# Imaging NOTES

Spring 2012
Vol. 27 » No.2

EARTH REMOTE SENSING FOR SECURITY ENERGY AND THE ENVIRONMENT

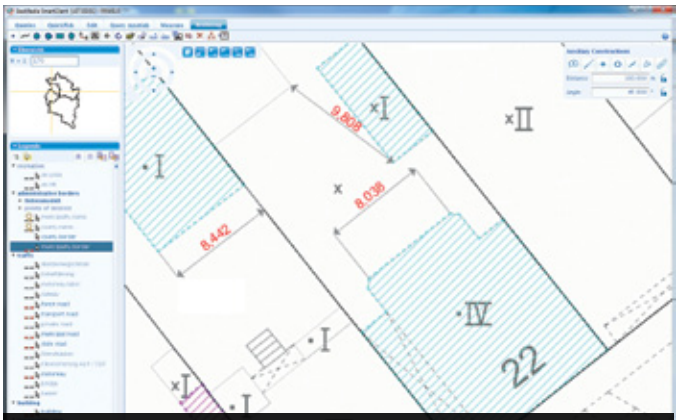
# GOOGLE EARTH BUILDER UPDATE

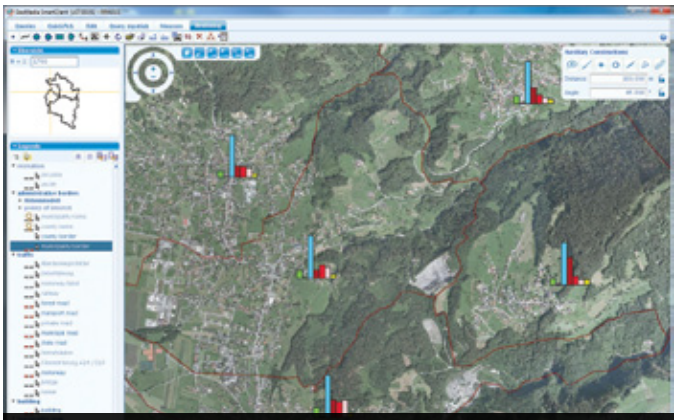
SPACE DATA RELAY

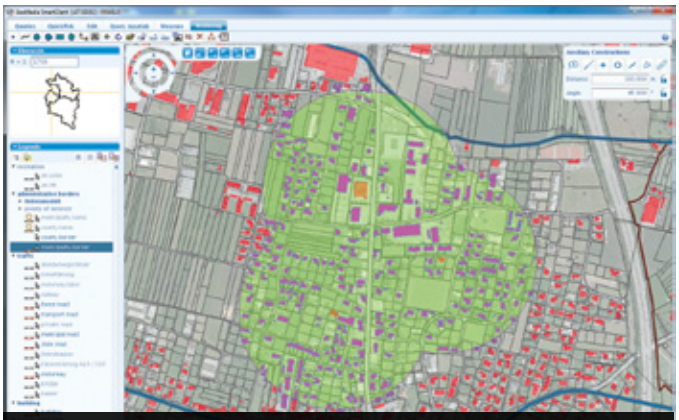
THE COST OF PIRACY

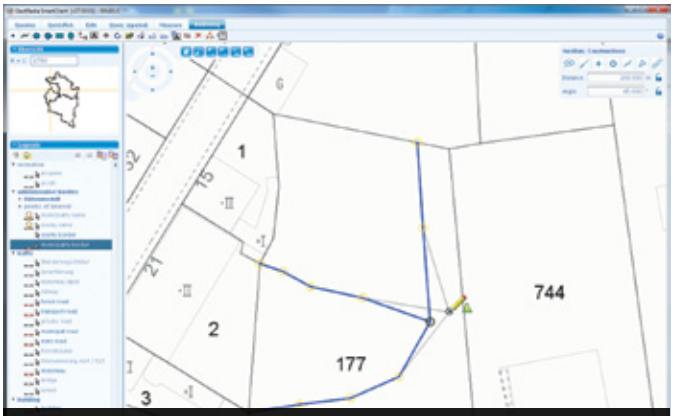
LANDSAT IS 40!

# DYNAMICALLY JUMPSTART YOUR GIS

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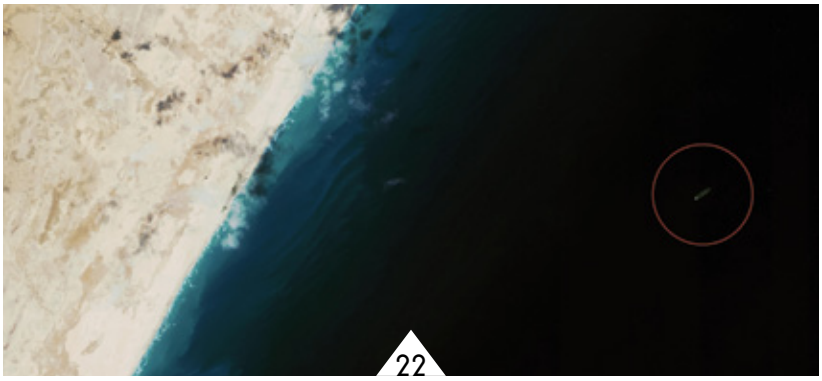



# Spring 2012

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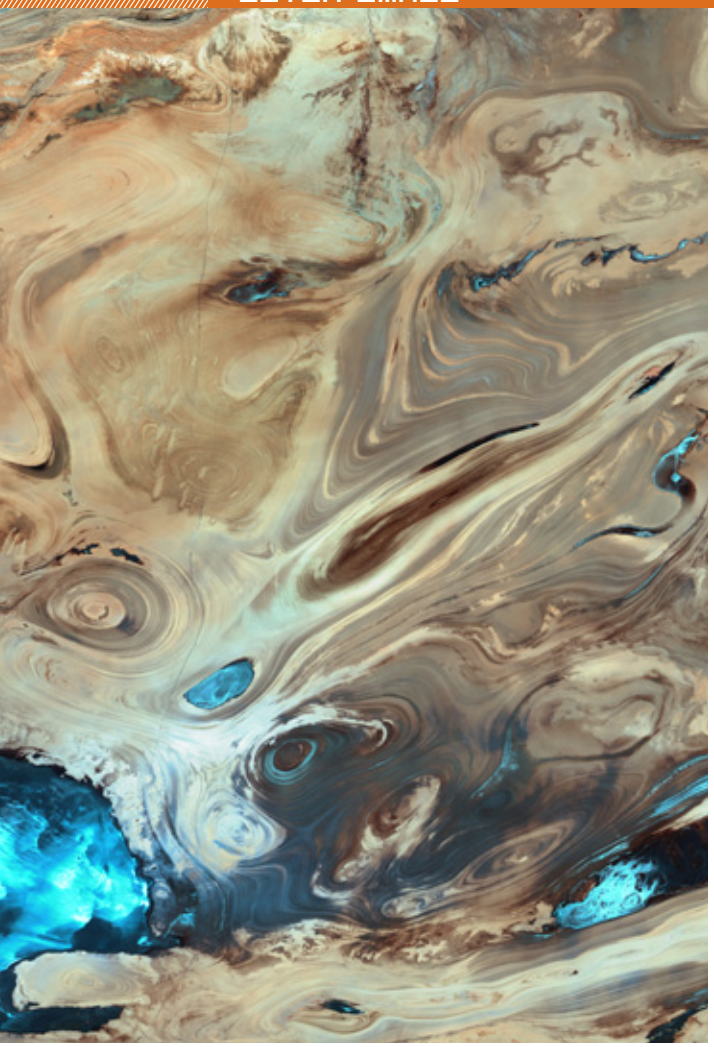
# Dasht-e Kevir, Iran

COVER IMAGE



*The Dasht-e Kevir, or* Great Salt Desert, is the largest desert in Iran. It is primarily an uninhabited wasteland, composed of mud and salt marshes covered with crusts of salt that protect the meager moisture from completely evaporating. The Landsat-7 image was taken Oct. 1, 2000.

With this issue, *Imaging Notes* celebrates the 40th Anniversary of Landsat, as you can see in the feature article on page 14.


Imaging NOTES

Spring 2012 / Vol. 27 / No. 2


## Our Mission

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

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

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



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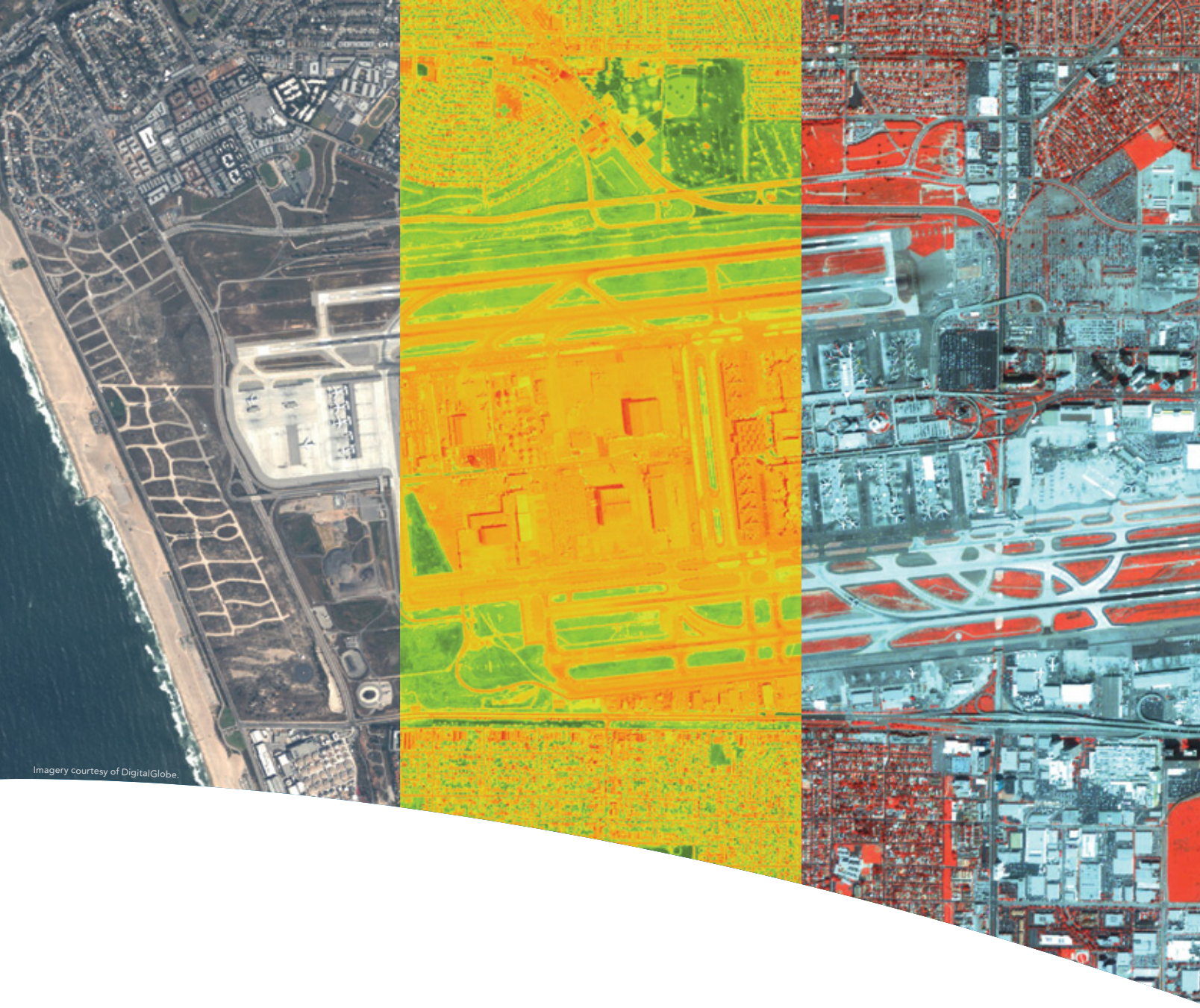


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# Urgency and Commitment: A Global Look at Space Sustainability

SECURE WORLD FOUNDATION FORUM

*Imaging technologies and capabilities were frequently* front and center at the International Space University's 16th Space Symposium. Convened under the title "Sustainability of Space Activities: International Issues and Potential Solutions," the event gathered more than 150 people in Strasbourg, France, for a three-day, interdisciplinary look at emerging environmental challenges to space activity.

As might be expected, the multiple challenges of space debris and its mitigation filled a large part of the agenda, but space weather; ground station vulnerabilities; concerns about weaponization of space; and the political and economic complexities of data sharing, policy coordination, and risk assessment also received attention.

In the keynote address, international concerns about threats to the continued use of space were presented by Gerard Brachet, President of the French Air and Space Academy, Former Chairman of the UN Committee on the Peaceful Use of Outer Space (UNCOPUOS), and member of the Secure World Foundation Board of Advisors. Summarizing the growing emphasis UNCOPUOS is placing on this issue, he repeatedly emphasized the concern that "our ability to use outer space in the long term is not guaranteed."

Over the next three days, 44 papers and 22 posters supported this assertion, offering various levels of optimism that the challenges we now face could be overcome.

A paper by Dr. Jens Utzmann of Astrium made a strong case for employing earthward-looking space-based telescopes to supplement the surveillance and tracking of debris. (See ***Figure 1***.) The paper inspires the question whether other sensors or technologies developed by the imaging community might be adapted for application in the effort to keep critical orbits more secure from space trash. Focusing on the particular problems of debris in the LEO (Low Earth Orbit), GEO (geostationary orbit) and sun-synchronous belts, several papers proposed methods for removing the clutter through various forms of direct action ranging from large deployable nets to the use of lasers both on the ground and in orbit.

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While generating a lot of technical interest and earning some cautious credibility, these proposed solutions were also greeted with considerable political and legal concern recognizing the fine line between their potential for peaceful use and their adaptability to more hostile applications.

In a paper co-authored with Alanna Krolikowski from the University of Toronto, the German space agency DLR's Emmanuelle David noted the extent to which a vehicle designed for On Orbit Servicing would be a "perfect space weapon," and conceptualized the policy that fact raised. She also addressed issues that will be on the critical path in any future implementation of commercial on-orbit servicing, emphasizing as did a poster by ISU Masters student Meagan Kane that the problem of debris may harbor commercial opportunities.

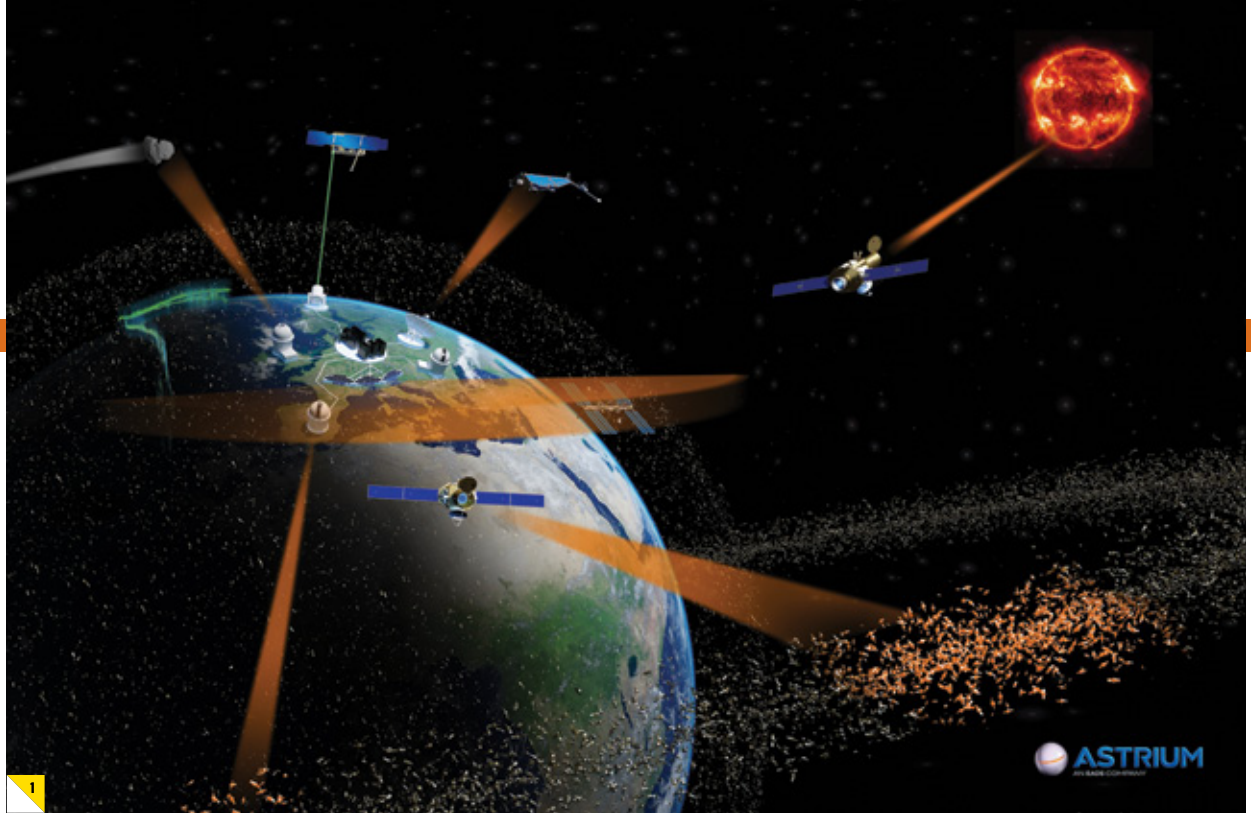
Any doubt that these issues were also of concern to governments and their space agencies was dispelled by presentations from the U.S. Department of State, NASA, the French space agency (CNES), the Japanese (JAXA), and the European (ESA).

Sharing substantial areas of agreement, these presentations all conveyed a sense of urgency and a commitment to seeking international solutions with particular emphasis on the importance of upcoming UN deliberations on Transparency and Confidence Building Measures (TCBM) and on ongoing discussions about an international code of conduct for space activity.

A sobering note in the French presentation reflected that country's analysis of specific problems France has had with debris-caused damage to its satellites, reporting that France calculates that it faces a 1% chance per year of losing one of the country's 17 satellites in LEO due to a collision with a medium-sized object (defined loosely as trackable fragments larger than 10 cm). Given that seven of these birds are classified as active earth observation satellites, this hits pretty close to home.

A paper by Akira Kato and Yukihito Ktazawa of JAXA argued strongly for increased physical shielding of spacecraft against collisions with small objects, while a paper by Nathalie Meusy, Head of the Coordination Office on Sustainable Development at ESA, focused on issues of terrestrial environmental and economic sustainability connected to space activity.

Tiffany Chow of the Secure World Foundation, in a paper she co-authored with her colleague Brian Weeden, presented grounds for optimism that cooperative




international solutions to space sustainability could be found. This paper showed creatively how the work on "governing the commons" by Nobel Prize winner Elinor Ostrom could be applied to the task of advancing the sustainable use of space.

An issue of potential concern to everyone interested in developing and using new space applications was raised in the several papers advocating increased shielding as the most logical solution to protecting satellites from small debris. Inevitably, extra shielding means tilting the mass budget from sensors and processors to exterior satellite structure. When this cost is combined with the extra fuel required by strategies focusing on maneuvering spacecraft out of harm's way, the resulting reduction in payload mass or increase in cost could have a braking effect on innovation and access to space assets.

An extremely rewarding aspect of the symposium was the addition of papers on space weather. Many participants noted that they rarely had the opportunity to mix the communities researching space weather and space debris and they found the experience very worthwhile.

Space weather papers not only discussed the impact of solar maxima on debris orbiting the earth, but also addressed several examples of space weather phenomena that could threaten satellite operations and ground station capabilities.

While ISU's symposium provided a rich opportunity to explore the interrelated issues confronting the long-term sustainability of space activities, it may have done its greatest service by stimulating thought about what is to come. Although most papers and posters had a practical focus on the challenge of protecting current space assets and capabilities, they also included hints of the threat to future development posed by the rapidly growing volume of troublesome space objects.

What seems to be emerging is a recognition that the problem of what could be called static sustainability (protecting what we have) is only a small part of a more troubling problem. There seems to be also a challenge of dynamic sustainability in which our ability to innovate and expand, and to broaden participation and extend the population of potential space beneficiaries beyond current levels could be put at risk by the rising costs and complexities of adapting to our own carelessness.

▲ **FIGURE 1.** *Illustration of space-based telescopes proposed by Astrium's Dr. Jens Utzmann for tracking debris, courtesy of Astrium.*

The failure to keep orbits clear and accessible, the unmet threats of space weather to satellite durability, and the unfilled need for more clearly established policy and procedures to permit rapid coordination among governments and major commercial players all complicate the lives of mission planners, spacecraft designers, operators, and users as they seek not only to preserve current capabilities but also to build new ones for the future.

The good news is that space is not only congested, contested, and competitive, as U.S. speakers often point out – it is also invested. In the 54 years since Sputnik 1, we have put a lot of junk into space, but we have also put enough resources there to build a large constituency of people with an interest in both static and dynamic sustainability.

As we think of keeping space available and accessible not only for today's projects but for those we dream of for the future, we should remember that the greatest of the resources we have invested in that future is ourselves.

# Google Earth Builder

## PRODUCTIZING SERVER FARMS FOR STORING AND PROCESSING GEOSPATIAL DATA

*Google Earth Builder (GEB), which Google released last fall, enables private companies and government agencies to store and process their geospatial data on Google's huge server farms and display it through Google Earth, Google Maps, and applications on Android phones. Like a company that buys a building much larger than it needs for its own operations and then leases some of this space, Google is productizing some of its computing capacity by licensing GEB.*

*Meanwhile, to maximize the benefits of this new product for their clients' specific needs, more than a dozen Google Enterprise Partners around the world are developing custom applications that run on top of Google Earth's public application programming interfaces (APIs). Early adopters of GEB include the U.S. National Geospatial-Intelligence Agency (NGA), the giant Australian utility Ergon Energy, and satellite imagery company GeoEye.*

### Acquiring and Managing Imagery

Typically, large organizations that deploy GEB have a direct relationship with imagery providers, such as GeoEye or DigitalGlobe, and task them to procure the specific imagery they require to create their own globe, says AJ Clark, the president of Thermopylae Sciences and Technology (TST). "The whole concept of using a private Google Earth globe is that you have some kind of access to imagery that the rest of the world doesn't and you want to maintain some degree of control over it." GEB gives users complete control as to who is allowed to view the imagery that they upload to Google's cloud. However, licensing Google Earth's software is not the same as licensing all of Google's imagery. Often people confuse the soft-

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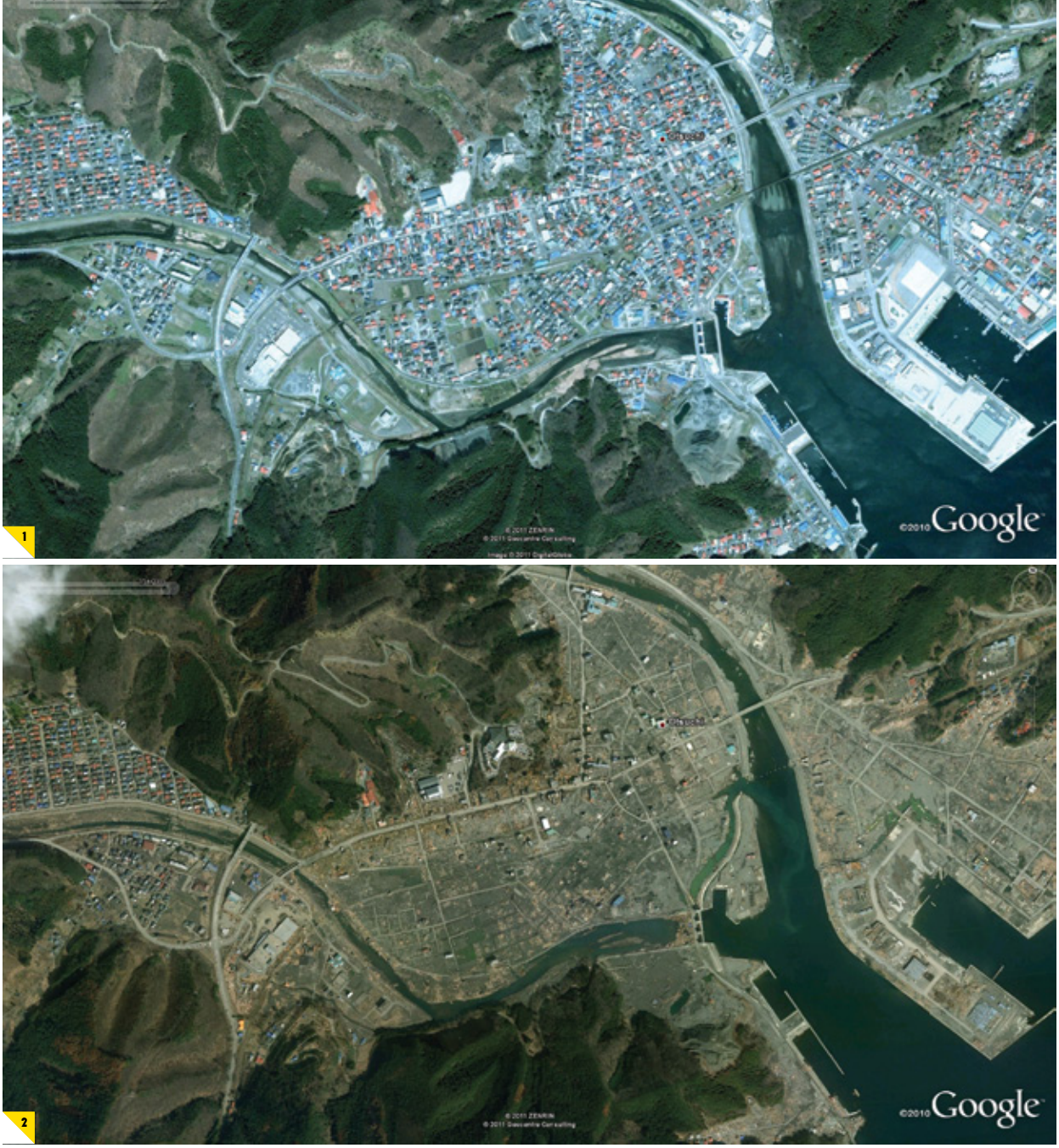
**EDITOR'S NOTE:** The first in-depth story about plans for Google Earth Builder appeared in *Imaging Notes'* Summer 2011 issue, prior to their Fall 2011 launch. This article is a follow-up to that story.




▲ **FIGURES 1-2.** *Google Earth Enterprise images of Otsuchi, Japan, before and after the tsunami.*

ware that makes Google Earth's globe available in a Web browser or on a desktop with the imagery it contains, but those are two separate products.

GEB allows users, who may not have much background in GIS or imagery, to easily upload their raw raster or vector data and create layers that they can open in Google Earth, explains John-Isaac Clark, TST's Chief Innovation Officer. "You can't do those things right now really easily as an end user through some of the higher-end GIS tools."

Another advantage of GEB is that it enables users to import imagery of many different types and then export that imagery to other proprietary software, such as Esri, via OGC services, such as WFS or WMS. To take imagery out of GEB, you draw a polygon around the area that you want to extract and export it to a portable globe. "That's what nobody else is doing," says AJ Clark. "They turn imagery into a commodity."

## Google Maps for Business

GEB is one of four products in Google Maps for Business that "provides enterprise organizations with the tools they need to bring mapping into their day-to-day decision-making process," says Dylan Lorimer, GEB's product manager. The other three are Google Maps API for Business, Google Earth Pro, and Google Earth Enterprise, which enable them to add spatial context to their Web sites and business applications, display some of their own data on top of Google's basemap and imagery, and build and host their private Google Earth and Google Maps layers, respectively. "Our strategy with Maps for Business is to bring Google's simple-to-use, intuitive geospatial technology into these business settings, with appropriate enterprise controls and services," says Lorimer.

## The Business Model

Google does not want to be seen as a provider of imagery, but of the capability to manage it. Having invested massively in server farms, it wants more customers to put data onto its servers and pay to access them. "That's where they see an economy of scale and a competitive advantage in the future," says AJ Clark. Therefore, Google licenses GEB to its customers as a platform for use with their own mapping data. "Customers pay only for the amount of storage they require and the amount of consumption of their published maps," says Lorimer. In other cases, data providers such as GeoEye are using the platform to commercially distribute their data.

Will Google further productize its server farms? "With GEB, we are absolutely committed to exposing the entire geospatial infrastructure that we used to build our consumer Google Earth and Google Maps, where it makes sense," says Lorimer. "We process all kinds of data — imagery, vector data, 3D models from LiDAR, terrain models, and so forth. I think you'll see that, as customers request it and it makes business sense, we'll certainly expose more and more of that functionality within GEB."

Google extends its reach through its partners. For example, in the Asia-Pacific Region, Dialogue Information Technology has about 30 account executives that operate across more than 2,800 Australian organizations, says Glenn Irvine, the company's National Practice Manager for Google Enterprise. "So, we provide them with sales reach and we talk daily with the Google team here in Australia about current opportunities."

## Custom Applications

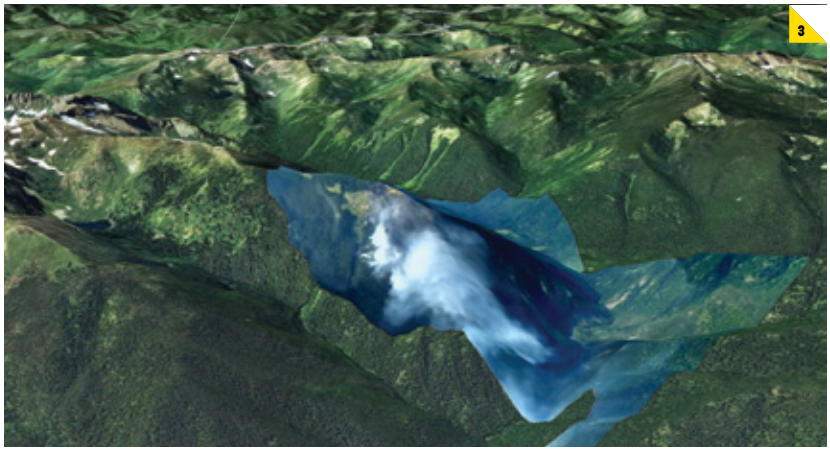
While Google software developers wrote all of the code for all of Google's Maps for Business products and continue to write updates, many Google partners work with Google Enterprise customers to build custom services on top of those products. They listen to their needs, decide whether a Google product exactly supports those needs, and then build value-added products, Lorimer explains. Therefore, Google gave its partners access to GEB a few weeks before launching it commercially, "because we wanted them to be able to port some of their applications to our APIs," he says. Several of these applications were on display at the annual Google Earth Federal Users Conference in early March. Organizations that buy these applications also benefit from the power of Google's cloud, says Lorimer. "It's all the folks who typically would use geospatial data and who invest in GIS. GEB is an enterprise product, so its success is certainly tied to the success of our customers."

"We have written a number of applications that integrate directly with the Google platform, whether it is the security and authentication service or visualizing the maps and Earth layers or other data pieces or a custom search," says Chris Powell, director of geospatial programs at NT Concepts.

Navagis, which has been a Google Enterprise Partner since 2008, works solely with Google's Geo products, primarily with federal government agencies, large engineering firms, utilities, oil and gas companies, and telecommunications companies. "We work a lot with GEB as well as Google Earth Enterprise," says David Moore, the company's founder and president. "We focus on creating custom products for customers around GEB. We also do support and services for GEB for companies that are setting up a GEB account for themselves. We'll come in, we'll help them out and teach them how to use it, load all their data, all that."

"We also have a product that we've developed called Mobile Recon, which allows you to collect data in the field and synch it up with GEB." Two years ago, Navagis gave tablet devices loaded with Mobile Recon to contractors who were responding to a huge oil spill in Michigan. They used it to collect the locations

▼ **FIGURE 3.** *Imagery published from Google Earth Builder read directly into Google Earth Public Globe courtesy of NT Concepts.*



of the oil and synch them back up to a Google account in real time, so that the data could be analyzed and used to direct the response.

Dialogue Information Technology, too, integrates GEB into existing systems. For example, says Irvine, a utility that manages all of its assets in its enterprise resource planning (ERPs) system may want to be able to present that asset information through Google Earth. Additionally, the company provides initial implementation and training, and assists its clients with their licensing requirements.

NGIS became a Google Earth Enterprise partner about 15 months ago, when it was assisting several of its clients with their GIS requirements. "All had a common theme, which was to find a tool that enabled the wider community of stakeholders, both internal and external, to view the GIS data," says Chris Erikson, the company's director of sales and marketing. "The heavy lifting is still done in Esri, MapInfo, SmallWorld, Oracle Spatial, those types of systems. We weren't looking to replace them, clearly, but we saw an opportunity for Google to provide the internal and external users of our clients' data with a way to view their GIS layers. Google Earth Builder is getting GIS data out of the GIS department and into the hands of all stakeholders and employees."

"We run a help desk that acts as a liaison between our clients and Google," Erikson says. "We resolve most troubleshooting internally, but Google certainly provides a vast amount of support resources also, so our role depends on each client's support requirements. We find that, in most cases, once Google Earth Builder is deployed, it is almost plug-and-play."

TST, launched in 2007 by a group of former government employees, military personnel, and Silicon Valley software developers, focused on challenges around the defense and intelligence community. "We saw an appetite within those customer bases for the same kind of commercial technology that they had access to when

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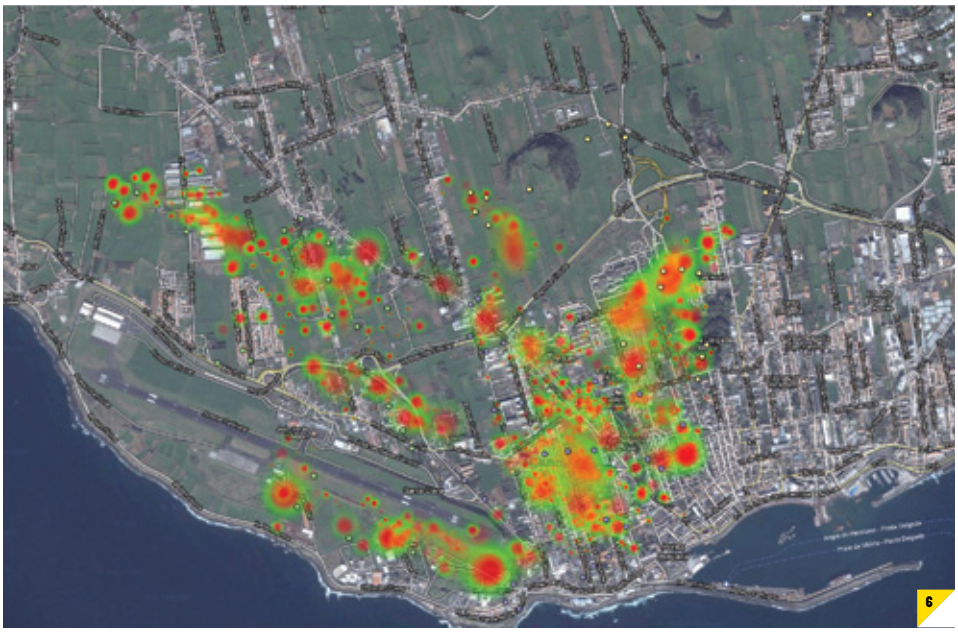
▲ **FIGURE 4.** *The iSpatial application displaying feature collections on a Google Earth globe, courtesy of Thermopylae Sciences and Technologies.*

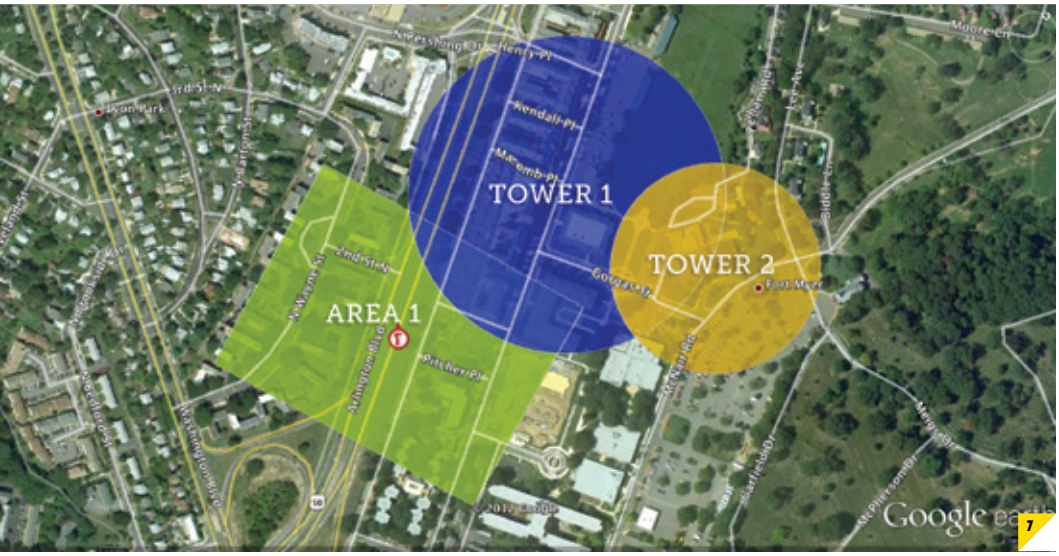
▲ **FIGURE 5.** *GEB displaying text, image and video data collected in the field by a smartphone, courtesy of Navagis.*

they went home and planned their night out or traveled to a different city," says AJ Clark. "So, we would look at a capability like Google Earth and ask, what are the obstacles to a customer using this more predominantly in their mission?"

In 2008, he recalls, the U.S. State Department's Bureau of Diplomatic Security asked TST to develop for it a capability to better visualize all of its security vehicles and personnel who were moving around in a high-threat area, such as Iraq, Afghanistan, or Yemen. While TST's initial project was focused on using the Google Earth desktop product, soon the company recommended creating a system that would enable many people to see all of the data in Google Earth through a Web browser.

Within Google Earth, AJ Clark explains, a piece of software called






Google Earth Fusion allows an organization to fuse to a basic Google Earth globe — Google calls it a Blue Marble — all of its latest imagery, which can then be displayed either in a Web browser or on the Google Earth desktop software. "It is very good at fusing terrain, imagery, and data that don't change very often," he says. However, some data — such as the location of a moving vehicle — is not well suited to be fused to that globe. "You need some other means of dealing with dynamic data like that. We ended up building an entire product, called iSpatial, around that concept." It was then adopted by other government agencies, he says, including the Social Security Administration, the Air Force, the Army, and the Defense Intelligence Agency.

▲ **FIGURE 6.** *A heat map showing customer foot traffic overlaying store location with sales data, courtesy of Navagis.*

▲ **FIGURE 7.** *The iSpatial application running on a Google Earth globe, courtesy of Thermopylae Sciences and Technology.*

TST, which released iSpatial about three years ago, is now making it available as a hosted solution. This allows people who may not be GIS experts — such as county officials responding to a tornado or a flood — to create content, such as lines, geometries, or features, and then upload them to GEB, share them with others, or add them to a collection, explains John-Isaac Clark. "It's making it a lot more accessible to the everyday user who is already used to interfacing with Google Maps and Google Earth."

NT Concepts, Navagis, Dialogue Information Technology, TST, and other value-added resellers of Google's products also act as geospatial subject matter experts for their customers and troubleshoot technical and administrative issues with Google on their behalf. "The APIs within GEB are continuing to evolve and our engineers are interacting with the Google team on a weekly basis with respect to several projects where we are using GEB and leveraging those APIs," says Powell. "There are new features and functionality each day that we are trying to incorporate into custom applications. One that we've implemented is a single sign-on service, which would allow somebody from within their corporate environment to use their active directory or their security and authentication mechanisms to authenticate with the Google authentication system." Similarly, Irvine says: "There is a lot of liaison from a technical point of view, where our engineers will be talking to Google engineers around specific requirements or a unique case that a client might have."

## Ergon Energy and GeoEye

Ergon Energy, Lorimer says, is "a good example of how energy and utilities companies see the benefit of using our cloud for all of their data to build common operational maps that they can share out with their users" — both in the field, using mobile devices, and at the office, using the Google Earth client from their desktops.

GeoEye is working closely with Google to make it possible for someone who wants imagery of an area to simply draw a square around it and ask for it. The

message would go through GEB to GeoEye and the customer would receive a response through the Web browser with the price and quality of the image and the option to buy it, explains AJ Clark. "GEB will be great for customers because it allows them to build a subscription imagery service using it, where they can push-button publish their processed imagery into the hands of their users and just as easily revoke access," says Lorimer. "So, they built an annuity term-based subscription model, where in the past they've provided data via FTP or on DVD."

## Other uses of GEB

Other users include many national, state, and local governments. A company that sells a software package that can be used for a "call before you dig" underground infrastructure application is using GEB behind the scenes to store all the data in the cloud and then expose it through an API within their application, Lorimer says.

GEB can be used to provide a common operating picture for disaster management. It has been used in the past ten natural disasters, says Lorimer. For example, during Hurricane Irene, one of Google's government customers used GEB to display imagery taken over the coast of North Carolina on a public map that was used for disaster response. In Australia, which has had significant floods, cyclones, and brush fires in recent years, some state agencies are also looking to Google Earth Enterprise and/or GEB environments to manage that common operating visualization picture for managing disaster declarations and claims and organizing communities' responses, says Irvine.

## From Google Earth Enterprise to GEB

Google Earth Enterprise, which Google released with the original acquisition of Keyhole well before GEB, allows organizations to build globes and maps on their own networks, behind their firewalls, and, if needed, disconnected from the Internet. This is one reason it is still used by many government organizations, especially defense and intelligence agencies, which are reluctant to expose their networks to the Internet or are prohibited by law from doing so.

However, deploying Google Earth Enterprise requires a much greater investment and background knowledge in IT infrastructure than GEB. "Many of the organizations with which we work may spend $500,000 just on hardware, where if you use GEB you don't have to spend any money on hardware, because Google provides all that," says Moore. "To use a Google Earth Enterprise model, you have to be familiar with servers, hardware platforms, and Linux," Powell says. "In some cases, to be proficient, you also need to have a pretty good understanding of geospatial processing, geospatial data formats, pixel size, resolution, and data projections — because these are all areas in which common errors can occur in importing, hosting, and styling data."

By contrast, he explains, with GEB you can upload files into Google's cloud-based environment much more easily and process them much more quickly. A Google Earth Enterprise deployment also requires a huge amount of storage. "Some of our clients have well more than 100 terabytes of storage online within their Google Earth Enterprise environment, managing their globes and maps, on a protected client environment."

Additionally, Google Earth Enterprise's license caps the number of users who may hit a server to 1,000 per year. By contrast, GEB, which resides on Google's cloud like Google Earth and Google Maps, has no such limit. It allows multiple levels of users to access the data, while still enabling the organization to protect it at the appropriate level. "You could envision an organization like the Department of Homeland Security or FEMA using GEB to share geospatial information with thousands of relief workers or humanitarian assistance or disaster recovery folks," says Powell.

NT Concepts became a Google Earth Enterprise partner in 2006 and was the first one to contract with the U.S. federal government, says Powell. It has been deploying Google Earth Enterprise solutions to support many federal government clients, including the Army, the Air Force, and the Fire and Aviation Management group of the U.S. Forest Service. This last agency has been using for years a Google Earth Enterprise solution and a network link KML service to maintain a globe and overlay on it dynamic information on forest fires and the aircraft that are responding to them, he says. NT Concepts is now investigating how their client might port this application to GEB. "This currently is a hybrid project, where we are still relying on our underlying Google Earth Enterprise system to manage and visualize the data, but we are now experimenting with how we can bring in additional layers from GEB," Powell concludes.

Google Earth, launched in June 2005, expanded by orders of magnitude the number of people who view aerial and satellite imagery and who use basic GIS functions, such as turning layers on and off and measuring distances. GEB expands that reach further, by making it much cheaper and easier for organizations to share with internal and external users their investment in GIS data and in dynamic data feeds from sensors. «

# 40 YEARS

## THE LASTING LEGACY OF LANDSAT

*"For man must rise above this Earth – to the top of the atmosphere and beyond – for only thus will he fully understand the world in which he lives."*

*– Socrates, roughly 400 B.C.*

**THAT COMMENT BY THE CLASSICAL GREEK ATHENIAN PHILOSOPHER IS** fitting as part of celebrations marking the 40th anniversary of the U.S. Landsat program.

Since 1972, Landsat spacecraft have cast their respective sensor sets on Earth, collecting spectral information from the planet's surface and producing a historical archive unmatched in quality, detail, coverage, and duration. See ***Figure 1***.

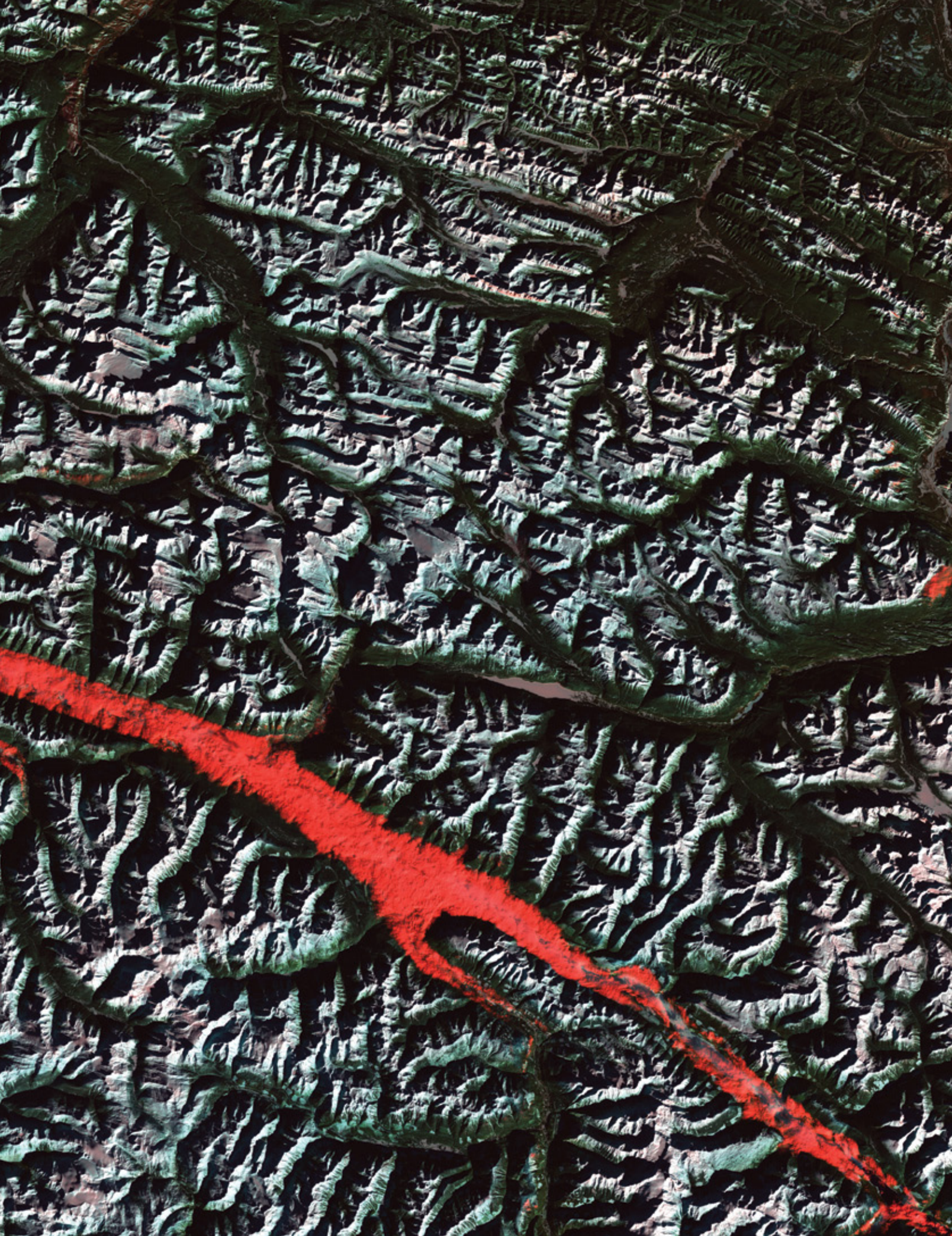
The Landsat Program is jointly managed by NASA and the U.S. Geological Survey (USGS). "Because Landsat enables us to see Earth's surface so clearly, so broadly, so objectively, we gain invaluable insights about the complexity of Earth systems and the condition of our natural resources," said USGS Director, Marcia McNutt.

Many others have also heralded the value of Landsat over the decades. "Landsat is akin to the Earth's free press. With its global perspective, we have objective and indisputable evidence of the condition of the planet," contends Curtis Woodcock, team leader for the USGS Landsat Science Team and a Boston University professor.

But while being heralded, Landsat is a program in limbo. There's the lack of a permanent agency home for Landsat and the threat of a data gap. Also, as reviewed in a recent Congressional Research Service report on Landsat and its future, "Despite its wide use, efforts in the past to commercialize Landsat operations have not been successful. Most of the users of the data are other government agencies. For that reason, funding a replacement for the failing Landsat orbiters has been a federal responsibility. A number of factors have made it difficult for Congress to assure that the project successfully meets the goal of bridging the impending Landsat data gap."

**LEONARD DAVID**
Research Associate
Secure World Foundation
www.swfound.org

▶ **FIGURE 5.** *This image of the Rocky Mountain Trench was taken Feb. 1, 2004 by Landsat 5. What appears to be a stroke of thick red paint is actually a remarkable interplay of low sun elevation and low clouds in the Canadian Rockies. The trench is a valley that extends from Montana in the U.S. to just south of the Yukon Territory. The red stripe is near the border between the Canadian provinces of Alberta and British Columbia.*



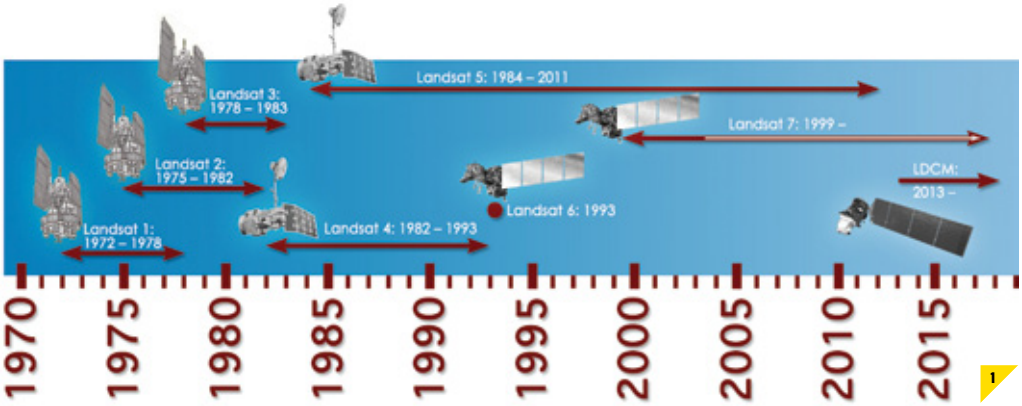
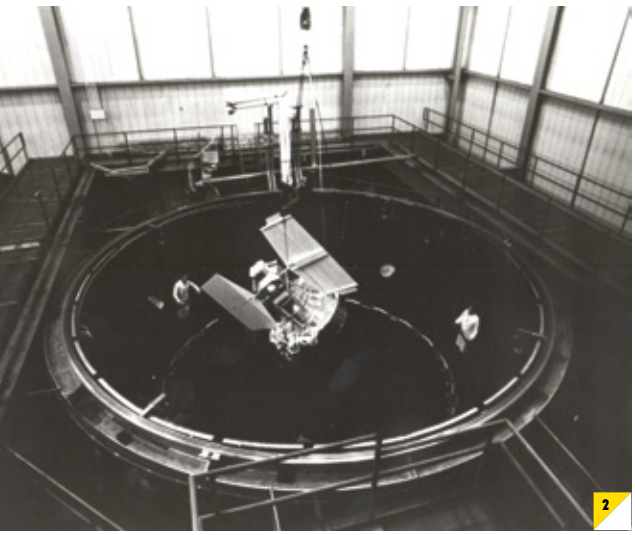



**FIGURE 1.** *Landsat Mission history, courtesy of NASA.*

**FIGURE 2.** *The Earth Resources Technology Satellite (ERTS) mock-up is shown here in a space chamber test at General Electric's Space Division. Later dubbed Landsat-1, the satellite was built on a weather satellite platform, which is why the satellite so closely resembles the Nimbus weather satellites. Courtesy of NASA.*



## Mid-Life Crisis?

Speaking before the Association of American Geographers during their annual meeting in February, Anne Castle, Assistant Secretary for Water and Science, U.S. Department of the Interior, titled her talk, "Landsat at 40: Prime Productive Years or Mid-Life Crisis?"

Castle noted in her talk that in October 2008, the USGS made the entire Landsat archive — over 3 million images — available via the Internet at no cost. The opening of the Landsat archive reshaped the future of moderate-resolution Earth observations, she reported. Indeed, that act, she said, spurred Adam Gerrand of the Food and Agriculture Organization of the United Nations to observe, "The opening of the Landsat archive to free, web-based access is like giving a library card for the world's best library of Earth conditions to everyone in the world." Castle underscored in her talk, in regard to Landsat, that studies indicate societal value exceeds data acquisition and distribution costs. Furthermore, the program encourages development of research applications leading to innovative commercial endeavors. "Commercial data use has increased under the free distribution policy," she noted.

## Time Is of the Essence

"The 40th anniversary of the Landsat program is definitely a cause for celebration," said William Townsend, an aerospace consultant and former NASA and industry executive. "Landsat has produced an incredible, unbroken 40-year record of global land surface multispectral imagery that is unparalleled in the history of satellite remote sensing," he told *Imaging Notes*.

These data are routinely utilized today, Townsend emphasized, to support such diverse activities as mapping environmental changes and supporting decision making in fields such as agriculture, forestry and land use.

"When the Earth Resources Technology Satellite (ERTS, aka Landsat-1) was successfully launched on July 23, 1972, the designers and builders of that system could hardly have imagined that the program would demonstrate so much utility that it would continue for another 40 years," Townsend said. See ***Figure 2***.

"But this has not been easy…nor without some old fashioned good luck," Townsend noted. The failed attempt to privatize the system in the 1980's, coupled with the failure of Landsat-6 to achieve orbit in 1993, seriously threatened the continuation of the program. Offsetting this were the incredible 25-plus years of successful Landsat-5 operations that managed to carry the program through these difficult times and beyond until just this past fall.

"But now the program is threatened again. Landsat-7 is expected to run out of fuel in the not-too-distant future. The Landsat Data Continuity Mission — or LDCM, aka Landsat-8 — has yet to be launched, although that event is coming up in January of next year. And, most importantly, there are no concrete plans for the continuation of the Landsat program beyond LDCM."

Townsend pointed out that the leadership of the program was recently transferred from NASA to USGS via the 2010 National Space Policy — and has yet to get any significant traction in its new home. The Congress has questioned the wisdom of this transfer, and has refused to fund it at the requested levels. Accordingly, the White House Office of Science Technology Policy (OSTP), Office of Management and Budget (OMB), USGS, NASA and NOAA have formed a team to study possible options for future Landsat missions, with an emphasis on dramatically reducing the cost of future Landsat systems, given that the cost of LDCM is approaching a billion dollars.

"With Landsat-9 planned for launch in 2018, 5 years after LDCM, time is of the essence given the vagaries of government studies and the funding approval

cycle. Even assuming a successful launch and activation of LDCM, the program is once again threatened with a break in coverage, given the current lack of concrete plans for a Landsat-9," Townsend said.

## Synoptic View

In reviewing the history of Landsat, Ray Williamson, editor of *Imaging Notes* and Senior Advisor to the Secure World Foundation, underscored the program's shaky and skeptical start.

"For one thing, there was a lot of argument over whether we needed the Landsat at all," Williamson said, recalling the claims of some that it could all be done with aerial photography. "Those making that case didn't appreciate the synoptic view that satellite imagery can provide…and they weren't looking at its international value."

There was early debate about Landsat utility strictly in economic terms. There were those who said, if it has value, then it ought to have value in the marketplace. "Also, the whole system was over-sold early on in terms of what it was going to produce…and that hurt it in the sense that advocates couldn't show immediate return," Williamson said.

Given the 80-meter resolution of the initial Landsats — while scientists by and large embraced that view of Earth from space — it was clear they wanted higher resolution, which became available with Landsat 4 and 5, Williamson added.

## Cliffhanger

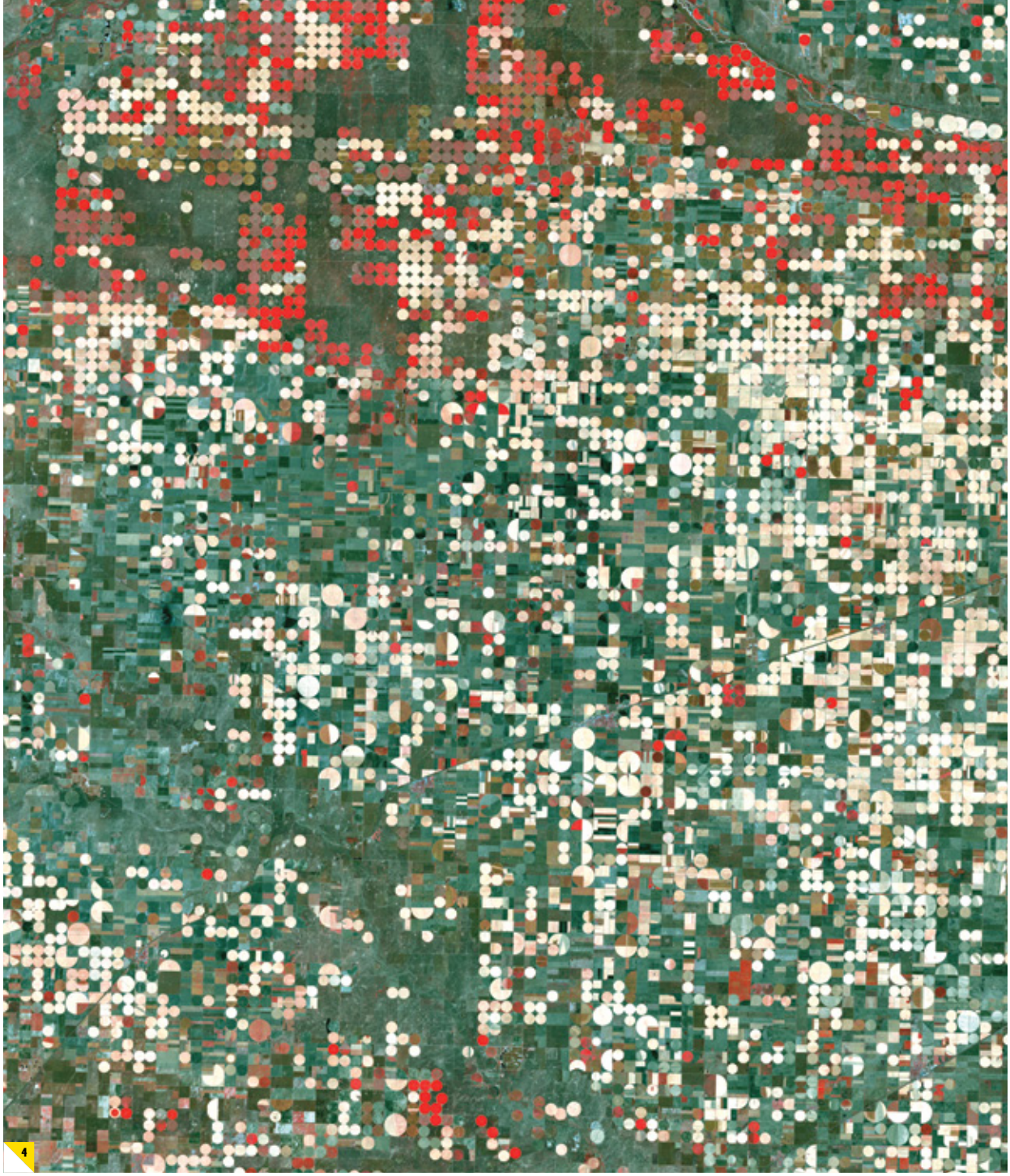
Fast forward to today: Williamson said that he feels the worth of Landsat and systems like it should be seen more in the "public good" realm. One of the lessons to be learned, in developing a new technology that's not well known in user circles, is that it takes time.

Likewise, "One of the great values of Landsat was demonstrating to the world community that 'satellite imagery works' and could be used for a variety of applications," Williamson said. "In my view, one of the greatest accomplishments of the Landsat program is that it engendered many of the optical systems in orbit right now."

Lastly, the value of merging moderate-resolution data with other types of remote sensing, be they radar, higher-resolution satellite or aerial imagery, is yet another plus for Landsat, Williamson suggested. "So there's room for the Landsat data to continue, and as a public good. The continuity of the data enables users to look back on changes in an area and understand what those changes mean. You really need that longevity of information."

Kudos aside, Williamson said he

**FIGURE 3.** *The Landsat Data Continuity Mission (LDCM) satellite will continue the Landsat observatories' heritage, obtaining unique multi-spectral land images and data to be used in agriculture, geology, forestry, regional planning, education, mapping, global change research, emergency response and disaster relief. Courtesy of Orbital Sciences.*



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continues to be perplexed that the continuity of the Landsat program "has always been a cliffhanger." In his view, there's been lack of innovative approaches and ingenuity to chip away at expensive systems like Landsat. A philosophy of 'build the system that you can afford and then upgrade over time' is worth considering, he advised.

## Public Service

"I use the term 'evolutionary' in looking at our advancement," said James Irons, Landsat Data Continuity Mission (LDCM) project scientist at NASA's Goddard Space Flight Center in Greenbelt, Md. "I think Landsat itself has been a notably successful program throughout its history, despite a rather chaotic history of the program's management and operation," Irons said. "The program has yet to find a secure, permanent home in either the government or the private sector."

Irons said that he considers the Landsat data archive a public good and the program itself a public service. "At the scale we collect data, and

◀ **FIGURE 4.** *Garden City, Kansas image shows center pivot irrigation systems creating these circular patterns in crop land. The red circles indicate irrigated crops of healthy vegetation. The light-colored circles represent harvested crops. Landsat-7 image taken Sept. 1, 2000, courtesy of USGS.*

the purposes to which the data are intended and applied," he told *Imaging Notes*, "it's not an area where private industry could expect to have a return on investment commensurate with the large investment to begin a spaceflight project."

In terms of the Landsat user community, "We still have a ways to go… to make the data and the information inferred from the data user-friendly," Irons said. "We have historically left challenges to the people who download the data that they had to overcome, before they could get the data into a form that was immediately useful."

## Institutionally Courageous

The 2008 judgment by the USGS to provide Landsat data at no cost was an action that Irons considers "institutionally courageous," in addition to terrain-correcting the data. "That was a big step forward in making the data more user-friendly," he said.

At present two spacecraft — Landsat-5, launched in 1984, and Landsat-7, launched in 1999 — are in orbit and continuing to supply images and data. Both, however, are experiencing technical issues. Irons flags a good dose of luck that's ensured Landsat data continuity. Many of the spacecraft are lasting well beyond their design life.

The LDCM spacecraft is being built by Orbital Sciences Corporation. See ***Figure 3*** on page 17. The main instrument onboard Landsat 8 (LCDM-1) payload is the Operational Land Imager (OLI) instrument. A passive (i.e., fixed) imaging radiometer, OLI will capture imagery of the Earth's surface via panchromatic/multi-spectral bands at 30 meters to 15 meters (moderate) resolution. This capability is similar to instruments deployed on Landsat missions 4 through 7. In addition, a Thermal Infrared Sensing Instrument (TIRS) is being flown.

"The good news is that we're going to collect data from both that will extend the historical archive. The advancements of Landsat-8 will improve our capacity to characterize and detect changes in all sorts of land cover, which is the primary objective of the mission," Irons said.

After four decades, the Landsat program commemorates the longest continuous global record of the Earth's surface and continues to deliver visually stunning and scientifically priceless images of our home planet. See ***Figures 4-5*** opposite and on page 15.

Still, putting festivities aside, William Townsend concluded, "So, while the 40th anniversary of Landsat is indeed a cause for celebration, it is also a time for a call for renewal of the Nation's commitment to a sustained Landsat program…because good luck can last only so long." «

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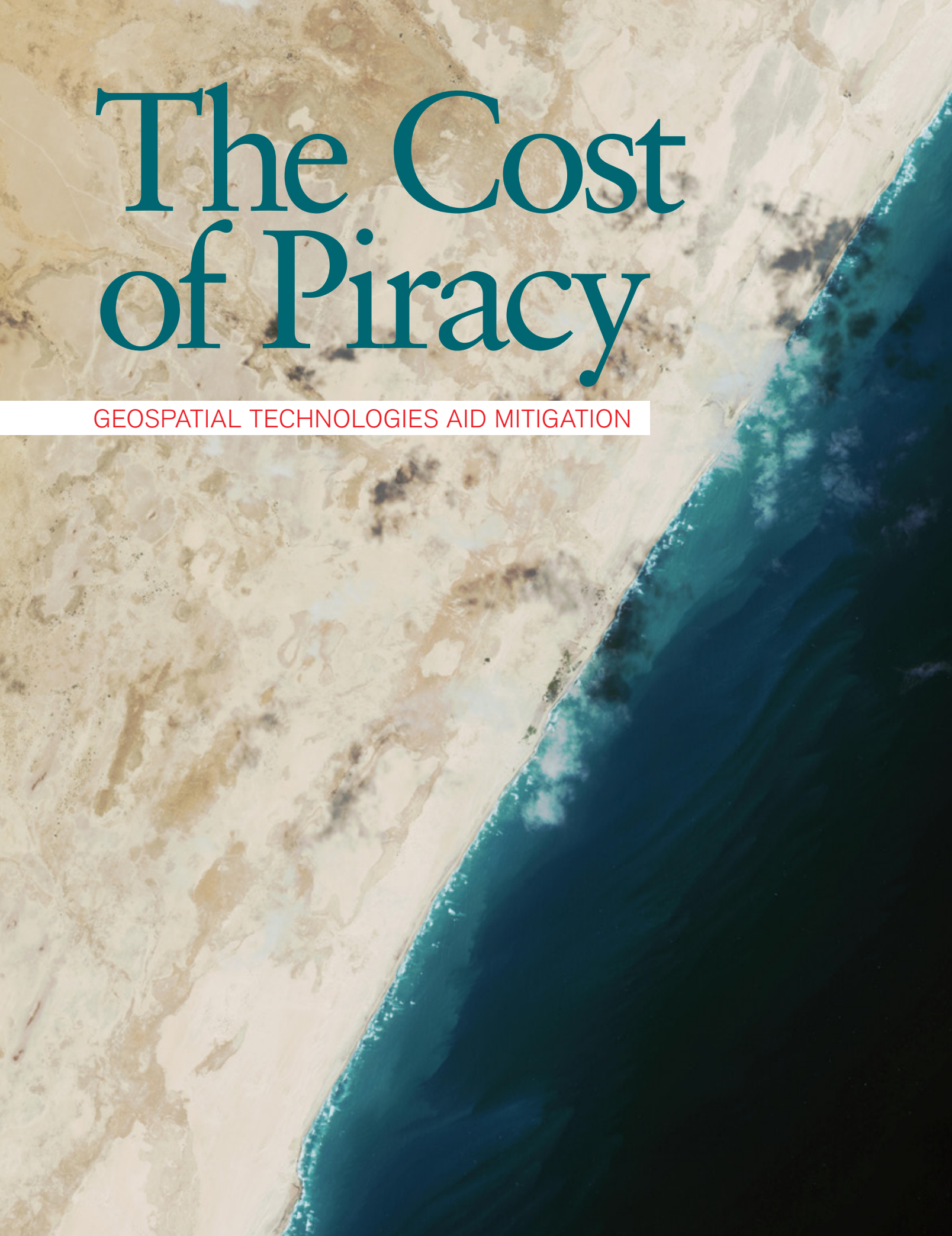
# The Cost of Piracy

## GEOSPATIAL TECHNOLOGIES AID MITIGATION



## Curtailing the Cost of Piracy

By definition, piracy is the act of robbery on the high seas. While the life of the pirate has been highly romanticized, with historic depictions fueling blockbuster movies, piracy continues to be a high-risk and high-reward pursuit. What's increasingly clear in today's global economy is that the damage done by pirates to trade and the environment far exceeds their take.

It's hard to understand how such activities can continue unchecked today given our sophisticated monitoring technologies. The fact that our oceans make up two-thirds of the surface of the globe provides some understanding of the problem, making it difficult to achieve any level of persistent surveillance with moving targets over such broad geographies. Geospatial technologies have a strong role to play in piracy mitigation, with sensors and systems combining to help detect and track today's ocean robbers.

## Somali Lawlessness

The vexing problem of Somali piracy is one of global concern, with broad economic impacts on shipping companies, governments, and individuals. Problems that started as illegal fishing and taxation of fishing vessels by private coast guards have escalated to widespread hijacking and hostage-taking for ransom that is now growing in geographic scope.

Somalia is responsible for 60% of all global piracy, with 62 deaths as a result of piracy since 2007. The unique challenge is in large part due to the lack of a local rule of law with the dissolution of the central Somali government in 1991. The mix of poverty, concentration of shipping, and the extensive coast line, together with competing tribal entities, and the requirement for young men to have a dowry to marry, all exacerbate the problem.

A global lack of ownership of this problem exists largely because piracy doesn't amount to a national security or military threat to western countries. Any country or company that takes action has an issue of what to do with captured pirates; with competing jurisdictions and a lack of local courts, most are just released.

## Tangled Issues

To date, the thorny legal and moral issues surrounding piracy have meant that little progress has been made on the problem. Oceans Beyond Piracy, an issue-focused initiative of the One Earth Future Foundation (www.oneearthfuture.org), is hard at work to harness expert opinion on the interconnected issues of piracy and economy, with the aim of providing long-term solutions.

At the forefront of their efforts is an influential annual report that quantifies the economic cost of Somali piracy on a global scale. The report puts a $7 billion yearly price tag on the problem. The need to increase vessel speed is the largest cost segment, with poor fuel economy stacking up, followed by military expense, investment in on-board security personnel and equipment, re-routing delays and costs,

**FIGURE 1.** *GeoEye satellite image shows the Sirius Star, a Saudi-owned crude oil carrier hijacked by Somali pirates in November 2008. Image taken Nov. 20, 2008, courtesy of GeoEye.*

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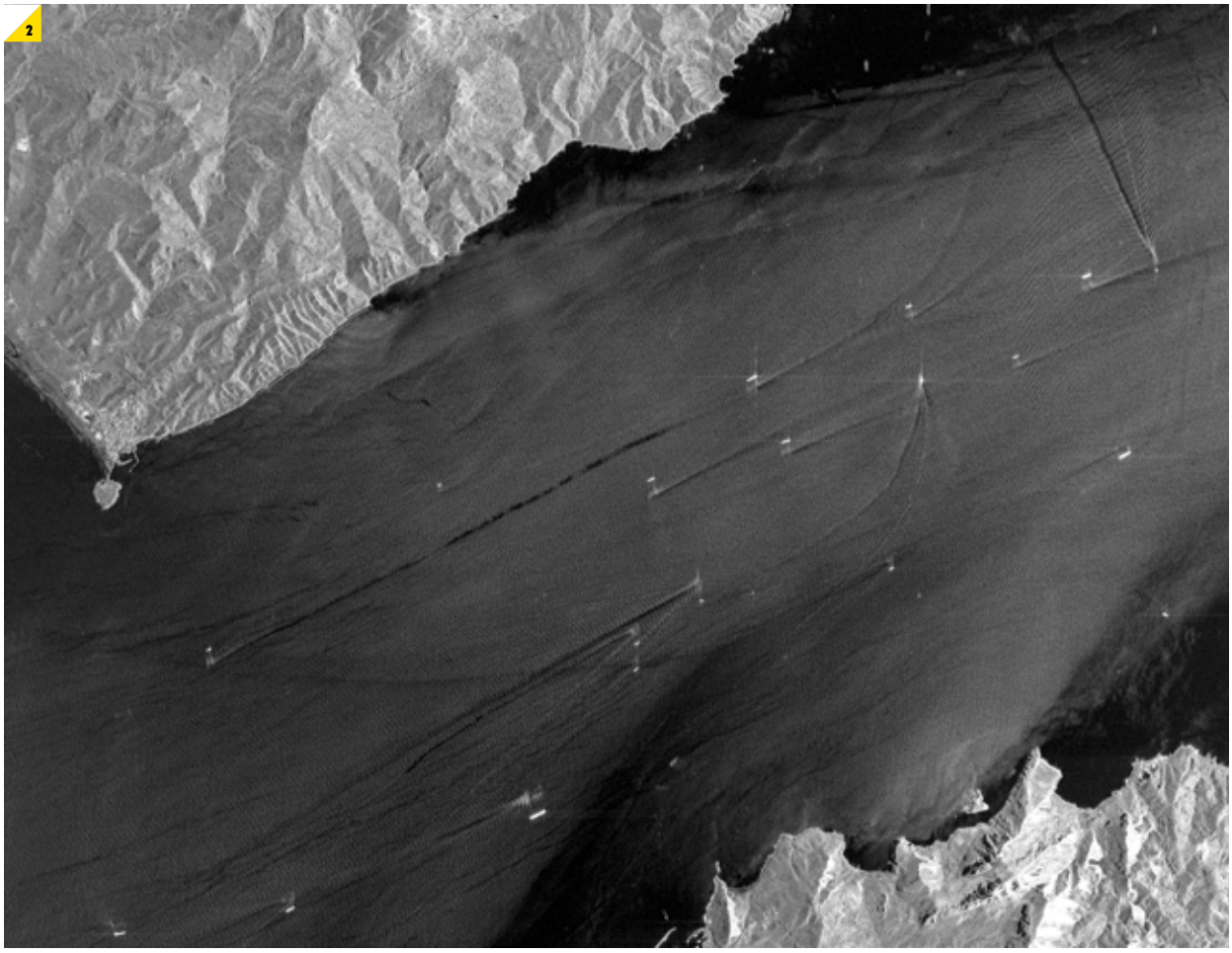
**EDITOR'S NOTE:** Special thanks to Oceans Beyond Piracy, a project of One Earth Future, which sponsored an event detailing Somali Piracy in partnership with the Sturm College of Law at the University of Denver in March 2012.

insurance expenses, hazard pay to the crew, and finally, the ransoms. While the common assumption is that ransom is the biggest expense, it turns out that it's only two percent of the total. The recurring annual costs of these mitigation strategies make up 99 percent of the expense, with very few funds going toward long-term solutions.

The human cost is an additional burden that proves hard to quantify. From the Somali side, young teenage boys are coerced into service, set loose to capture a ship, and told not to come back if they don't succeed, with many never returning. The crews of the captured vessels are largely poor Asian men, whose working conditions include piracy as a very real threat to their safety. In India, where many crew originate, it has been calculated that each crew member held for ransom has a direct impact on the livelihood of seven individuals, according to Dr. Swadesh Rana, Oceans Beyond Piracy, India. If that figure were to be extrapolated to the 1,181 hostages taken in 2011 alone, the cumulative impact on those personally affected becomes quite a large number – well over 8,000.

▼ **FIGURE 2.** *TerraSAR-X radar satellite image illustrates the unique capabilities of SAR to capture the wakes of ships. This StripMap acquisition of the Strait of Gibraltar shows busy vessel traffic, with the shape and trajectory of the wakes helping to determine ship speed and location. Image courtesy of Astrium GEO-Information Services.*



## Geographic Spread

The pirates' effectiveness has been somewhat curtailed with enhanced private armed security aboard ships, but armed guards are a costly deterrent. The crackdown has helped reduce the number of effective incidents this past year, but it has also led to a geographic spread of operations further East toward India, and northeast toward the Gulf of Oman and the Strait of Hormuz, with pirates seen as far as 600 miles off the Somali coast. See ***Figure 1*** on pages 22-23.

Tracking and apprehending pirates is a capability of Navies from around the world, and the combined forces of the NATO Operation Ocean Shield, the European Union, and the Combined Maritime Forces of the U.S. coalition are making some mark. This operation has included helicopter surveillance as well as surveillance aircraft that travel the full extent of the Somali coastline collecting aerial imagery.

Because pirates often operate in early morning or in periods of low visibility, infrared imagery has proven to be a powerful tool. In addition, synthetic aperture radar (SAR) imagery can be used at night and can penetrate clouds during the day. SAR imagery can pick up the wakes of ships, with the shape and trajectory of the wake helping to determine ship speed and location. See ***Figure 2***.

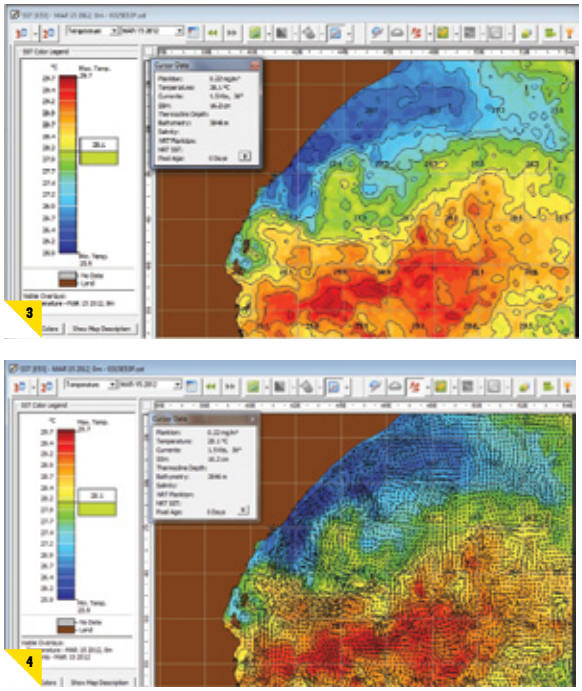
Ocean Shield has operated since 2008, and been involved in several actions against pirates, but captured pirates are often released for lack of sufficient grounds for prosecution. Actions against individual pirates treat only symptoms rather than the disease, which is the lack of stable institutions in Somalia. With greater monitoring, and an improved understanding of the overall impacts, the hope is to channel international support to programs that can make a long-term difference.

## Taking Fish

From a conservation perspective, it's ironic that the activity of Somali pirates patroling and accosting ships along their coasts is having a positive impact on fisheries. Tuna and marlin populations are thriving where commercial fishing trawlers have been chased away, and the negative impact to the $6 billion tuna industry in the Indian Ocean are an additional economic factor not accounted for in the costs outlined above.

The challenges of sustainability can be summarized in the realization that we currently have enough resources to fit our needs, but not our greed. Perhaps nowhere is this greed more apparent than with illegal, unreported and unregulated (IUU) fishing and the use of illegal means such as drift nets to catch fish. These acts are rightly deemed piracy because they flout international controls to avoid the fate of fisheries that have collapsed due to overfishing, taking resources without regard to long-term environmental health, and risking food security for the sake of profit.

The spread of Somali-style piracy certainly isn't the answer to curb the costs of illegal fishing or to sustain this resource for future generations, but something must be done. The U.S. government assesses global costs of illegal fishing at $23 billion in lost license income and lost catches for legal fishermen, as well as the economic cost to local communities who lose the resource. Additionally, there is an ecological cost that plays out over a much longer period of time, with many of the methods used to catch fish illegally causing damage to fish habitat that will last for decades.



▲ **FIGURES 3-4.** ***GeoEye's SeaStar Service provides insight into current conditions. These dynamic maps of the Western Indian Ocean show sea surface temperature (SST) above, overlaid with ocean currents (below). The map returns detailed values based on where your cursor is placed, and is updated daily.***

## Vessel Monitoring

Satellite imagery and information service provider GeoEye compiles oceanographic data from multiple satellites on a daily basis through their SeaStar Fisheries Information Service. The service looks at such indicators as plankton concentration, water temperature, weather and current patterns, and 3D oceanographic maps to provide a detailed picture of real-time fishing conditions. See ***Figures 3-4***.

"We started the SeaStar service to help fishermen find fish, but over the last few years we've seen a push toward monitoring the seas to make sure that highly migratory species like tuna are not being overfished," said Chris Wilson, senior director, sales and marketing of Marine

Services at GeoEye. "There is a lot of government surveillance taking place to detect IUU vessels, with effort to monitor and look for vessels that aren't compliant. We need to be cognizant of the efforts and support these initiatives for the good and longevity of the entire industry."

Most regulated waters now include a tracking device for every licensed vessel, so that governments can now look specifically for vessels without the device. GeoEye has combined on-board sensors, satellite reporting, and recording systems into a vessel monitoring service to help governments and fishery observers to monitor and record fishing activities. The need to pinpoint where boats go, and why, can also be informed through such services as GeoEye's SeaStar Service in order to help plan enforcement efforts most efficiently. All the vessels, including those acting illegally, will be in areas of good fishing along temperature and plankton fronts, and knowing where legal vessels are helps pinpoint where IUU vessels might be.

## Fishing Efficiency

Today's fishing vessel is well equipped with technology, with GPS, radar, and sonar systems on board, and with augmented insight through satellite data. These tools have greatly improved the efficiency of vessels to catch their quotas quickly. With this improved fishing efficiency there is heightened concern that we're overfishing our oceans.

The growing pressures on fisheries, with increasing human populations and impacts of climate change, place urgency on education and action to maintain sustainability. A wide number of organizations have banded for a common vision of environmental sustainability that connects directly to our plates.

The International Seafood Sustainability Foundation (ISSF) is working on a global scale to assess the health of fisheries and to curb the IUU problem. The ISSF compiles and maintains data on the health of fisheries as well as a database of unique identifiers of vessels that comply with conservation measures. The focus on tracking vessels makes it tougher for vessels to make illegal catches, and with support from processors, traders and importers that do business only with those vessels in the program, those that skirt the system will face shrinking markets.

## Robotic Monitoring

The need to more tightly monitor fishing vessels is leading to new sensor-based approaches to help curtail the costs and unworkable logistics of having observers aboard every boat.

Archipelago Marine Research is working alongside ISSF, and has outfitted a Spanish tuna fishing vessel as a test case. A video-based electronic monitoring system uses an array of sensors to monitor key fishing gear and to trigger video cameras when it detects fishing activity. A central control center manages the system and logs the data, along with vessel location, speed, and heading information provided by the system's GPS receiver. The system delivers hourly updates via satellite throughout the trip, and when the vessel returns to port, any portion of the logged data can be reviewed.

This new level of on-vessel monitoring helps to deal with depleted fishing stock, and places a monitor where human observers aren't a practical option. Based on feedback from this project, the system will be fine-tuned and could provide an unprecedented level of oversight to curb not only illegal fishing, but also the ecological issue of catching non-targeted species such as endangered sea turtles.

Whether we're concerned with national/human security or food security, the problem of piracy has broad implications for both economies and the environment. The complexity of the problem is underscored in Somalia, where the lack of institutions makes it very difficult to coordinate a response. Yet, geospatial technologies play a key role in detection and mitigation, and with technological advancement and improved coordination, we can curtail the costs and decrease harm.

**RESOURCES**


- Oceans Beyond Piracy, a project of One Earth Future, www.oneearthfuture.org, *Economic Cost of Somali Piracy 2011 Report*, www.oceansbeyondpiracy.org/sites/default/files/economic_cost_of_piracy_2011.pdf
- BBC News, *Piracy Crisis Series*, Jan. 2011, www.bbc.co.uk/news/world-africa-11813168
- International Seafood Sustainability Foundation (ISSF), www.iss-foundation.org
- GeoEye SeaStar Service, www.geoeye.com/CorpSite/products-and-services/information-services/marine-services/seastar-fisheries-information-service.aspx
- GeoEye Vessel Monitoring Service, www.geoeye.com/CorpSite/products-and-services/information-services/marine-services/vessel-monitoring-service.aspx
- Astrium's TerraSAR-X, Ship Surveillance with TerraSAR-X Scansar, http://sss.terrasar-x.dlr.de/papers_sci_meet_3/paper/OCE0105_gabban.pdf.
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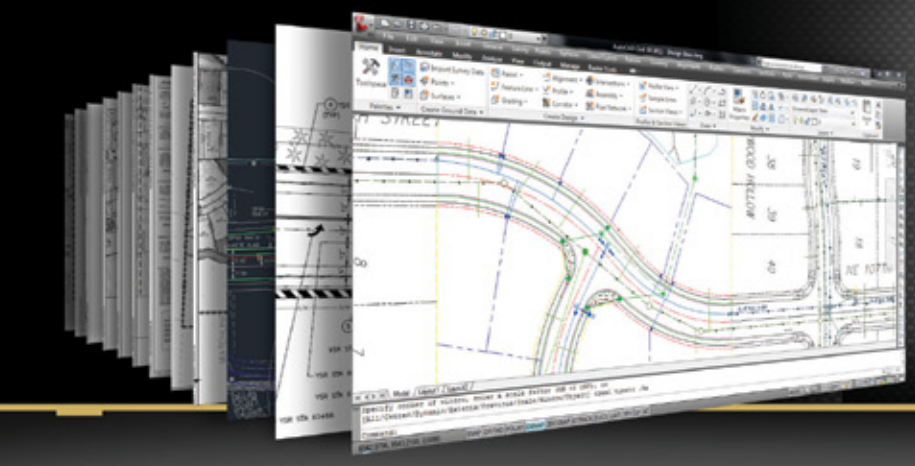

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## DIGITALGLOBE'S ANALYSIS CENTER

**In a crisis,** every second counts. Lives can be lost if decision makers cannot react to a situation fast enough. Up-to-date information is the most important factor in preventing loss of life. Whether the disaster is natural or man-made, geospatial intelligence can play a critical role in the effective management of on-the-ground personnel. To fill the spatial and logistical voids often associated with disasters, DigitalGlobe launched the Analysis Center one year ago.

**Q.** *What inspired DigitalGlobe to form the Analysis Center?*

**A.** Based on the feedback from our long-standing customers, we realized many wanted more than just images – they wanted answers. Our customers wanted to know what they could do with the imagery and what valuable information it could provide. DigitalGlobe's Analysis Center provided the answers to their questions. We looked directly inside DigitalGlobe to find the right people to help end users and customers and formed a team of research analysts, geospatial experts and image analysis experts. The


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◀ **FIGURE 4.** *The port of Sendai, Japan image shows rebuilding after the tsunami. It was taken Feb. 11, 2012.*

selected experts had significant domain experience in the industries we serve and a deep understanding of DigitalGlobe's systems from collection to production to imagery exploitation and analysis.

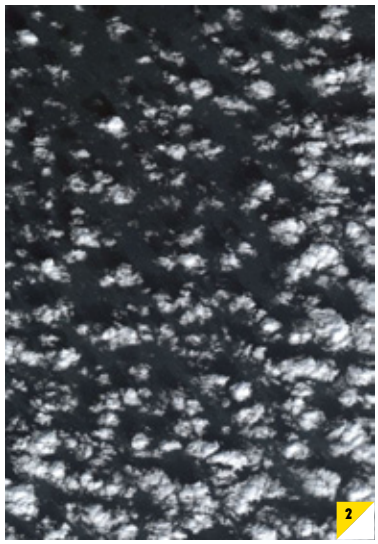
**Q.** *How does the Analysis Center assist disaster relief?*

**A.** A picture may be worth a thousand words, but in the hands of an expert analyst, who can provide context and insight, it can be worth vastly more. Many assume that DigitalGlobe and other satellite providers have automated tools to search through the massive number of images taken each day by satellites circling the Earth. But that's not the case. The search still comes down to the people – the analysts (who are enabled by software and GIS tools) sifting through images daily to identify what's most important. With direct access to DigitalGlobe's satellite constellation and with the ability to exploit the growing global data in our ImageLibrary, the Analysis Center experts help leaders, decision makers, investors, media and the general public to see the full picture.

DigitalGlobe's rapid delivery and analysis of high-resolution imagery has supported first responders in evacuation planning, disaster response and recovery, and restoration efforts worldwide. Our near real-time monitoring capabilities help governments, rescue workers, and international decision makers better understand and manage natural disasters and crucial political situations. The Analysis Center helps our customers quickly respond to disasters by assessing the damage and deciding where rescue teams should be sent.

**Q.** *How has the Analysis Center progressed over the past year?*

**A.** The Analysis Center was officially opened in January 2011. Over the past year, our analysts have discovered unique images of the Chinese aircraft carrier Varyag at sea (see ***Figures 1-2***), the Costa Concordia shortly after the Italian cruise ship ran aground (see ***Figure 3***), the Arab Spring protests in Egypt and the Fukushima Daiichi nuclear power plant disaster in Japan. For every crisis situation and new discovery, DigitalGlobe's analysts have dedicated long hours, and even nights, to examining the magnitude, severity and scope of each event. Before the Analysis Center was officially developed, the analysis was being done more informally across multiple departments. Our experienced analysts now have a central hub and dedicated resource base to assess critical situations strategically.



Here at DigitalGlobe, we know firsthand the incredible impact that satellite images have in the aftermath of a natural disaster. In many instances, such as the tragedy in Japan or the recent uprising in Syria, satellite images can often be the only way to see and understand immediately the full scope of what's happening on the ground.

**Q.** *In addition to DigitalGlobe's constellation of satellites, what other resources do your analysts have to discover vital images?*

**A.** DigitalGlobe has committed to providing the most current information available by recently launching an analytic offering – FirstWatch.

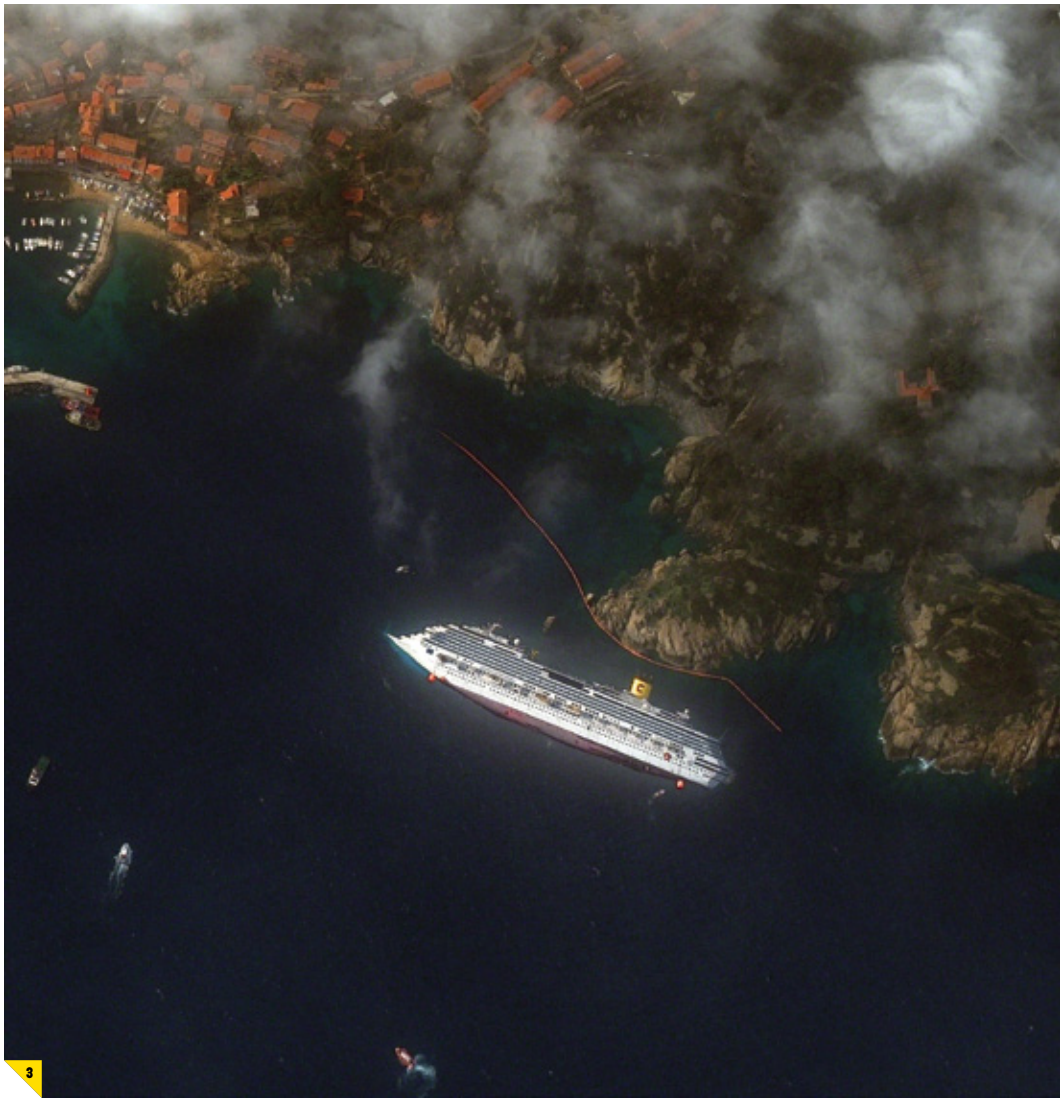
While the foundation of our offerings is derived from our core assets – our satellites – we often begin the analytic process by searching, mining and integrating open source data. Through careful and skilled research, we are able to focus our time and analysis on the areas that are most important. With the explosion of unclassified, open source content and social media, we are finding that our imagery data combined with other data enables us to provide our customers with a more complete understanding of events and issues around the world.

In the event of a disaster, up-to-date images are matched with archived images from the DigitalGlobe ImageLibrary, which is the largest in the world and dates back to 2002. Our analysts compare the current imagery with previous historical imagery, using professional imagery exploitation and GIS software tools. These comparisons allow analysts quickly to understand the extent and specifics of damage on the ground. This analysis is then published into a comprehensive DigitalGlobe FirstWatch report within hours after the event occurs.

The wide range of information included in a FirstWatch report is critical in assessing the scope and magnitude of an event. A FirstWatch report is most valuable for providing

◀ **FIGURES 1-2.** *Images show the Chinese aircraft carrier Varyag ship at sea on Dec. 8, 2011, and the corresponding wider zoomed version that shows the clouds over the ocean. This shows the power of the analysts who were able to pick the Varyag ship out of the clouds.*

▼ **FIGURE 3.** *This image of the Costa Concordia cruise ship off the coast of Italy was taken Jan. 19, 2012.*



vital details that are visible only from a satellite view. The human element in the FirstWatch service is what sets it apart, as DigitalGlobe analysts often are able to identify parts of pictures that untrained recipients of the imagery can't locate. Details included in a report can include evidence of structural damage, infrastructure failures, changes to topography, flood water depth, and other potentially life-threatening elements. With the necessary insight into the situation, decision makers are freed up to begin formulating the most effective response plan.

**Q.** *What led to the development of DigitalGlobe's new analytical offering, FirstWatch?*

**A.** The development of our FirstWatch offering stemmed from customers' requests and needs. Customers in crisis situations needed to know how to get to the affected area to help save lives and start rebuilding. Imagery is a starting point, but what our customers really needed were the answers, which FirstWatch helps provide. We also found that many new non-traditional customers lacked their own in-house imagery analysis capability, and needed to search through the imagery and understand the significance of the crisis. In 2011 alone, DigitalGlobe produced more than 50 FirstWatch reports for events worldwide.

One of the most notable series of FirstWatch reports was that produced following the aftermath of the earthquake and tsunami in Japan in early

▶ **FIGURES 5.** *Fukushima image was taken Feb. 2, 2012, showing the rebuilding occurring in that area of Japan.*


6

2011. During this crisis, DigitalGlobe satellites constantly monitored the area for ten consecutive days and captured the explosions and failures at the nuclear facility, the state of the country's highways, and the damage at major infrastructure like the airport and sea port at Sendai, Japan. See ***Figures 4-5*** on pages 28 and 32. DigitalGlobe's FirstWatch report allowed users to visualize rapidly the destruction on a street-by-street basis and to enact targeted response and recovery plans for rescue, humanitarian aid and rebuilding.

**Q.** *When sorting through thousands of images, how do your analysts know where to focus their time?*

**A.** With our years of experience, our analysts observe historical trends, sift through volumes of news and open source reports and examine current events to decide which images are the most noteworthy, such as the Chinese aircraft carrier Varyag taking its first test run in the Yellow Sea, images of the Syrian uprising when no western journalists are able to get into the country (see ***Figures 6-7***), and updated imagery to the Japan disaster from Spring 2011.

For example, for the last 10 years, we've captured images and followed the progress of Varyag. Last year, we combined our images with open source, publically available unclassified research to anticipate when the sea trials were coming. From our research and due to our agile satellite constellation, we were able to determine the best collection plan to implement to narrow down the search for the carrier. The ultimate image came down to human intuition and diligence to look through the cloudy image to spot the Varyag on its initial sea trial. The human aspect in the Analysis Center is the key to DigitalGlobe's offering.

DigitalGlobe's team of analysts applied the same principles to other disasters in Japan, Syria, and other trouble spots. By understanding the magnitude of the events and cross-referencing with what's already available in the ImageLibrary, our experts ensure we're collecting the right zones. The open source, publically available analysis and ground photos combined


▲ **FIGURES 6-7.** *Images from Homs, Syria show smoke and craters (taken Feb. 25, 2012), and various areas of Homs during a pipeline fire (Feb. 15, 2012).*

with the equipment to cross-reference with satellite images help the analysts sort through our collection of images.

**Q.** *What other industries can benefit from the Analysis Center?*

**A.** DigitalGlobe's Analysis Center isn't engaged only in times of crisis. Satellite mapping and imaging play vital roles in preserving important historical sites, conserving natural resources and helping governments in developing countries create food and water sustainability. Our experts can assist several other industries beyond government disaster relief, such as the oil, gas and insurance industries, to determine oil inventory and monitor insured assets.

Just recently, DigitalGlobe delivered high-resolution satellite imagery of significant heritage sites for the Global Heritage Network (www.globalheritagefund.org/gh_network), an early warning monitoring system for endangered cultural sites. In addition, we are currently monitoring 16 glaciers for Extreme Ice Survey (www.extremeicesurvey.org), and we have been working with the Jane Goodall Institute (www.janegoodall.org) for several years, providing satellite imagery of areas in Tanzania, Uganda and Congo in order for them to make effective conservation decisions.

Many of the current members in the Analysis Center previously worked on these longstanding projects and are able now to work closely with them to understand what they need, how they need it delivered and what type of information DigitalGlobe can extract from the images. Our experienced analysts have the knowledge to interface with DigitalGlobe's systems and processes to better serve the customer.

These customers may not be as high-profile as the government, but they share very similar needs. Ultimately, they need analyses of before and after images to build a strategy, and DigitalGlobe's Analysis Center helps fill those needs.

**Q.** *How do you see the Analysis Center developing over the next few years?*

**A.** Analysis is part of DigitalGlobe's vision for the fourth "era" of the commercial satellite industry. For government customers, the need for rapid and accurate analysis of imagery is becoming as important as the imagery itself.

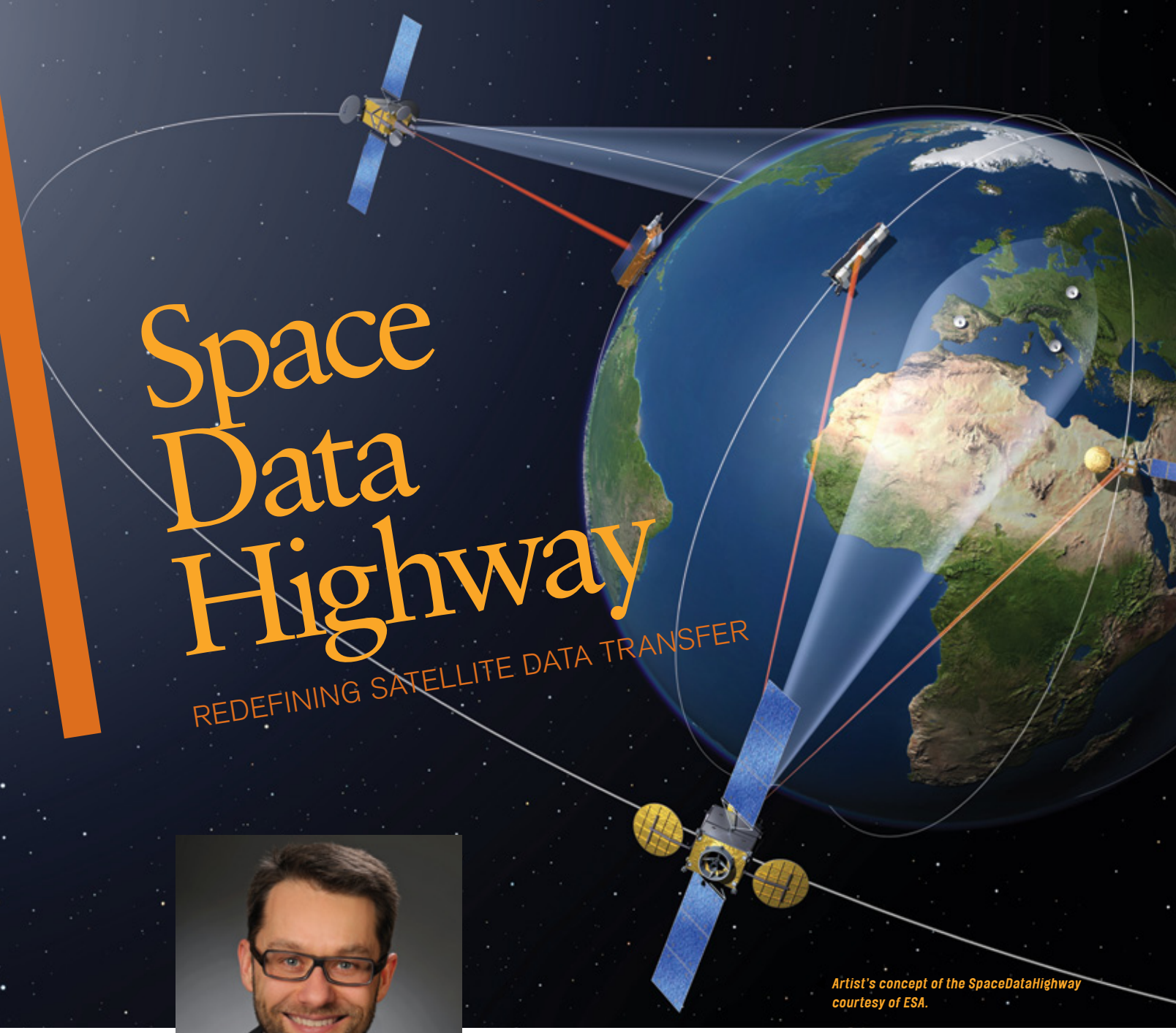
Another important component of the effective use of imagery is cloud services. This solution of cloud services is especially valuable to government agencies and humanitarian organizations that are responding in a crisis situation. We predict that in the next couple of years, there will be a growing demand for delivery options to store, manage and disseminate data. Our customers across several industries want to use and integrate the full extent of our current and historic imagery content with the power of our cloud services, without having to buy and manage additional data storage services. Real-time information and the knowledge of former trends are essential in developing a unified strategy.

DigitalGlobe's Analysis Center will continue to focus on and to analyze what's most important – changes that help our customers save lives, resources, and time. We keep a constant eye on the world to help our customers gain an early insight into the business, military, environmental, and political changes that impact people around the world.

Going forward, it is clear that the insight derived from imagery will become more important than just the pixels themselves. The insight provided by a partner in the sky can make an important difference in evacuation planning, disaster response, recovery, and rebuilding in regions worldwide. DigitalGlobe's Analysis Center has the newest tools and the right people, which decision makers need in their rapidly advancing toolboxes to face the challenges of our rapidly changing world.

# Space Data Highway

## REDEFINING SATELLITE DATA TRANSFER



*Artist's concept of the SpaceDataHighway courtesy of ESA.*



**AKOS HEGYI**
Head of EDRS Services
Astrium Services
Munich, Germany
www.edrs-SpaceDataHighway.com

### Today's Data Transfer Challenges

Recent years have brought unprecedented development in satellite-based Earth observation (EO): a rising number of operational satellites, together with the enhanced resolution of acquired imagery, have resulted in a dramatic increase of data generated in space. Additionally, improved and novel applications (particularly in the fields of emergency services, security applications and rapid monitoring) require rapid tasking capabilities and shorter data delivery times. These developments are stretching the capabilities of current and future EO systems, particularly in regard to the performance of the ground segment in charge of retrieving the data.

Satellite operators today frequently rely on a network of polar and temperate ground stations to ensure coverage and latency for their missions. However, such networks are costly and complex, and require extensive terrestrial networks for data repatriation and distribution. With the number of satellites in Low Earth Orbit (LEO) continuously growing, the capacity, particularly of the polar ground stations (which provide the most access time to polar-orbiting satellites) is increasingly stretched, leading to potential data transmission interference when several satellites are passing over the station at the same time. Moreover, the ground station networks require the satellite operators to route the data over foreign territory, which can be an issue for some users.

In addition to these ground networks, a number of national data relay assets have been implemented and operated in various countries. These are, however, often overloaded, many are dated, and service continuity is at the moment not secured beyond the lifetime of the current systems.

## Providing Data at the Right Time at the Right Place

To address these challenges, Astrium Services is implementing the SpaceDataHighway,[1] the most advanced high-performance alternative for data transfer. The SpaceDataHighway fills a service gap for data relay capacities that is apparent to satellite operators already today and will become even more important in the future.

## The SpaceDataHighway provides:

**RAPID TASKING:** With the SpaceDataHighway, satellite operators are able to stay in contact with their satellites for all orbits and for longer times during each orbit. This enables them to re-program their space assets in almost real time in case of time-critical or unforeseen data requirements, resulting in significantly improved reactivity and flexibility of satellite missions.

**NEAR REAL-TIME DATA:** The SpaceDataHighway enables immediate broadband data transfer to the ground, reducing the delivery time of acquired data from several hours to just a few minutes.

**LARGE DATA VOLUME:** The state-of-the-art laser communication technology on board the SpaceDataHighway facilitates data transmission at an unprecedented data rate of up to 1.8 gigabits per second. Combining this high-speed data transfer and the increased contact time results in a data transmission capacity of at least 50 terabits per day shared among all SpaceDataHighway users.

**EFFECTIVE GROUND OPERATIONS:** Routing the data through the SpaceDataHighway infrastructure reduces the need for an extensive ground station network. Moreover, data can be easily transferred to the users' own archiving or processing facilities anywhere in the world.

**SECURE AND TRUSTED INFRASTRUCTURE:** With the SpaceDataHighway, satellite operators can avoid sovereignty issues connected with routing data through foreign territory or infrastructure. The high availability and redundancy of the system, as well as the future system extensions, provide a safe and future-proof data transmission infrastructure.

## Moving from Mapping to Monitoring

By providing unparalleled data transmission, the SpaceDataHighway has the potential to enhance a wide range of time-critical applications:

**HUMANITARIAN ORGANIZATIONS AND CRISIS INTERVENTION TEAMS** will benefit from timely provision of EO data over disaster areas, helping them to manage and coordinate rescue activities more efficiently and ultimately to save human lives.

**MILITARY AND SECURITY OPERATIONS** will benefit from timely and substantiated ground knowledge to plan and conduct missions more effectively and safely and to enable the people in charge to react rapidly to new developments on the ground.

**MARITIME SURVEILLANCE AND SHIP DETECTION** governing bodies, public authorities and international organizations will benefit from timeliness of data provision. Near real-time delivery of vast quantities of data will support these users in monitoring their areas of interest and will enhance maritime domain awareness.

**AUTHORITIES AND ORGANIZATIONS IN CHARGE OF MANAGING AND PROTECTING OUR ENVIRONMENT** and the environmental impact of human activities will be able to observe developments and changes over large areas in a more timely and effective manner. The SpaceDataHighway will provide them with EO data for wide-area monitoring of our natural resources, facilitating the timely identification of hotspots (e.g. illegal logging, water pollution) even in remote areas and providing substantiated information for the implementation of recovery actions.

Ultimately, the SpaceDataHighway supports a paradigm shift from the current quasi-static observation mode of operation to a much more dynamic real-time monitoring and surveillance of the earth.

*With the number of satellites in Low Earth Orbit continuously growing, the capacity, particularly of the polar ground stations (which provide the most access time to polar-orbiting satellites) is increasingly stretched, leading to potential data transmission interference when several satellites are passing over the station at the same time.*

## Novel Technology Solution

The SpaceDataHighway uses geostationary satellites to provide two-way broadband data relay services among LEO satellites, spacecraft or UAVs and fixed ground stations.

Key System Features:

- Bi-directional data transfer between EO satellites and ground stations:
  - Downlink of data from the LEO satellite / spacecraft / UAVs to the ground
  - Transfer of tasking messages between the ground and the spacecraft
- Optical laser inter-satellite link (ISL) technology with up to 1.8 Gbps relay capabilities
- Radiofrequency ISL with up to 300 Mbps relay capability
- Scalability of solution for both forward and return links

The novel Laser Communication Terminal (LCT) that enables the high-speed, high-volume data transfer has been developed by the Astrium subsidiary TESAT. This innovative piece of equipment has already been successfully tested during in-orbit verification between the German radar satellite TerraSAR-X and the American NFIRE satellite.

Operations of the system commence with the launch of the first payload embarked on-board a commercial telecommunication satellite at the end of 2014. The system will then be enhanced with a second, dedicated satellite in 2015, providing an increased field of coverage and system redundancy. These two parts will form the initial core space infrastructure of the SpaceDataHighway, providing direct coverage for LEO satellites flying over Europe, the Middle East, Africa, the Americas, Asia and the Poles. The enhancement of the system with further spacecraft is already under planning, affording complete coverage of the earth and providing long-term system redundancy.

## A Landmark Partnership

The SpaceDataHighway is developed and implemented within the EDRS Public Private Partnership program between the European Space Agency (ESA) and Astrium Services. As Prime Program Manager, Astrium builds, owns, operates and co-finances the system's infrastructure; Astrium also implements and provides the data transmission services to ESA and customers worldwide.

ESA funds the infrastructure development and is the anchor customer through the Sentinel satellite missions. The SpaceDataHighway provides data relay services for the Sentinel satellites within the European initiative Global Monitoring for Environment and Security (GMES), facilitating a rapid downlink of large volumes of imagery.

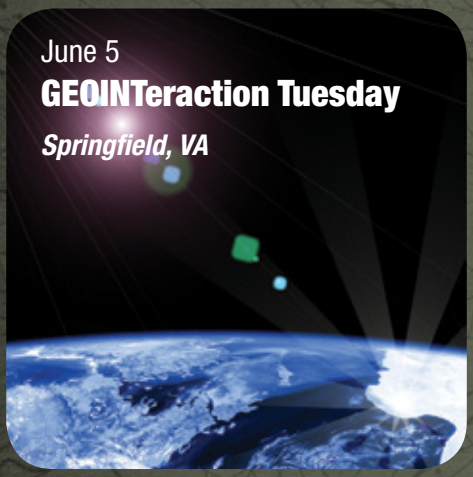
Astrium Services is in a unique position to implement and operate this revolutionary service, as the company can capitalize on its extensive expertise as operator of Earth Observation and telecom satellites, and as provider of Earth Observation and telecom satellite services.

**FOOTNOTE 1:** EDRS (European Data Relay System) - the SpaceDataHighway is developed and implemented within a Public Private Partnership between the European Space Agency and Astrium Services. Astrium holds the exclusive rights to sell data relay services to customers worldwide. See www.edrs-spacedatahighway.com.

USGIF
United States Geospatial Intelligence Foundation

June 4
**USGIF Workshop Series**
*Hyatt Regency Reston, Reston, VA*

June 5
**GEOINTeraction Tuesday**
*Springfield, VA*



# 2012 GEOINT COMMUNITY WEEK

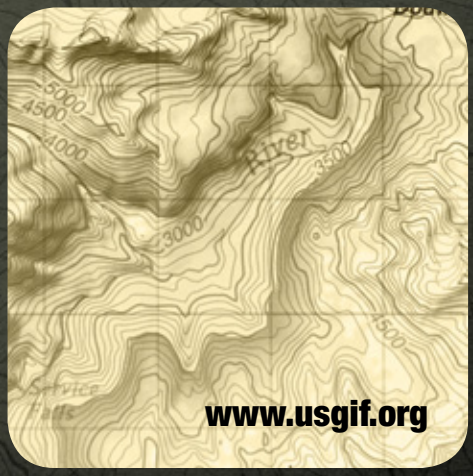
June 4-8
Northern Virginia

June 6
**NGA Tech Showcase East**
(TS//SI/TK)
*NGA Campus East, Springfield, VA*

**Held annually in the *Northern Virginia* area, GEOINT Community Week brings together members from the defense, intelligence and homeland security communities, for a week of networking, classified briefings, technology exhibits and learning workshops.**

June 7
**USGIF Technology Day**
*Hyatt Regency Reston, Reston, VA*

June 8
**USGIF Invitational**
*1757 Golf Club, Dulles, VA*




**www.usgif.org**

# LOCATION-BASED SERVICES

Whether it's navigation, fleet management, online mapping, or telecommunications, DigitalGlobe's high-resolution world imagery is at the core of many LBS applications. Transformed from a simplified, flat experience into a window on the world, users can now explore, plan, and navigate with the confidence that only comes from a real world view.

RICH MAPPING LAYER

ALIGNED TO YOUR BUSINESS MODEL

NO ADDITIONAL DATA MAINTENANCE COST

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