellite data and run an NDVI (Normalized Difference Vegetation Index) together with say a new tool that she has developed to produce a map of biomass based on these data and some new algorithms they have developed.

The data are sourced via Creative Commons licensing, that in the case of these particular datasets lets others distribute, remix and build upon the work, even for commercial purposes, as long as they credit the original creators and license any new creations based on the work under the same terms (known as an Attribution-Share-Alike or CC BY-SA license). This truly liberates spatial data. Like the data, the apps that enable easy searchability and creation of maps are also under a Creative Commons license and are readily available from the marketplace as well.

Accuracy and authentication are critical to success, so we will be encouraging a single custodian to act as a steward for each dataset offering a single point of truth.

Finally, the industry is set to benefit greatly from the combination of the move to open standards and Creative Commons licensing, together with high speed broadband and the increasing availability of open access data. ☒

Location SmartBrief: Business Game Changer

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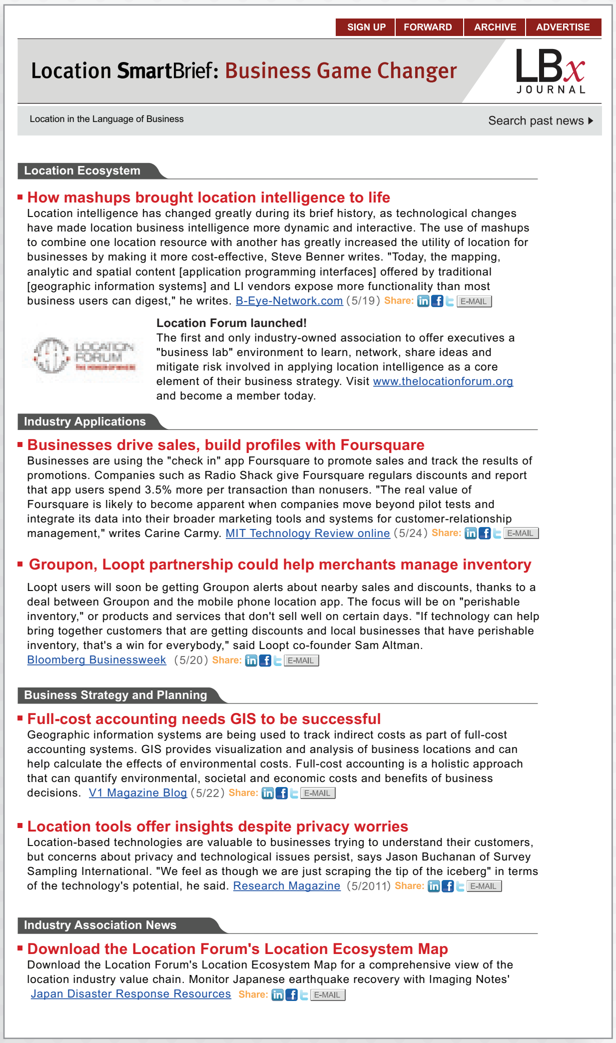

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Location in the Language of Business

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Location Ecosystem

How mashups brought location intelligence to life
Location intelligence has changed greatly during its brief history, as technological changes have made location business intelligence more dynamic and interactive. The use of mashups to combine one location resource with another has greatly increased the utility of location for businesses by making it more cost-effective, Steve Benner writes. "Today, the mapping, analytic and spatial content [application programming interfaces] offered by traditional [geographic information systems] and LI vendors expose more functionality than most business users can digest," he writes. B-Eye-Network.com (5/19) Share: E-MAIL

Location Forum launched!
The first and only industry-owned association to offer executives a "business lab" environment to learn, network, share ideas and mitigate risk involved in applying location intelligence as a core element of their business strategy. Visit www.thelocationforum.org and become a member today.

Industry Applications

Businesses drive sales, build profiles with Foursquare
Businesses are using the "check in" app Foursquare to promote sales and track the results of promotions. Companies such as Radio Shack give Foursquare regulars discounts and report that app users spend 3.5% more per transaction than nonusers. "The real value of Foursquare is likely to become apparent when companies move beyond pilot tests and integrate its data into their broader marketing tools and systems for customer-relationship management," writes Carine Carmy. MIT Technology Review online (5/24) Share: E-MAIL

Groupon, Loopt partnership could help merchants manage inventory
Loopt users will soon be getting Groupon alerts about nearby sales and discounts, thanks to a deal between Groupon and the mobile phone location app. The focus will be on "perishable inventory," or products and services that don't sell well on certain days. "If technology can help bring together customers that are getting discounts and local businesses that have perishable inventory, that's a win for everybody," said Loopt co-founder Sam Altman. Bloomberg Businessweek (5/20) Share: E-MAIL

Business Strategy and Planning

Full-cost accounting needs GIS to be successful
Geographic information systems are being used to track indirect costs as part of full-cost accounting systems. GIS provides visualization and analysis of business locations and can help calculate the effects of environmental costs. Full-cost accounting is a holistic approach that can quantify environmental, societal and economic costs and benefits of business decisions. V1 Magazine Blog (5/22) Share: E-MAIL

Location tools offer insights despite privacy worries
Location-based technologies are valuable to businesses trying to understand their customers, but concerns about privacy and technological issues persist, says Jason Buchanan of Survey Sampling International. "We feel as though we are just scraping the tip of the iceberg" in terms of the technology's potential, he said. Research Magazine (5/2011) Share: E-MAIL

Industry Association News

Download the Location Forum's Location Ecosystem Map
Download the Location Forum's Location Ecosystem Map for a comprehensive view of the location industry value chain. Monitor Japanese earthquake recovery with Imaging Notes' Japan Disaster Response Resources Share: E-MAIL

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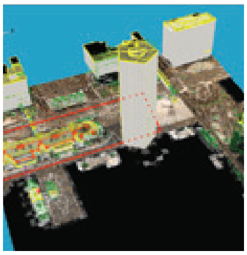

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