

A P O G E O

S P A T I A L

ELEVATING GLOBAL AWARENESS

NGA Seeks
Commercial Solutions p. 18
Josh Hartman

Astrium's
WorldDEM p. 36
Gertrud Riegler

New CEO
of TerraGo p. 24
Chris Broderick

The Age of Disruption

→ SPECIAL REPORT

TOP 10 MARKET DISRUPTORS

by **Sensors & Systems** p. 22

Small Satellites p. 26, 32

UAVs p. 10

Colorado Flooding p. 2

FORMERLY

Imaging
NOTES

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LMA
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“Surrey believes the constellation is fundamentally changing the economics of space.”

– Dr. John Paffett, CEO, Surrey Satellite Technology, U.S. p. 32

“The age of disruption provides a means of great opportunity, but also holds the potential to undermine the business plans of big players.”

– Matt Ball, Editor, *Sensors & Systems* p. 22

Aral Sea image taken by UK-DMC2, which is a small sat. Courtesy of DMCii. See details on page 6.



The Historic 2013 Colorado Floods

The Town of Lyons, Colorado

North St. Vrain Creek

Considerable flooding in area of confluence
of North and South St. Vrain Creeks

State Highway 7

South St. Vrain Creek

This image of Lyons, Colorado, was taken during the historic floods on Sept. 14, 2013. Visible is U.S. Highway 36 from the bottom right, going north. At the dead end, following the highway left is the center of the Town of Lyons. The dark brown color is water standing among the green of the trees. Lyons is known for the live music venue Oskar Blues, where the beer company of the same name was founded, and for their bluegrass and folk music scene, in particular the spectacular outdoor venue, Planet Bluegrass, which was damaged in the flood, as was most of the town. Image is a Natural Color Image. Courtesy of DigitalGlobe Analysis Center.

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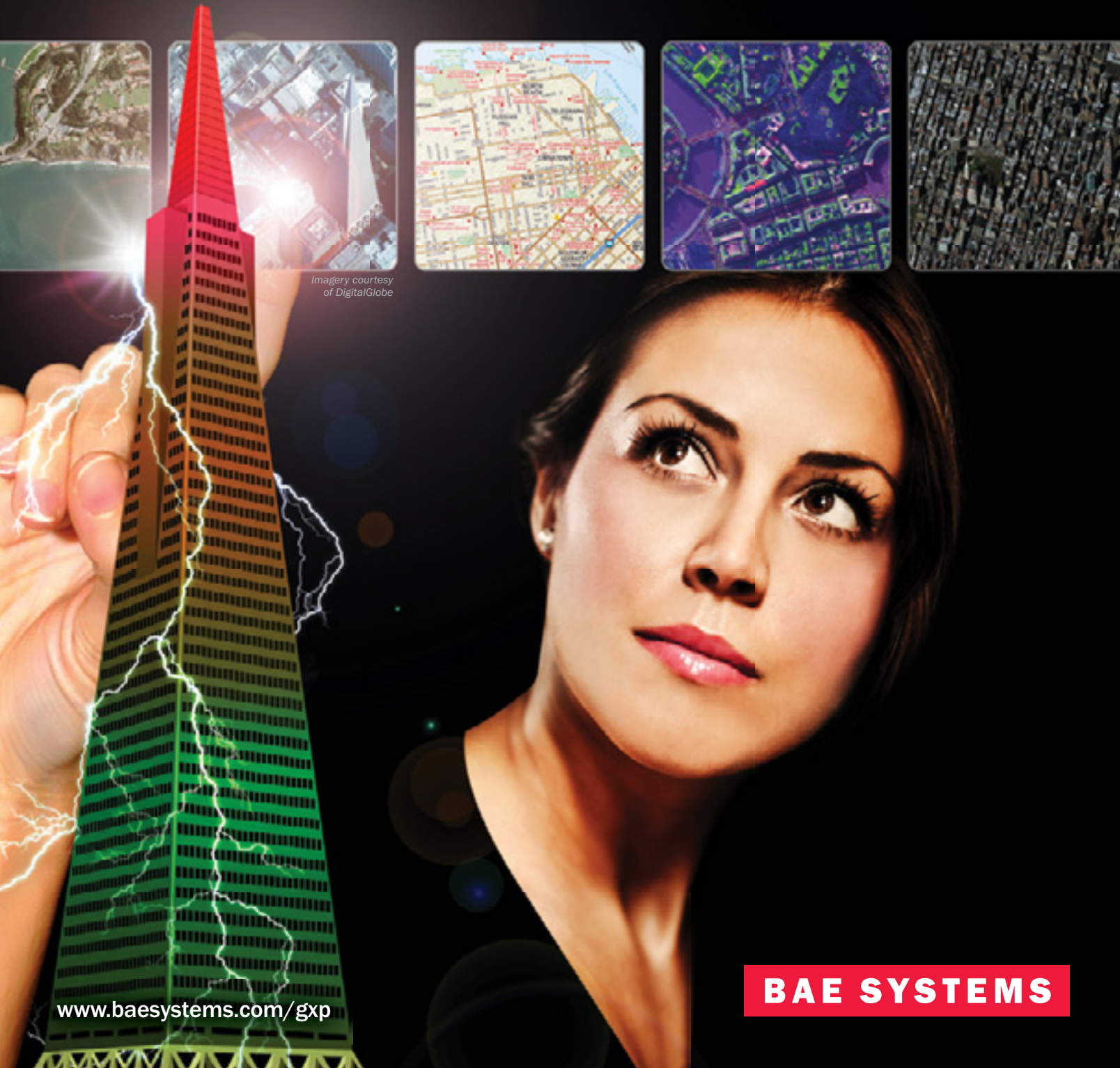
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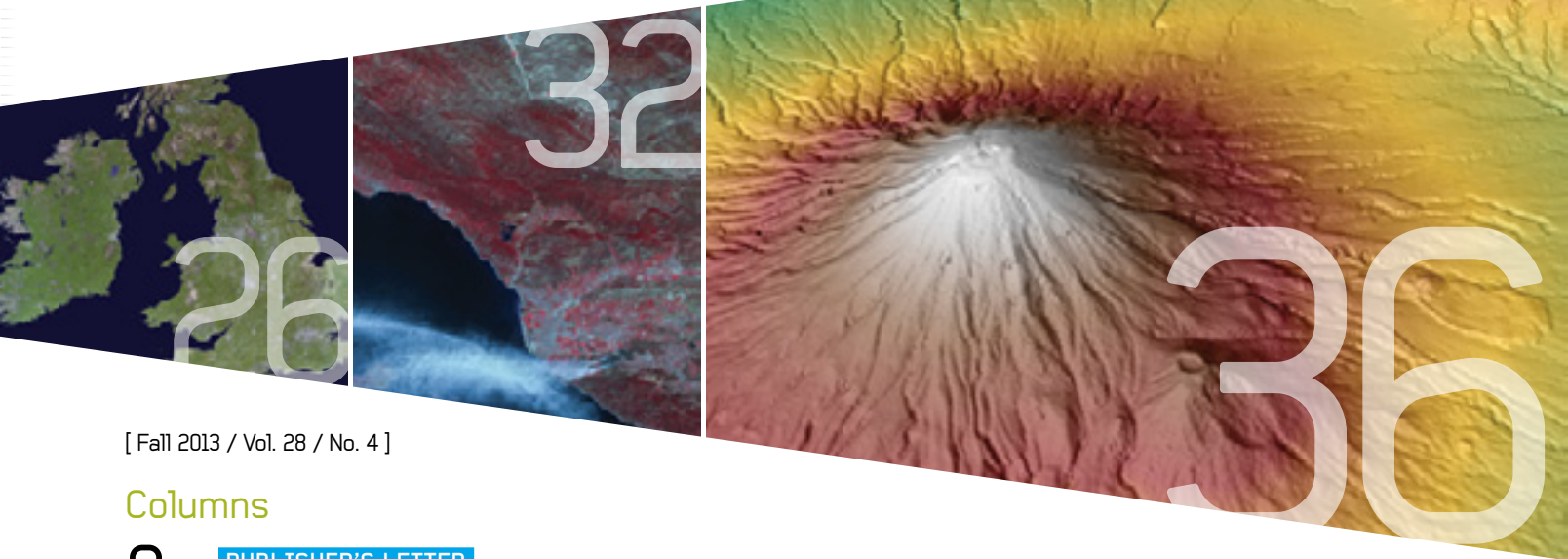
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[Fall 2013 / Vol. 28 / No. 4]

Columns

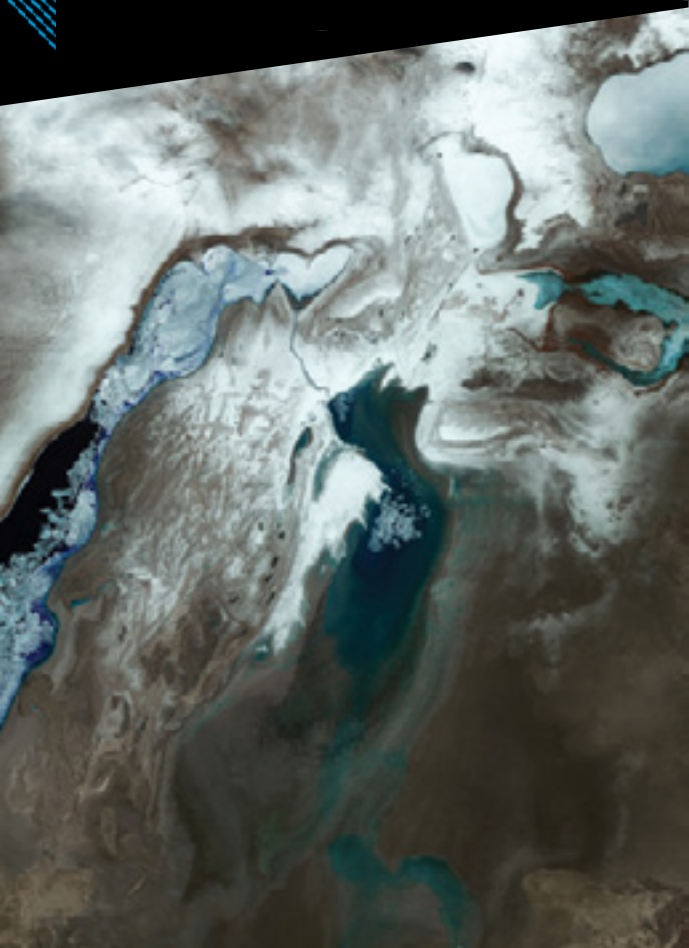
- 9** **PUBLISHER'S LETTER**
The Age of Disruption
By Myrna James Yoo
- 10** **SECURE WORLD FOUNDATION FORUM**
UAS for Good
By Tiffany Chow
- 14** **ON THE EDGE**
Uncontrolled Experiment
or Planetary Accident?
CIVILIZATION AS AN
EXTINCTION-CLASS EVENT
By Hans-Peter Plag, PhD
- 18** Reshaping the GEOINT
Community
TAPPING INTO THE COMMERCIAL
MARKETPLACE
By Joshua Hartman, Horizon Strategies Group

Departments

- 16** **LBX JOURNAL NEWS**
Location News from
SAP, Nokia's Here
Platform and more
- 17** **SENSORS & SYSTEMS NEWS**
Geospatial News from
Trimble, NJVC, USGS,
NCAR and more

Features

- 22** **SENSORS & SYSTEMS**
Top 10 List of
Disruptors
TO GEOSPATIAL
BUSINESS MODELS
By Matt Ball, Editor, *Sensors & Systems*
- 24** **SENSORS & SYSTEMS**
Chris Broderick
CEO OF TERRAGO
Executive Interview
- 26** The Small Sat Revolution
MORE EO AT LOWER COST
By Matt Ball, Editor, *Sensors & Systems*
- 32** Changing the
Economics of Space
SURREY SATELLITE OFFERS
MORE OPTIONS
By Kevin Corbley, Consultant
- 36** Elevating Information
WorldDEM GETS READY
by Gertrud Riegler, Astrium Services



Aral Sea

THIS IMAGE IS of the partially frozen Aral Sea, which lies between Kazakhstan and Uzbekistan and is often of interest due to its decrease in size from the 1960s. The cover image was taken March 21, 2012 by UK-DMC2, which is owned and marketed by DMCii (Disaster Monitoring Constellation International Imaging).

This issue focuses on the Age of Disruption that we are experiencing in the geospatial industry, which includes the rise of small sats, such as those built and launched by Surrey Satellite Technologies, which are then owned and marketed by DMCii and other organizations. Their unique business model is covered on page 32.

Other small and micro sat companies are covered on page 26.

Our Top 10 List of Disruptors is on page 22, and other articles are included throughout this issue. ▲○

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[Fall 2013 / Vol. 28 / No. 4]

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STAFF

Publisher/Managing Editor	MYRNA JAMES YOO myrna@apogeospatial.com
Editor	RAY A. WILLIAMSON, PhD
Contributing Writers	LEONARD DAVID MATTEO LUCCIO
Creative Director	ANDREW STERNARD www.andrewsternard.com

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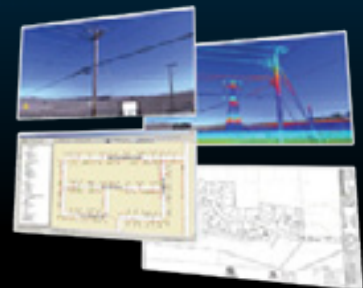
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The Age of Disruption

DEAR READERS,

What an incredible time we live in! The multiplication of technology disruptions that are taking place in the geospatial industry is quite remarkable. As a dynamic technology niche that combines hardware, software and sensors, there is rarely a dull moment, but the sheer number of disruptive technologies and policy forces at the moment has to be at a record high. This brings both excitement for the future as well as some trepidation that business models are needing to be drastically rewritten.

This issue focuses on several disruptors to the way the geospatial industry has traditionally done business, from the NGA seeking solutions from non-traditional companies (on page 18) to small sats offering significantly less expensive options for countries around the world to have access to Earth imagery (on pages 26 and 32).



A Top Ten List of Disruptors appears on page 22. One of these is wearable computing, or “wearables,” such as Google GLASS, which I am wearing in the photo above, and for which the release date has been moved to 2014.

The pending disruption of Unmanned Aerial Systems (UAS, or vehicles, as UAVs) may be the most dramatic. UAS represent a significant improvement in efficiency of aerial collection and monitoring, and yet they’re still caught in limbo in the United States while in other countries, companies can gain a leap of practical application experience with little restriction. The technology appears to be moving forward rapidly in research circles, and the use cases are building up; it’s going to be a chaotic and exciting time when FAA restrictions fall and interesting and impactful

applications begin to proliferate.

This July, the FAA gave permission to ConocoPhillips to use UAS in Alaska. This is the first time a private company has received permission to fly UAS in America for non-experimental purposes. It is perplexing that this permission was given only to one private company.

The recent Colorado floods saw an interesting and potentially game-changing use of UAS technology. Falcon UAV flew areas of high water in Longmont, Colo., providing a service that would have been impossible by satellite because of cloud cover, and very difficult for manned aircraft due to emergency air rescue activity. Very quickly, Falcon UAV’s fixed-wing craft collected details of the flood impact and extent, as well as a reliable high-resolution record of the quickly-changing conditions on ground. See <http://bit.ly/16AsxMu>. The company was shut down by FEMA before they

were able to capture some of the more dramatic damage up the road in Lyons, Colo. (We include a satellite image of Lyons from DigitalGlobe on page 2.)

While it’s understandable that there should be tight control of airspace in a disaster zone, it also seems that an

opportunity was missed where the technology could have filled an important gap in disaster management and damage assessment. The Secure World Foundation Forum addresses the opportunity of “using UAS for good” on page 10.

For more articles on The Age of Disruption, please see the other publications of the Location Media Alliance: *Sensors & Systems* (www.sensorsandsystems.com), *Informed Infrastructure* (www.informedinfrastructure.com), *LBx Journal* (www.lbxjournal.com), and *Asian Surveying and Mapping* (www.asmmag.com).

Please let us know how we can better serve you.

Sincerely,

Myrna James Yoo

myrna@apogeospatial.com



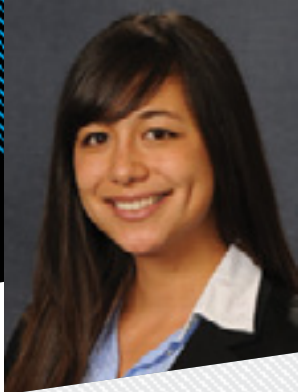
Myrna James Yoo

Publisher and
Managing Editor
Apogeo Spatial
(formerly *Imaging Notes*)
and *LBx Journal*

Co-founder
Location Media Alliance

Owner
BlueLine Publishing LLC

◀ The Colorado APEX Technology Conference in September 2013 brought together Scott Wyatt, CEO of Advantage Integrated Solutions; Myrna James Yoo, Publisher of *Apogeo Spatial*, wearing Google GLASS; Dianna Herbst of Critigen; and Rob Rusher, CEO of On3, Inc., a developer of apps for Google GLASS.



Tiffany Chow

Project Manager
Secure World Foundation
Broomfield, Colo.
www.swfound.org

UAS for Good

PUBLIC IMAGE MAKEOVER

UNMANNED AERIAL SYSTEMS (UAS) SUFFER from a public image problem these days. Between reports of U.S. drone attacks killing Pakistani civilians¹ and the FBI spying on U.S. citizens with drones,² it is easy to overlook the vast array of UAS-enabled applications for positive impact. Today, UAS are being used to help fight wildfires, to monitor soil moisture for more efficient farming and flash flood warnings, and to improve search and rescue operations.

Despite what is typically portrayed in the mainstream media, UAS are currently being used for a wide variety of civilian purposes and more applications seem to be discovered or invented all the time. The potential for UAS to provide geo-spatial tools for building a more sustainable world seem endless. In this issue, we highlight some of the companies focusing on these “UAS for good” services and the challenges they face, which include the regulatory sphere as well as fighting the negative image of “drones.”

Black Swift Technologies is all about building UAS for the everyday user. Their business focuses on intuitive, user-friendly, automated systems that can collect data for a wide range of end users, be they farmers or firefighters. Founded in 2011 by three University of Colorado PhD students, Black Swift has developed rapidly.

The company can now boast about a

recently-secured NASA contract for developing an unmanned aircraft to map soil moisture, which will be the first of its kind. This project will build off of a NASA prototype used to assist evacuations during the flash floods that devastated Texas a few years ago. That prototype weighed hundreds of pounds; understandably it was not a system that was easy to use or fly, but Black Swift intends to change that. Together with their partners at CU's Center for Environmental Technology (CUCET), Black Swift has developed a one to two pound version of the sensor and expects the system to be commercially marketable in two years. Not only will this system be able to make flash flood evacuations more efficient, which will be so valuable in situations like the recent Colorado floods, but it could also be used for a range of agricultural applications, improving farming practices anywhere.

What makes Black Swift Technologies particularly exciting is that they intend to offer these types of UAS to the average, everyday user. Their customers will need very little, if any, training to operate Black Swift UAS. As a result, they should be able to collect data easily and affordably, improving and even saving lives.

Editor's Note:

A future issue will provide an update on privacy issues raised in part by UAS civilian use.

Footnotes:

1. <http://www.nationalturk.com/en/400-civilians-killed-in-us-drone-strikes-in-pakistan-in-9-yrs-42079>
2. <http://www.csmonitor.com/USA/Politics/2013/0619/FBI-uses-drones-on-US-soil-Senators-want-assurances-on-privacy-video>

The Black Swift system takes off autonomously and lands itself. Some can even fit into a briefcase. This will make the Black Swift system optimal for use in high-stress and time-sensitive scenarios such as fighting wildfires or in search and rescue operations. In fact, the founders of the company are particularly passionate about this application. As avid backcountry skiers and hikers, they were fundamentally motivated by the potential for UAS to improve search and rescue efforts dramatically.

Black Swift Technologies is not the only company currently examining the potential for drones to improve lives and benefit people in everyday life. Rocketship Systems is in the business of building user-defined, customized “robots that fly” for all applications except armed robotics. This was both a philosophical and business decision. Rocketship Systems believes that the future and value of UAS truly lies in these human and environmental security applications, not in the military or wartime purposes they serve so frequently today.

Rocketship’s contribution to the future of UAS lies in creating small, user-driven designs. Counterintuitively, Rocketship Systems plans to provide customers with tailored systems that are more affordable than any mass-produced option available. For Rocketship Systems, the negative image associated with UAS is an educational issue. An important conversation needs to take place in the public sphere in the United States about the many civilian applications and

In Europe, companies like the Swiss-based senseFly have designed and are manufacturing lightweight drones for civilian applications such as two-dimensional orthomosaics and three-dimensional elevation models that plug easily into GIS or agricultural software. (This is not yet legal in the U.S.)

► FIGURE 1.
This image was created to demonstrate the meteorological utility of UAS (c) 2012 Jack Elston University of Colorado, courtesy of Black Swift Technologies.

▲ FIGURE 2.
A shot during a test flight over a cornfield. (c) 2010 Jack Elston University of Colorado, courtesy of Black Swift Technologies.





3

▲ ▼ FIGURE 3-4.
Images courtesy
of senseFly.

potential for good that drones can offer. Black Swift co-founder Brad Cheetham agrees, as UAS applications continue to benefit people. “This will speak for itself when we’re able to deploy these systems.” Unfortunately, there are some regulatory obstacles in the way of that happening.

Currently, the Federal Aviation Administration (FAA), responsible for overseeing UAS in the United States, only certifies UAS for a very restricted group of users, primarily government and academia. This severely limits the work that can be done to showcase the benefits associated with civilian UAS.

In Europe, where such regulations do not slow down civilian UAS use, companies like the Swiss-based senseFly have designed and are manufacturing lightweight drones for civilian applications such as two-dimensional orthomosaics and three-dimensional elevation models that plug easily into GIS or agricultural software. When asked about the impact that the negative image of drones has on their business, senseFly indicated that this is really a U.S.-specific problem. “More and more people understand now the social benefits of civil UAVs, especially because they are used in many countries

around the globe (Europe, Australia, South America, Canada),” said Baptiste Tripart, senseFly’s North American Sales Manager. senseFly has also been involved in and sponsors Drone Adventures, a Swiss non-profit that works to demonstrate the “many great applications of drones in conservation, cultural, humanitarian and search and rescue domains.”

Until FAA regulations are updated to facilitate greater use of UAS for civilian applications, U.S. companies like Black Swift Technologies and Rocketship Systems must find ways to work within these restrictions. Black Swift Technologies works very closely with the FAA to secure certifications for all of their flights. Rocketship Systems keeps itself in business through its Flying Foam venture that sells components and kits for primarily recreational uses. Both companies are well-positioned in Colorado, where Senator Udall is working hard on legislation to update the current laws regulating UAS. With a combination of legislative review and the entrepreneurial spirit of companies like those highlighted in this article, drones may be getting a public image makeover very soon. ▲◊



4

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Uncontrolled Experiment or Planetary Accident?

THE GLOBAL HIGH-ENERGY, GROWTH-ADDICTED CIVILIZATION IS AN “EXTINCTION-CLASS EVENT”

Prof. Hans-Peter Plag, PhD

Climate Change and Sea Level Rise Initiative

Old Dominion University

Norfolk, Va.

www.odu.edu/research/initiatives/ccslri

AT THE AMERICAN GEOPHYSICAL UNION (AGU) SCIENCE POLICY CONFERENCE held on June 24-26, 2013, in no better place than Washington, D.C., the acknowledged center of power of our global civilization, several participants pointed out that we are conducting an “uncontrolled experiment” with the planet. Language is important to connect facts to our worries, and I would like to challenge the term “uncontrolled experiment” as misleading.

We have changed the atmospheric composition; redesigned and reengineered the planet’s surface through deforestation, mining, and water regulations; polluted waters, soils, and air; reduced biodiversity dramatically; and covered the planet with a sprawling built environment that seen from airplanes or satellites has resemblance to malignant skin cancer spreading out rapidly and replacing the healthy skin of our planet. As

why the patient isn’t feeling well. I am sure, many would agree with me that we would not like to be in the care of physicians who only focus on one symptom and never seriously discuss the underlying cause: the lifestyle of the patient.

The session on potential mega disasters at the AGU conference reviewed the threats posed by solar mega storms, asteroids, tsunamis and extreme floods caused by atmospheric rivers.

“The story is that Nature isn’t natural any more... due to human impact.”

– James Balog, *Chasing Ice Documentary Film*

James Balog said at the conference in his excellent plenary feature convincingly documenting the anthropogenic changes, “Essentially, the story is that Nature isn’t natural any more ... and it is not natural due to human impact.”¹

“Global warming” is another easily misleading term that is not characterizing the scale of the event. Global warming is a symptom, not the cause. By focusing on a scientific and societal discussion of global warming, we are like physicians who are focusing solely on the temperature of the patient, without noticing the many other symptoms, and without trying to understanding

With respect to asteroids, the term “extinction-class events” was used for impacts of objects exceeding 1 km in size, and these events have recurrence periods of 50 to 100 Million years.² They are “planetary accidents” changing the biosphere and the dominant

physical processes for good. In the discussion, volcanic eruptions of the Yellowstone-class were mentioned as a similar extension-class event.

But nobody dared to term the current event of us changing the planet’s chemistry, physics and biosphere at a speed unparalleled in the past (except for the rare times of extreme volcanic eruptions and large impacts) as what it is: an extinction-class event, albeit a slow one.

Reviewing the existential threats for humanity, we end up with a list of planetary events including uncontrollable pandemics, mega volcanoes, large asteroids, a large, rapid sea level rise—a despot



making full use of today's biological and chemical means to reduce the number of fellow humans.

Floods and droughts are major threats that potentially could reach planetary extent, particularly through secondary economic and social impacts.³ The increased occurrence of large floods in recent years, sometimes simultaneously on several continents, and most recently in several areas of Colorado (see *Figures 1-2*), is illustrating this threat. A mega solar storm would impact our infrastructure on a global scale, too.⁴ Earthquakes and tsunamis frequently cause disasters that eventually could exceed the immediate coping capacity of the global economy, particularly since we have built mega cities in hazardous areas that are now ready to be harvested by natural hazards.

Those relatively frequent hazards with major impacts are on our radar screen; they cause fears and worries. The more we learn to cope with them, the less we are worried. Importantly, the more we can handle these 50-100 years events, the less we are worried about the 200+ years events. As a consequence, threats from the 500 years flood, drought, and volcano eruption are grossly underestimated and not accounted for in the disaster risk discussion. But all of this appears minor compared to the threat of climate change.

The current change in atmospheric carbon-dioxide is a 1-Million-year (or more) event and so are other changes we have inflicted on the planet as a result of our uncontrolled growth during the last few centuries. The threat associated with this very low-probability, high-impact event called "the end of humanity" only compares to the other disastrous 1-Million year and more events, just like an eruption of the Yellowstone volcano and the impact of a 1-km asteroid. In the past, these "planetary

accidents" have changed our planet and initiated new epochs in Earth's geological history.

Many of us still believe that humanity cannot impact the planet to any significant extent. For ages, we have assumed that we cannot change the basic operating conditions of Earth. Again, referring to James Balog, in a profound intellectual revolution, the idea that people can't change Earth is being overcome similar to other societally accepted "immutable truths" that were overcome just in the last 150 years, such as "slavery is necessary," "child labor is acceptable," and "women shouldn't vote."¹

Some claim that the current impact of humanity on the planet has already resulted in a new epoch: the Anthropocene. Again, language is important, and I would like to state that the Anthropocene is not a new epoch. Rather, it is the accidental transition from the Holocene to a coming post-Holocene epoch, which most likely will be very different from the Holocene. It will be different from the epoch that allowed the global human civilization to emerge. It is not clear whether it will be a state in which a global civilization can be sustained. That is the nature of an accident: you never know who will survive the event.

But let's be very clear: we are not witnessing an "uncontrolled experiment." What we are experiencing is a global "extinction-class event" caused by an increasingly powerful humanity unwilling to accept the obvious and act accordingly. ∆σ

▲ **FIGURE 1.** Image shows flooding of the Greens neighborhood and Twin Peaks Golf Course in Longmont, Colorado, from the St. Vrain River, taken Sept. 13, 2013. Image courtesy of DigitalGlobe Analysis Center.

▲ **FIGURE 2.** Flooding along the St. Vrain River, from Lyons south to Longmont, Colorado. Image taken Sept. 13, 2013, courtesy DigitalGlobe Analysis Center.

Footnotes:

1. Balog, J., 2013. See Webcast at <http://spc.agu.org/2013/live-webcast/>.
2. Johnson, L., 2013.
3. Jones, L., 2013.
4. Zanetti, L., 2013. [Mega solar storm.](#)

QUARTERLY LOCATION BUSINESS NEWS

Here are the most interesting or important articles from the Web, according to *Location SmartBrief* readers:

LOCATION ECOSYSTEM

- 1. U.S. Geospatial Industry Tallies Estimated \$73 Billion in Revenues** August 7, 2013

The U.S. geospatial industry has generated \$73 billion in revenues and saved organizations that use geospatial services around \$1.4 trillion, according to estimates from Boston Consulting Group. The industry also has created a half million high-paying jobs. Globally, the geospatial industry has generated \$274 billion in revenues, according to a separate study from Oxera. <http://bit.ly/1eJfPF6>
- 2. Analysis: Nokia's Here Platform Could Compete with Google** Sept. 4, 2013

After selling its handset business to Microsoft, Nokia will retain three divisions that interim CEO Risto Siilasmaa says will carry "a much stronger balance sheet." These are the Nokia Solutions and Networks telecom equipment unit, the Here location-based services division, and an Advanced Technologies arm focused on sensor materials and cloud and Web technologies. Nokia's Here platform, with its mapping, A/R and navigation capabilities, could be a contender against Google and its Glass device, David Meyer writes. <http://bit.ly/18rkzWw>
- 3. Forrester Analyst: Location Offers Mobile Marketing Advantages Far Beyond Mapping** July 3, 2013

The fact that consumers spend as much as 90% of their time indoors complicates the use of GPS for location-based marketing, acknowledges Forrester Research Senior Analyst Tony Costa. But marketers should still take advantage of the technology, because location means much more than maps and can include enhancing the consumer's indoor experience by using analytics to deliver personalized service. <http://bit.ly/16f453U>

INDUSTRY APPLICATIONS

- 1. Graduate Student Educates about Online Privacy with Twitter Mapping App** August 28, 2013

Master's degree student Chris Weidemann has developed an application that mines geospatial information shared by Twitter users and analyzes it using Esri's ArcGIS software to create a geospatial picture of a specific Twitter user or a region's users as a whole. Weidemann next plans to take his app, Twitter2GIS, a step further and allow Twitter users to test the app and see what it can deduce about their movements. "My intent is to educate social media users and inform the public about their privacy," Weidemann said. <http://bit.ly/18twkBU>
- 2. GIS Mapping Provides Clues to Gettysburg Conflict** July 3, 2013

An inability to see the terrain of Gettysburg properly might be one of the decisive factors that led to the defeat of Gen. Robert E. Lee's Confederate troops, according to a digital map of the battle put together by researchers. Middlebury geography professor Anne Kelly Knowles used GIS mapping to combine battlefield reports of troop movements with modern data as well as an historically accurate map stored in the National Archives' Treasure Vault to create an interactive picture of what happened. <http://bit.ly/16f453U>
- 3. SAP Adds Location-based Analytics to Financial Industry Products** July 17, 2013

SAP will use services from location-analytics firm Esri to add decision-making tools based on location information to its product suite for financial service providers. The tools will allow companies to determine where to increase resources and efforts in locations that might process more loans when local or national laws change, SAP's Marie Goodell said. <http://bit.ly/1dkx5MX>

BUSINESS AND STRATEGY PLANNING

- 1. What Areas of the U.S. Have the Best High School Graduation Rates?** June 19, 2013

This analysis looks at high school graduation data by U.S. county and looks at the relationship between graduation rates and per capita income, plus access to health insurance. <http://bit.ly/16f7Arg>
- 2. The Big Business of How Americans Have Fun** June 5, 2013

Major theme parks such as Walt Disney World and Universal Studios draw diverse visitors from across the country who plan their vacations around park visits. Resort ambiance such as spas, luxurious rooms and fine dining broadens the parks' appeal to more affluent groups. Companies that know who their visitors are can continually update their attractions, encouraging their loyal visitors to return. <http://bit.ly/16au77u>
- 3. Researcher Visualizes Manhattan's Wealth Gap with Esri Data** August 21, 2013

Web researcher and artist Nickolay Lamm built a 3D map of Manhattan that visualizes the island's income inequality with building height. Lamm used demographic data from the 2010 census and made available on the Esri website to show how the wealthy neighborhoods surrounding Central Park tower over the low-lying neighborhoods of Harlem and the South Bronx. <http://bit.ly/1992P4t>

FOLLOWING ARE THE TOP TEN NEWS STORIES for each month prior to this issue as recorded via visitor views to the daily updates on *Sensors & Systems* (www.sensorsandsystems.com). The stories at the top received the most views for the month. <http://bit.ly/194R5jB>

JULY	AUGUST	SEPTEMBER	
<ul style="list-style-type: none"> ■ Research and Markets: Global GIS Market in the Natural Resource Industry 2012-2016 http://bit.ly/15YF1xa 	<ul style="list-style-type: none"> ■ Trimble Launches Connected Farm Dashboard http://bit.ly/1460ibt 	<ul style="list-style-type: none"> ■ Satellites Help Track Algal Blooms in the Great Lakes http://bit.ly/1egmZPX 	
<ul style="list-style-type: none"> ■ Long-time Google Partner Pushes Into Geospatial Solutions http://bit.ly/15vuWfw 	<ul style="list-style-type: none"> ■ MIT Researchers Create a 3D Map in Real-time Using Kinect Camera http://bit.ly/18kctPI 	<ul style="list-style-type: none"> ■ 400-year Study Finds Northeast Forests Resilient, Changing http://bit.ly/19VD8Fx 	
<ul style="list-style-type: none"> ■ New Director of the National Center for Atmospheric Research Announced http://bit.ly/194cHwj 	<ul style="list-style-type: none"> ■ New World Gravity Map at Highest Resolution http://bit.ly/1efFdkK 	<ul style="list-style-type: none"> ■ Oil and Gas Producers Look to Increase Use of Earth Observation http://bit.ly/163kxKA 	
<ul style="list-style-type: none"> ■ AGCO Unveils Global Precision Farming Initiative http://bit.ly/18kbgHP 	<ul style="list-style-type: none"> ■ A Look at Landsat: Sustaining and Enhancing the Nation's Land Imaging Program http://bit.ly/19V5orW 	<ul style="list-style-type: none"> ■ Help Solve Climate Change with MIT's Climate CoLab Project http://bit.ly/17ZidSy 	
<ul style="list-style-type: none"> ■ Ecologists Map the Benefits of Our Ecosystems http://bit.ly/1aLRb59 	<ul style="list-style-type: none"> ■ Satellite Photos of Syria Reveal Destruction http://bit.ly/1eSoJOa 	<ul style="list-style-type: none"> ■ Montreal Protocol Endorsed for Fast Climate Mitigation http://bit.ly/14Yyj18 	
<ul style="list-style-type: none"> ■ NVIDIA Launches World's First GPU-Accelerated Platform for Geospatial Intelligence Analysts http://bit.ly/14Ta9E4 	<ul style="list-style-type: none"> ■ Trimble Launches AP15 GNSS-Inertial Board Set for High-Performance Positioning http://bit.ly/18oZFgP 	<ul style="list-style-type: none"> ■ The MapClub Aims to Create an OSM Ecosystem through Paid Memberships http://bit.ly/15w7wGS 	
<ul style="list-style-type: none"> ■ New USGS Streamer Online Map Service Traces Streamflow of America's Major Rivers http://bit.ly/16vkswF 	<ul style="list-style-type: none"> ■ Intergraph Mobile Alert App Enables Citizen Crowdsourcing http://bit.ly/193Gjc6 	<ul style="list-style-type: none"> ■ aisle411 Announces \$6.3 Million Series A Funding Led by Cultivation Capital http://bit.ly/1gkQoVV 	
<ul style="list-style-type: none"> ■ NASA Scientists Use Satellites to Measure Plant Health http://bit.ly/17BtcAP 	<ul style="list-style-type: none"> ■ \$1.1 Million Project Will Map Sinkhole Vulnerability in Florida http://bit.ly/162QyIX 	<ul style="list-style-type: none"> ■ NJVC Demonstrates Cloud Infrastructure in Support of Disaster Response http://bit.ly/19VDTOR 	
<ul style="list-style-type: none"> ■ The FAA Approves the First Commercial Unmanned Aircraft Systems http://bit.ly/1efElac 	<ul style="list-style-type: none"> ■ Phoenix Aerial Systems Develops a Small Commercial Unmanned Aerial LiDAR Platform http://bit.ly/18ldN4H 	<ul style="list-style-type: none"> ■ Students Encouraged to Submit Papers on Geographic Information Science http://bit.ly/1blLBWg 	
<ul style="list-style-type: none"> ■ NCOIC Geospatial Community Cloud Project for Disaster Relief Efforts Will Include Google Geospatial Services http://bit.ly/1efEPCA 	<ul style="list-style-type: none"> ■ GPS SmartSoles Provide Trackable Footwear http://bit.ly/19VCW9s 	<ul style="list-style-type: none"> ■ Booz Allen Hamilton Wins Centers for Disease Control and Prevention Contract to Deliver GIS Science and Technology Services http://bit.ly/1aD5XYg 	

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- Environment
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- Ocean
- Energy
- Security

Reshaping the GEOINT Community

Tapping Into the Commercial Marketplace

BY JOSHUA HARTMAN / CEO / HORIZON STRATEGIES GROUP
WASHINGTON, D.C. / WWW.HSTRAT.COM



A “New Industry,” made up of private equity, venture capital, and commercially focused technology companies, both established and start-ups, exists as the single largest disruptor to the National Geospatial-Intelligence Agency (NGA) mission and model. In a short time, companies like Amazon, Google, Apple, Twitter, and others not commonly known in the geospatial intelligence (GEOINT) community have caused rapid and drastic changes to the way the NGA and the rest of the community defines and integrates GEOINT. As a result of significant commercial demand of geospatial information and the introduction of game-changing technologies and data sources, the NGA finds itself needing to play catch up in a rapidly changing environment. The ability to embrace these changes and this New Industry will determine future value of the Agency.

The NGA should consider three things to remain viable and tap into the outside growth and investment.

{ FIRST }

CULTIVATING AND GROWING SOLID RELATIONSHIPS WITH THE NEW INDUSTRY WILL ALLOW NGA TO UNDERSTAND THE NATURE OF THE CHANGES AND THOSE WHO ARE DRIVING THEM.

Tomorrow’s GEOINT solutions are being seeded today by this new industry of commercial interests. The exponential growth in demand by common consumers for GEOINT (called locational information in the commercial sector) has largely been driven by the mobile-handheld market. Considering the implication of the Internet-of-Things and the realization by commercial businesses that this information can be mashed up to help businesses to gain valuable insights on customers, products, and business operations, the new industry

has spawned. This growth has caught the attention of hundreds of innovators, entrepreneurs, venture capitalists, and private equity companies, forming the constituents and concepts of a New Industry that will shape the GEOINT community. Significant investment is being made in the creation and use of locational information by this group across the country. Virtually all of the benefactor companies are small or mid-tier companies and represent non-traditional providers with game-changing solutions for NGA.

Cultivating relationships with this New Industry and establishing a dialogue early in the development process will enable and accelerate NGA's industry leadership while ensuring the success of the entire government geospatial user-set. Efforts to date have not produced the desired results by NGA or this non-traditional group. Fundamentally, at this point, the two communities speak vastly different languages and act on completely disjointed timelines. NGA could raise the priority of these relationships by carving out a portion of its Innovision organization or a better candidate group that focuses on and specializes in bridging this gap. NGA's best opportunity would be to play a key role

in early technology development by actively discovering game-changers within the New Industry and establishing early partnerships for tech investment.

Relative to traditional industry, the players within the New Industry are extremely risk accepting, but look for large profitable payoffs. The New Industry is looking primarily to the private sector for those profits. This ultimately means that NGA merely represents a single voice in a sea of customers; they don't depend on NGA to make their business case. This will change the typical relationship that NGA has with industry. In this context, NGA will not be driving things—rather just along for the ride.

{ SECOND }

UNDERSTANDING THE DIRECTION AND NATURE OF THE CHANGE WILL AID NGA IN TARGETING AND BUILDING THE VALUABLE RELATIONSHIPS DISCUSSED EARLIER.

While imagery products and maps are important, the value that additional and varied sources of information creates is driving advancement in the community. Many emerging GEOINT service companies focus primarily on achieving a basic foundational product and creating new content by mashing it with data from multiple sources—a concept not foreign to NGA but carried much further and faster in recent times by the New Industry. Changes have occurred where a picture may still be worth a thousand words, but today's locational information final products and services have several thousand words (and other things) embedded within them.

Driving this behavior is the fact that we live in a data-rich environment. Today's New Industry is leveraging an information explosion, with a plethora of primary, secondary, and tertiary data sources available at our fingertips via the internet and proprietary data streams. Private equity and venture capital funds are investing in dozens of companies working to develop ways to create knowledge for individuals and differentiated commercial groups. Some of these sources have been created from nontraditional methods like crowdsourcing and wiki-development.

These new and publicly available sources have generated unexpected interest and advancement in the community. In many cases, this crowdsourced data provides rich human geography and activity-based information that has unique access and content. In several recent examples, from reporting traffic, capturing

tactical details of the Arab Spring, or monitoring the devastating effects of a string of natural disasters, local observers have become unique and authoritative sources of collection, particularly in urban environments. Examples of the content creation typified by the crowdsourcing movement can be seen at sites like Flickr, Panoramio, OpenStreetMap, Wikimaps, Photosynth, Zoom.it, Seadragon Mobile, Twitter, Facebook, Waze, SimpleGeo, and Ushahidi. See *Figures 1-2*.

The New Industry with growing footprints in the geospatial arena have leveraged a dramatically different infrastructure than previously used by the community. These companies, through the cloud and other measures, have developed information technology architectures and processes that offer rapid data mining, high performance computing, application development, and data exposure. Growth in commercial infrastructures, exposure to geo-, temporal-, and meta-tagged data, decentralization of app development, and proliferation of mobile and handheld devices have driven new business opportunities and models. Commercialization of diverse data sources has shifted analytical capabilities toward complex pattern analysis of big data sets, finding value in them that the traditional GEOINT community has struggled to find. For example, development of apps perform complex functions like turning structured text into geographically representative data through scraping blogs and public sites to provide additional context to "locational understanding" about a person, place or event.

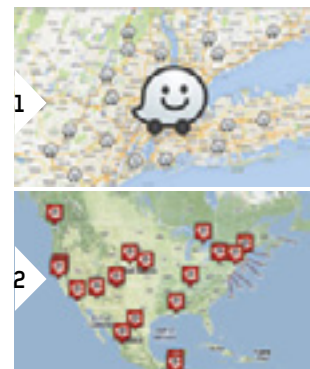


FIGURE 1. Crowdsourced Waze map, where users contribute their own real-time traffic information

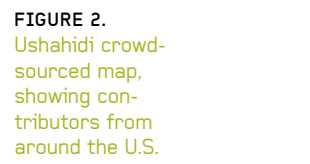


FIGURE 2. Ushahidi crowdsourced map, showing contributors from around the U.S.

The speed at which the GEOINT market space has shifted over this period has exceeded all expectations. As a single but critical indication, the Pew Internet and American Life Project measured that the growth of locational information services by mobile users and applications alone grew by 50% from 2011 to 2012. Suggesting continued shifts, research analysts from the International Telecom Union teamed with Morgan Stanley project the demand for and growth of data created by the mobile internet and the associated locational information services will explode by orders of

magnitude before 2020. They project that this will be driven by the sale and use of over 10 billion mobile hand-held units. Tremendous advances in machine learning, particularly as it relates to data mining and correlation, will offer new opportunities. This technology already stores user queries and satisfaction levels, automatically meta-tags data based on user interface and context, and leverages the stored information to improve speed and accuracy on future queries. The potential contribution of these alternative and non-traditional data sources has not yet been realized by NGA.

{ THIRD }


TARGETED CHANGES TO THE AGENCY MODEL AND APPROACH WILL INCENTIVIZE AND INTEGRATE THE NEW INDUSTRY INTO THE NGA FUTURE ROADMAP AND HELP THE AGENCY SUCCEED AT ITS MISSION.

A system to access, understand, and integrate the next generation of GEOINT technologies would greatly benefit NGA both in the long and short term. At a basic level, NGA should find a way to discover potential solutions, select and use those solutions, as well as compensate the developers in a way that sufficiently incentivizes industry to focus on NGA's needs. Such a system will likely be a complete departure from traditional acquisition models and take serious commitment by NGA (and its legislative and executive branch overseers).

Adoption of new business processes and models will facilitate the transition beyond traditional data, product, and system buys as well as evolve traditional industry solutions. A move from data-driven delivery and compensation to new methods like product- and application-use models would benefit all of the GEOINT community. Developing flexible contract structures and vehicles would enable short time lines and operate at a speed closer to that of New Industry. Considering new methods for compensation on new contracts would push all GEOINT companies to provide innovative commercial solutions to NGA's customers. Offering pilot programs under new business models and processes will allow NGA to test and properly implement game-changing processes emerging from the New Industry.

"Tomorrow's GEOINT solutions are being seeded today by this new industry of commercial interests."

As a first step, a comprehensive market assessment developed by NGA reaching out to the New Industry would support developing the necessary relationships, understanding the nature and scope of the change and of potential solutions, and understanding the knowledge base necessary to develop new models and approaches. Such an activity would allow the NGA to understand current practices while considering alternative investment and acquisition approaches such as usage-driven pricing, contests, and adoption of community-driven application programming interfaces, standards and open source architectures.

Commercial industry drives the development of geospatial products and services today. This New Industry has invested in enabling technologies and created new business models, creating an explosion in available geospatial information and tools. It has been a game changer and these services and products represent the future of GEOINT service for some time to come. It is possible that NGA can influence and participate in this boom, avoiding obsolescence and greatly benefiting the military and intelligence GEOINT users. However, to successfully do this, NGA will need to build its circle of friends and do things a bit differently. 

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PLUS: NGA has confirmed participation at DGI 2014!



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Top 10 Disruptors

to Geospatial Business Models

BY MATT BALL / EDITOR / SENSORS & SYSTEMS

It's a time of great disruption within the technology space, with a great deal of change taking place in how geospatial data is collected, stored, visualized and analyzed. There are new technologies and new approaches that have allowed new companies to emerge, and that have empowered existing players. Much more disruption is on the horizon that individually or combined will make it hard for practitioners and vendors to plan.

What does disruption mean? The recent Nokia news puts business model turmoil in perspective as the company was valued at \$250 Billion at the turn of the century and sold this past week to Microsoft for just \$7.2 Billion. This age of disruption provides a means of great opportunity to reach more users and provide more insight, but also holds the potential to undermine the business plans of big players. Here and throughout this issue are some

disruptive technologies that could re-write the geospatial technology marketplace.

1. UAVs

Surveyors are looking with some dread at these autonomous airborne vehicles that allow unskilled users to quickly map areas from the air with a great deal of detail with very little effort, often even using inexpensive consumer cameras. The largely automated flight planning and image

processing software promises more real-time solutions, and could particularly re-write how the AEC (architecture, engineering and construction) community monitors projects under construction, and how farmers keep track of crops. There will be a great many service businesses and applications that benefit from these monitoring and mapping technologies, pushing broader use in yet untapped markets.

2. EARTH OBSERVATION EXPLOSION

There are many Earth observation trends that are making space more accessible. Several venture capital-funded organizations are set to launch commercial constellations for global coverage of both microsatellites and cube satellites, increasing the amount of available data and opening it up to more cost-conscious applications, while also undercutting established satellite imagery providers. There's also Iridium's hosted payload Iridium Prime that offers integration on a planned constellation of up to 66 communications satellites set to launch by 2017. And then there's speculation that Google's Project Loon balloon communication network may include Earth observation. Together, an era of affordable real-time space-based observation is around the corner.

3. INTERNET OF THINGS

The sensed devices and networks of the Internet of Things (IoT) promises a much better understanding of our world. IoT empowers such concepts as Smart Cities where we improve our management of resources and infrastructure based upon performance. With this performance-based monitoring, we will improve operations while also increasing our understanding of the impacts of the built environment upon the environment. New businesses are being created around this opportunity as well as new forays by large traditional players that see the computing demand of these networks as the next big storage and computing opportunity.

4. OPEN SOURCE

Open sources software have been making inroads in the geospatial marketplace for more than a decade, with quite capable tools, particularly in the online mapping space. With budget cuts and a reticence of being locked into long-term licensing agreements, the solutions are becoming more common in the government space, particularly with the military. The moves being made by OpenGeo make the choice more appealing with new funding, an increase in recruiting the top open source



Editor's Note:

These articles were previously published in our partner publication, *Sensors & Systems*:
<http://bit.ly/16zsSD8>
<http://bit.ly/16jldEv>

minds, and a growing suite of tested software. Within the open source geospatial community there are opportunities for developers as well as integrators.

5. DEVELOPERS

The appeal of geospatial tools to the software development community is on the rise due to the accessibility. While this relates to open source, it's also an opportunity for those companies that offer software developer kits (SDKs) or application programming interfaces (APIs) to extend their products with custom solutions that are provided by skilled software developers. There has been an increased effort on behalf of Esri and others that see this community as an important extension that can build upon capabilities and return revenue via licensing the underpinning technology and data.

6. WEARABLE COMPUTING

Google Glass has ushered in a new era of mobile interface that could greatly assist field work. This platform has perhaps greater potential for streamlining operations, easing business communication, and improving on the accuracy and detail of geospatial data capture. One could imagine an RTK (Real-Time Kinematic) surveying system augmenting the location for very precise positioning, and improving our systems by orders of magnitude thanks to both this precision and the added context that we're able to capture with heads-up and hands-free devices.

7. 3D DATA CAPTURE

Today's LiDAR hardware does a good job of capturing a precise 3D reality from the air, from mobile platforms, and from stationary tripods from different perspectives and for different purposes. Point clouds generated from photographs are filling a lower-cost and lower-resolution niche, to make 3D modeling more ubiquitous. Together, there's a momentum to feed a model-based approach that blurs the line between BIM and GIS. While 3D hasn't yet become ubiquitous, it's an inevitable progression that is fed by augmented reality and the world's move toward greater urbanization. The need to capture details first in order to improve existing structures and infrastructure will only increase over time, and there are a number of opportunities here for new services as well as enhanced design and construction workflows.

8. CLOUD COMPUTING

GIS is increasingly being delivered via the infinite computing of the cloud as online solutions, custom services,

and as the platform-as-a-service model. The cloud offers a much greater flexibility to GIS practitioners, which takes away the onus of IT control, allowing for greater flexibility and creativity while also easing enterprise integration with other systems. The cloud would seem to favor larger players that appeal to larger user organizations, having the potential to shut out those that can't scale their systems and data offerings to compete. There are nagging security and access questions that are still making some organizations wary to make the jump.

9. BIG DATA

Geospatial information is the original Big Data, and thanks to increased interest in other sectors that have amassed large databases, the geospatial community is set to benefit from new hardware, data analyses approaches and automation. At the same time, incredible amounts of new data are being created, meaning that an exponential advancement is needed. The full promise of Big Data advancements lies in our ability to better monitor global change and understand impacts. There's a great deal of opportunity here for individuals who understand how to massage this data to fill new job categories, as well as for vendors to fill gaps in analysis and decision support services.

10. AUTOMATION

Increasingly, our computing systems are becoming automated through the use of algorithms for automation, such as in the financial services community. As the bots take further hold, the power of the few to craft these prediction bots will likely lead to a backlash, and when even those who craft the bots can't understand their behavior, more insight will be needed. The ability of GIS to visualize and analyze reality in a transparent way gives it a leg up when this inevitable need to understand automation occurs.

There is an increasing interest in maps and mapmaking now, with wider mainstream awareness and interest in the benefits that digital approaches have lent to the age-old practice of cartography. Maps have the ability to quickly condense data in a visually meaningful way for greater insight. Each of these disruptions adds to our insight for better stewardship of our planet. Hopefully any disruptions will add to our understanding, improve the revenues and reach of the geospatial marketplace as a whole, and aid individuals as well as corporations and governments. ▲◊

Editor's Note:
Age of Disruption
articles appear
on pages 18, 22
26, 32 and 36.

TerraGo Retools to Take on Broader Opportunities



Chris Broderick
CEO
TerraGo

TerraGo has provided one of the easier to use geospatial toolsets that has seen widespread adoption, particularly in the field and for the warfighter with their GeoPDF and mobile tools. Recently there have been some leadership changes, and a move of the company's headquarters. Sensors & Systems (S&S) editor Matt Ball spoke with Chris Broderick, the company's new CEO, about the tools, the geospatial market and the focus on new opportunities that is underway.

S&S *You have been at TerraGo for less than a month at this point, and the company headquarters are moving to the Washington, D.C. area. What has led to that change?*

BRODERICK Our board of directors made the location decision because TerraGo's business today is predominantly defined by federal government customers, and they like to be in close proximity to their vendors. So, having a location that helps us better serve and collaborate with our largest customer base makes a lot of sense for the company.

S&S *You come into the geospatial community with a background in software and solutions, but not necessarily geospatial exposure. Is that right?*

BRODERICK I think that's exactly right. I have no deep vocational experience in the GIS space. But I've spent the majority of my career in the software space, working with both small innovators and larger software companies. I spent quite a bit of time with Computer Associates, with their storage management business. I went on to work with a small company that was focused on high-end security solutions for the federal government (the Public Key Infrastructure space). Then, most recently, I was with a firm that was in the mobility space.

S&S *With the data management and mobility experience, there seem to be elements that mesh with TerraGo's offerings. I think of TerraGo's primary benefit as being a mobile ease of use tool.*

BRODERICK I think that's right. If you look at the core of what TerraGo does really well today, it provides the ability to consume and interact with geospatial information, and the way that we do it has a high degree of portability. We also operate in places where devices have low bandwidth or in areas where communication isn't possible.

That portability of distribution of information is really the secret sauce for TerraGo. We see an opportunity to expand this idea to more devices and peripherals, and to make the information easier to interact with. Both the public and private sectors have become comfortable with this idea of portability that the company has already perfected.

S&S *You've moved into the analysis of information, and the ability to ingest large amounts of data with the acquisition of Geosemble. Is the idea to better inform the context of location?*

BRODERICK If you look at the way that people have come to appreciate access to information, a lot has changed recently. If you think about the ways that individuals interact with their systems, they want simplicity and are comfortable interacting with disparate data sources. As a consumer, we don't care where information comes from; we just want it aggregated in a way that makes sense.

The idea of taking portable geospatial information coupled with the ability to overlay other types of information in the context of location is powerful. Those sources are social media, public media, government information, and others, all being presented in context in an area of interest.

S&S *You've come to the company at an interesting time, with a nice foundation of recently raised funds, but also at a time when the government is cutting back. What has the impact of the sequestration been, and is there a logical response to it?*

BRODERICK The biggest impact that the sequestration has is the uncertainty with our biggest buyer. The sequestration creates a lot of confusion with our customers. They don't know what it means, how long it will last, and it creates paralysis where they are unable to make commitments into the future. The window of thinking has

narrowed down to the now.

On the other side, you can say that the government does not appear to be willing to pare back the tools that support the warfighter and citizens that are abroad. Where we fit, related to the systems and the way that government customers use our software, is high in that priority stack.

We intend to identify and establish commercial markets that can lessen our dependence on the government. We have had some success in the oil and gas and utility business. We see other repeatable markets, similar to the needs of the government, to provide this portable ability to interact with information in the context of their location.

S&S *I know that you have a Software Developer Kit (SDK) and other offerings that are geared toward developers or enterprise customers to customize the offering. Would there be solutions tailored toward specific markets that you develop yourselves or is a third party doing that kind of thing?*

BRODERICK The trick of any successful software company is to be able to scale by solving problems that large numbers of organizations face. What we need are products and solutions that can be geared to a large number of vertical markets while maintaining a core set of intellectual property along the way.

We don't want to create a bunch of one-off solutions that go after narrow markets. That's really why the SDK is important for us, because there are other companies that have the expertise to service specific verticals. It's ideal for us to embed our technology into a broader technology or service that they provide. We do that today, and we'll continue to do that in the future.

Where we want to go is to have products that are broadly applicable, that can be sold at volume, and that can be implemented across a variety of use cases that address a broad set of verticals. We want to scale.

S&S *There are so many potentially disruptive technologies for geospatial businesses that are on the cusp of entering more mainstream use, such as wearable computers (Google Glass) and widespread use of UAVs, among others. Are these opportunities, but also a reason to tread cautiously on where you place your research and development dollars?*

BRODERICK What I think is happening in the GIS space is that innovation hasn't kept pace with other industries and other verticals, and it's why I like the opportunity so much. There are lots of opportunities to increase the pace of innovation, the simplicity of experience for the

end user, and create markets that may not exist today.

There are several areas of potential disruption that we're focused on. We're in the early days of thinking about the future, and prioritizing the investments that we're going to make. We're considering several of these disruptions, and will need to circle back with our plans when our ideas are more fully baked.

S&S *Are you comfortable discussing some of the areas where geospatial technology hasn't been as innovative as other verticals?*

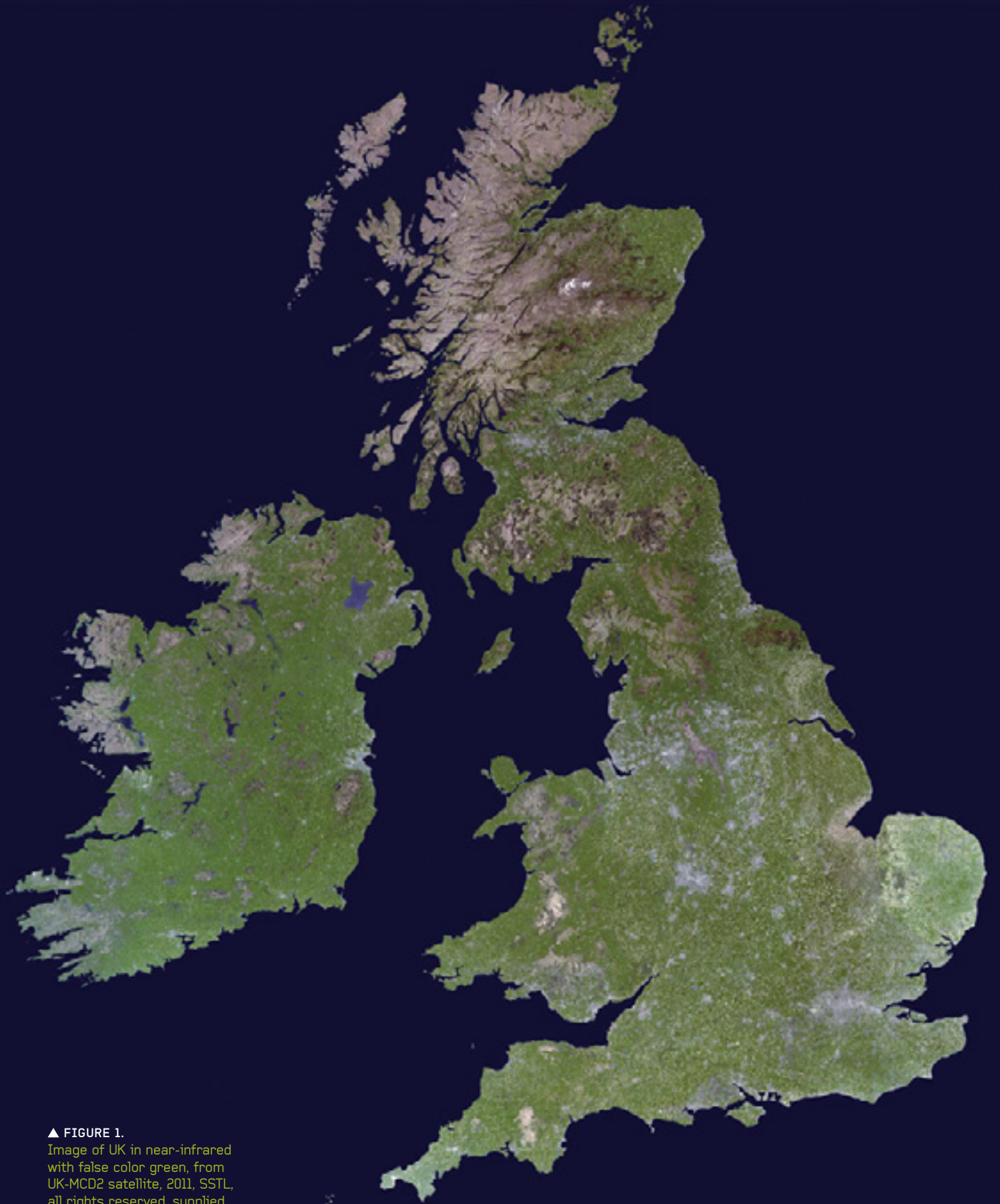
BRODERICK What has become obvious in the short time that I've been immersed in this space is that there's an overall move toward the democratization of GIS. It's something that I've heard; this idea of democratization seems to be real.

What I mean by democratization is that the creation of geospatial content and the access to geospatial content has historically been in the hands of the few and the highly specialized. A highly specialized skillset of a few are really the ones who have been responsible for the creation of geospatial information that gets distributed to consumers of geospatial information. There seems to be a strong desire amongst the organizations that create geospatial content to democratize this creation with simpler tools that can be used by individuals with far less skills to create and package geospatial information and make it valuable to their constituents.

What that means for the technology is really disruptive. You have a core set of tools that are being pressured to simplify the experience and open them up, which is creating an opportunity for new players to fill that gap.

S&S *TerraGo is interesting, because you've been both a long tail company in terms of getting this data into the hands of a lot of people, as well as selling to just a few large organizations that have a lot of people. Is part of the plan going forward to get in front of many more companies or to find more large organizations with a large workforce with similar needs to your existing large customers?*

BRODERICK I would say that the business model for TerraGo has been to focus on the individuals within organizations that make maps. The individuals and organizations that make maps have been public sector organizations or near public sector. I think that's changing a lot, and where we want to focus is on the consumers of geospatial information. If you look across the space, and look across what is available in the hands of the consumer of geospatial information and services, it's a relatively underserved market. ▲



▲ FIGURE 1.
Image of UK in near-infrared
with false color green, from
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by DMCi.

1

The Small Satellite Revolution

More Earth Observations at a Lower Cost

BY MATT BALL / EDITOR / SENSORS & SYSTEMS

+ WHILE THERE HAS BEEN MUCH discussion about an explosion of Earth observation satellites over the next few decades, much of that has centered around developing countries starting their own programs or existing countries adding to their capacity. New developments with smaller and cheaper satellites are now promising a surge of commercial space-based imagery platforms at a global scale.

A number of factors are at play with this rapid expansion, including: cheaper and more accessible satellite technology, more satellite launch choices thanks to the commercialization of space, a greater

awareness of the insight these imaging platforms afford in a rapidly changing world, and better web-based visualization and mapping systems that are ready to ingest and analyze near real-time imagery.

This trend toward smaller satellites has been happening over time, with much of the innovation taking place in developing countries where affordability has been the key driver. However, there are now several venture capital-backed U.S.-based companies that are set to make inroads with recently announced plans for multi-satellite constellations with global coverage.

These for-profit satellite constellations are fueled by the interest in more and more data for greater insight on global change, led by industries that are gaining market advantages through ongoing monitoring. The timing is ripe now as it matches the changes in computing capacity afforded by cloud computing, and new analytical tools that can make sense of these “Big Data” feeds.

Editor's Note:

See article about the unique business model of SSTL on page 32.

PIONEERING LOW COST OPTIONS

The trend toward smaller satellites has been led by the efforts of Surrey Satellite Technology (SST). This 30-year-old company has built a reputation for both small satellite construction and satellite constellation deployment, having success as the makers of the commercial RapidEye satellite imagery constellation, as well as their own spin-off company Disaster Monitoring Constellation International Imaging (DMCii). The company has now ramped up their presence in the United States, with the launch of SST-US.

“As we move forward, the role of the small spacecraft is becoming more important,” said Dr. John Paffett, CEO of SST-US. “That’s largely because every year the technology improves, with better computers and storage and payloads. The technological evolution improves, price points continue to come down, and now with a small 150-300 kg spacecraft for \$10-20 million, you can do what you were doing with a 1,000 kg spacecraft five to 10 years ago for \$500 million.”

DMCii was developed by SST as a constellation of satellites that fill a unique niche with 32-meter resolution that is compatible with Landsat, and a three-band imager to assess vegetation health. The constellation’s advantage is that it has a very large swath width to capture an image tile that is 600 km by 600 km, and can capture the same image for the same part of the Earth every day. See *Figure 1*.

The first-generation of four satellites were launched in 2002, another satellite was launched in 2005 with greater imaging capacity, and a sixth was launched in 2012. A second generation of satellites was launched in 2009 as NigeriaSat, with greater pixel density and 2.5-meter resolution panchromatic and 5-meter multispectral imagery. This imagery is owned by the Nigerian government and licensed to and sold by DMCii to enhance their offerings.

RapidEye offers 5-meter imagery, with five spectral bands, from its constellation of five identical earth observation satellites that were launched in 2008. After issues with its financial backers related to the economic downturn, the Blackbridge Group, Canada, acquired the assets of RapidEye AG, and are marketing their solutions primarily toward natural resources, targeting agriculture, forestry, and the environment as well as energy, security and infrastructure. See *Figure 2*.

MICRO SATS FROM SILICON VALLEY

Skybox Imaging (<http://www.skyboximaging.com>) is based in Silicon Valley, with headquarters near both

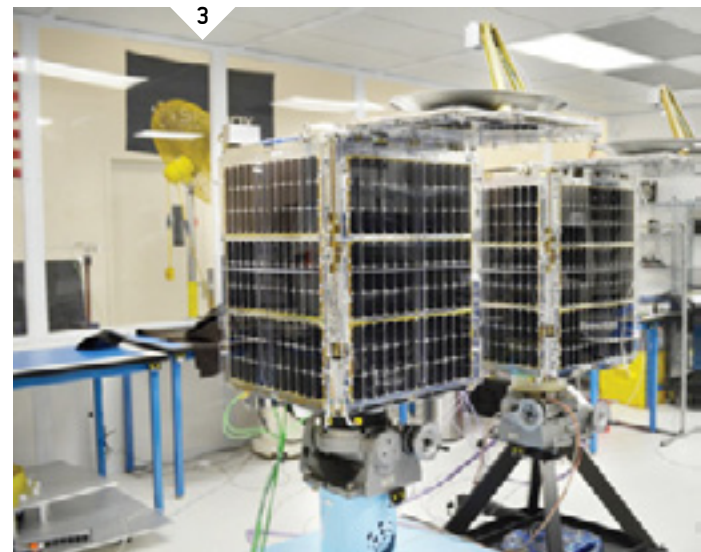
Google and Microsoft. The Skybox executive team met at the Stanford MBA program, and includes veterans of both NASA and the Pentagon. They have raised \$91 million in venture capital funding, with a plan to reduce the complexity of space.

They are building their own micro satellites of around 120 kg in size, with the ability to collect color imagery of less than 1-meter resolution. They are aiming to see manmade objects that move on a daily basis, including the ability to collect high-definition video up to 90 seconds in length at 30 frames per second. They decided to build their own satellites, because they couldn’t find a satellite provider to deliver the performance at the price point that they needed, likening the sourcing and integration of the components of their satellites to the building of agile software. See *Figure 3*.

“We’re really building a data platform where our sensors and satellites are enablers for that data stream,” said Ching-Yu Hu, director of marketing and customer relations, Skybox Imaging.

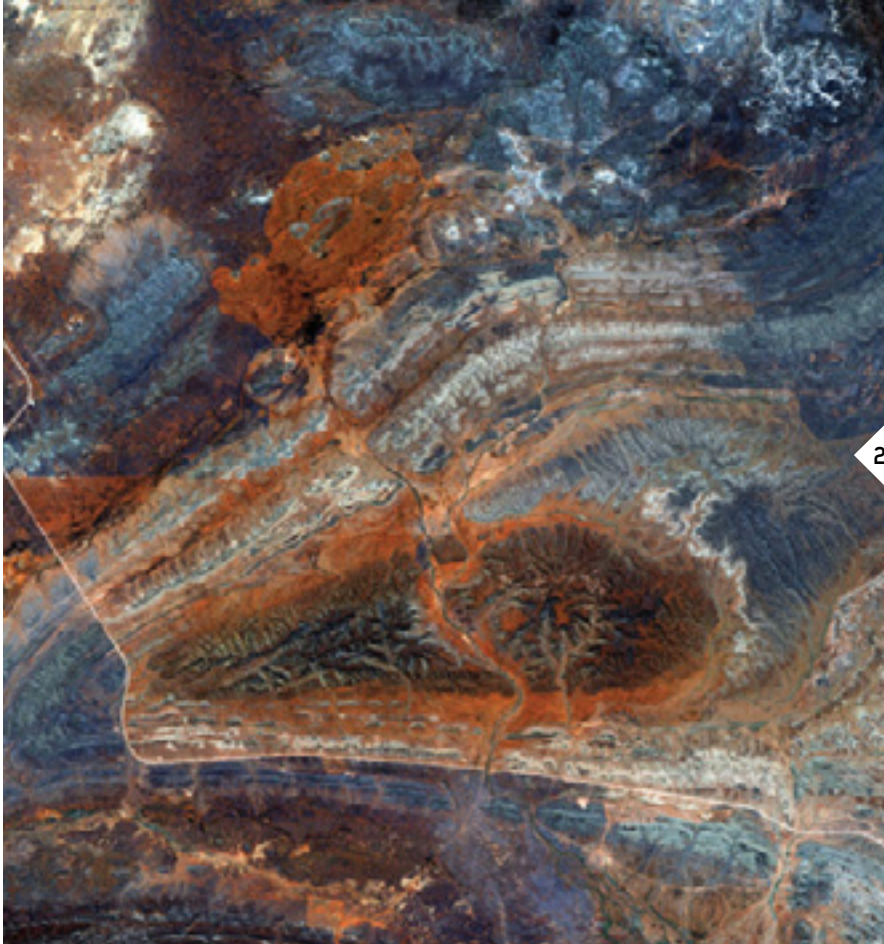
Their talent is skewed toward high-performance data platforms, with software engineers who have

► **FIGURE 3.** Skybox satellites SkySat-1 and SkySat-2 in the company’s clean room.



worked with Yahoo!, Netflix and Shutterfly. There are also imagery scientists on staff who are working to extract data from imagery to provide solutions.

The first Skybox satellite is scheduled for launch from Russia at some point this Fall. With their small size, these satellites can be launched as multiples from the same rocket, and their first two launches (the second being tentatively scheduled for first quarter 2014) will be secondary payloads. As their business plan to launch a constellation of 24 satellites progresses, they will be deploying multiple satellites at the same time from the same rocket.



have delivered a “Skynode” ground station to that company that will allow them to directly task the satellite for their region, designating what areas to capture.

◀ **FIGURE 2.** MacDonnell Range, Australia. Image collected November 14, 2012 at 5-m resolution, courtesy of RapidEye.

SMALLER AND LOWER

Planet Labs (<http://www.planet-labs.com>) plans to launch a fleet of 28 cube satellites (CubeSats) at the end of this year. The company has raised \$13 million in venture capital, and has already launched two trial satellites for test runs with Dove-1 and 2 launched in April of this year. Two more Dove satellites will be launched by the end of the year, and the entire constellation of 28 satellites called Flock-1, is set to launch early next year from an Antares rocket when it makes a cargo trip to the International Space Station. See *Figure 4*.

“After realizing the commercial potential of small satellites to revolutionize Earth imagery, the founders left NASA to raise money for their new venture,” said Tracy Nguyen, marketing and communications manager for Planet Labs. “They are makers at heart, so their method is to build, test and iterate quickly—on both hardware and software—using demonstration satellites as servers, pushing new code to them every day.” See *Figures 5-6*.

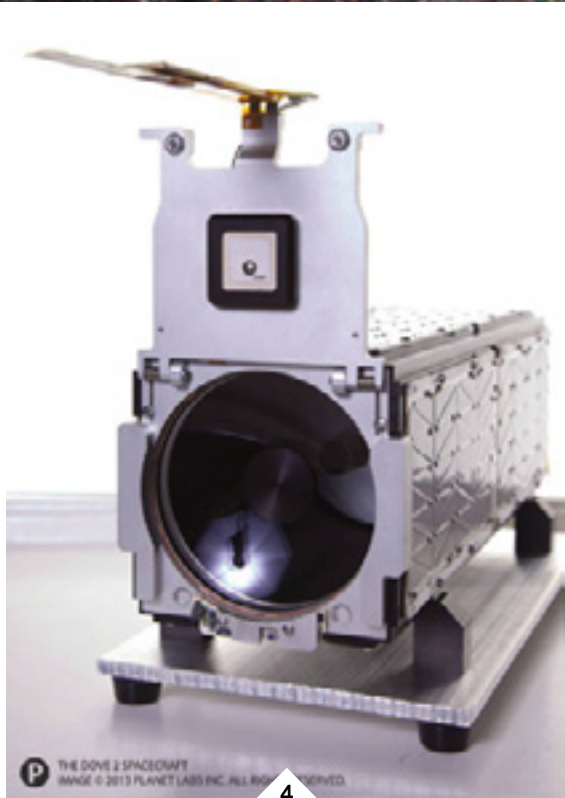
CubeSats are miniature in size, with a typical 10-cm cube and a mass of just 1.33 kilograms. The advantage of this design is its low cost and ease of launch, with the low-Earth orbit compensating for the size of the satellite and sensor. With so many satellites, the company aims for coverage and frequency rather than the ability to task the satellites for specific areas of capture.

Planet Labs aims to provide 3-5-meter resolution imagery of much of the planet within 52 degrees of the equator, an area with most of the world’s population and agriculture. Five ground stations will receive the Planet Labs imagery as the satellites pass overhead.

The goal of the company is to open imagery to the masses, to help them understand how they might use satellite imagery on a daily basis, with new applications for new industries.

“We are certainly looking to partner with satellite imagery resellers, especially for value added services,”

◀ **FIGURE 4.** One of the CubeSats, similar to those that will make up the planned Flock-1 constellation, in Planet Labs’ clean room.



The company is working to partner with existing companies in the satellite imagery space to grow the market. They have signed a contract with Japan Space Imaging, a subsidiary of Mitsubishi Corporation, and



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▲ FIGURES 5-6. These sample satellite images were captured by a test CubeSat called Dove-2 that was launched in April of 2013, courtesy of Planet Labs.

said Nguyen. “At the same time, our data delivery method to customers will streamline how people consume imagery, and we hope to innovate on the analysis portion as well, in the way we process the data.”

INCREASED ACCESSIBILITY

The CubeSat size has seen other entries this year, including the Strand-1 from Surrey Satellite with an Android smartphone as the processor, and Nanosatisfi (<http://www.nanosatisfi.com>) as an on-demand service to launch CubeSats. Nanosatisfi offers a full week’s access to their CubeSat, with a programmable Arduino board, for just \$250/week, and they’ve raised \$1.2 million in funding to make the vision possible.

Kickstarter crowdfunding efforts have been popular for CubeSats. SkyCube, a project from Southern Stars (<http://www.southernstars.com/skycube/index.html>) met its goal of \$100K in funding and will launch in late November from the International Space Station. SkyCube has an imagery sensor that can be tasked via an iPhone application, which is fitting since a project designed and funded by Southern Stars makers is one of the more respected iPhone

► FIGURE 7. Southern Stars is mission lead on SkyCube, and also maker of the popular astronomy app SkySafari.

and Android astronomy applications. See **Figure 7**. Part of their plan is a balloon that will inflate upon re-entry to allow users to see the satellite with their naked eyes as its orbit decays, and to track the satellite path with their smartphones.

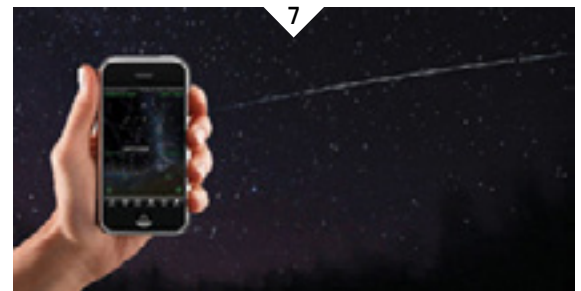
ArduSat is another Kickstarter-funded CubeSat that raised more than \$100K, which was well beyond their \$35K goal. This effort is again powered by an Arduino board, and is focused on powering applications and research projects. ArduSat has partnered with MySpectral, a group that is developing an open-source spectrometer, to offer a unique sensing capability for this size satellite.

The CubeSat size and configuration have been adopted widely by the academic community as a class project for scientific experiments and educational hands-on instruction. There is legislative action to remove some restrictions on these satellites for broader international adoption and interaction, taking away their military classification. The annual CubeSat gathering (<http://www.cubesat.org>) is in its third year, and will take place next spring at Cal State Poly in Pasadena, Calif.

MARKETS AND OPPORTUNITY

A number of potential uses for low-cost satellite imagery that is more frequent and that monitors broader areas are being explored by these satellite companies and potential clients. Skybox talks of financial markets that will be using their imagery to look at sugar and coffee market yields. Planet Labs points to government and humanitarian uses to help stop deforestation.

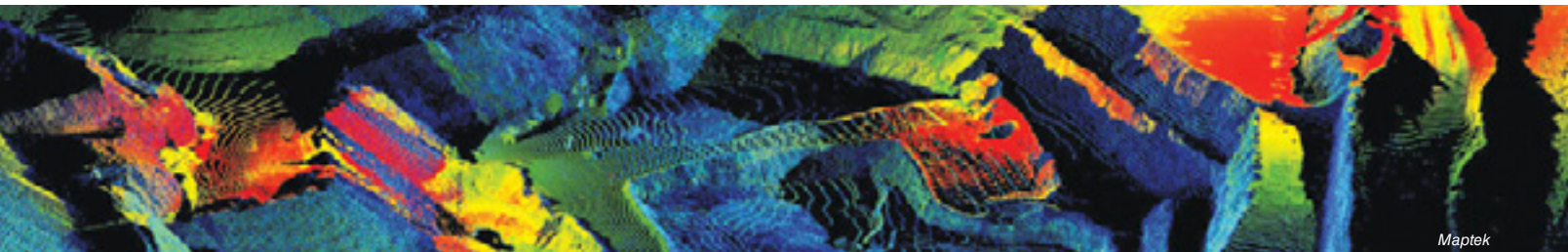
“What you are seeing is a transition of the market from an institutional domain into a more commercial domain,” said Paffett. “If you think about space commercialization today, you think about geostationary satellite communications. That was a change that took 20 years, where it started out institutional, went to quasi-institutional, and then commercial. Earth observation will follow that same path; it’s just 20 years behind.” ♂



7



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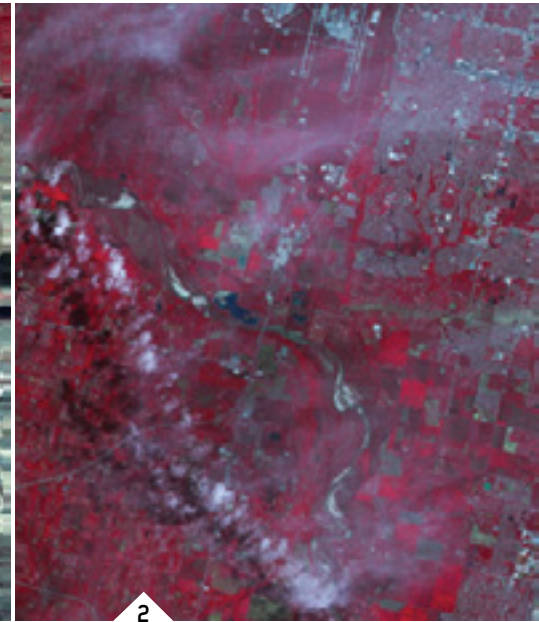
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Changing the Economics of Space for Satellites

Surrey Satellite Offers Sustainable Business Models

BY KEVIN P. CORBLEY / BUSINESS CONSULTANT / CORBLEY COMMUNICATIONS INC. DENVER, COLO. / WWW.CORBLEYCOMMUNICATIONS.COM



Immediately after the Indian Ocean tsunami struck in December 2004, emergency response officials worldwide knew a disaster of unprecedented magnitude had occurred, but they struggled to determine the full scope of its impact. In just a week, a newly formed UK company called DMC International Imaging (DMCii) provided a complete picture of the devastation in the form of a regional image mosaic captured by a constellation of Earth observation satellites.

“We imaged the entire perimeter of the Indian Ocean in six to seven days using as many satellites as we could,” said Paul Stephens, DMCii director of sales and marketing.

Stephens explained that DMCii had been created earlier that same year with the intent of coordinating the activities of the Disaster Monitoring Constellation, a consortium of four satellites at the time. The small satellites had been built and launched by DMCii’s parent company, Surrey Satellite Technology Ltd.

(SSTL, Guildford, England), as a coordinated constellation that could work together when needed to provide daily repeat imaging over the entire globe.

“This was in response to a series of disasters in the 1990s that could not be imaged due to the 16-day revisit cycle of Landsat,” said Stephens, noting the five original first-generation DMC satellites had 32-meter multispectral capabilities similar to the stalwart U.S. satellite but with almost four times wider 650-kilometer imaging swath.

For disaster response, the daily revisit capability offers three critical advantages:

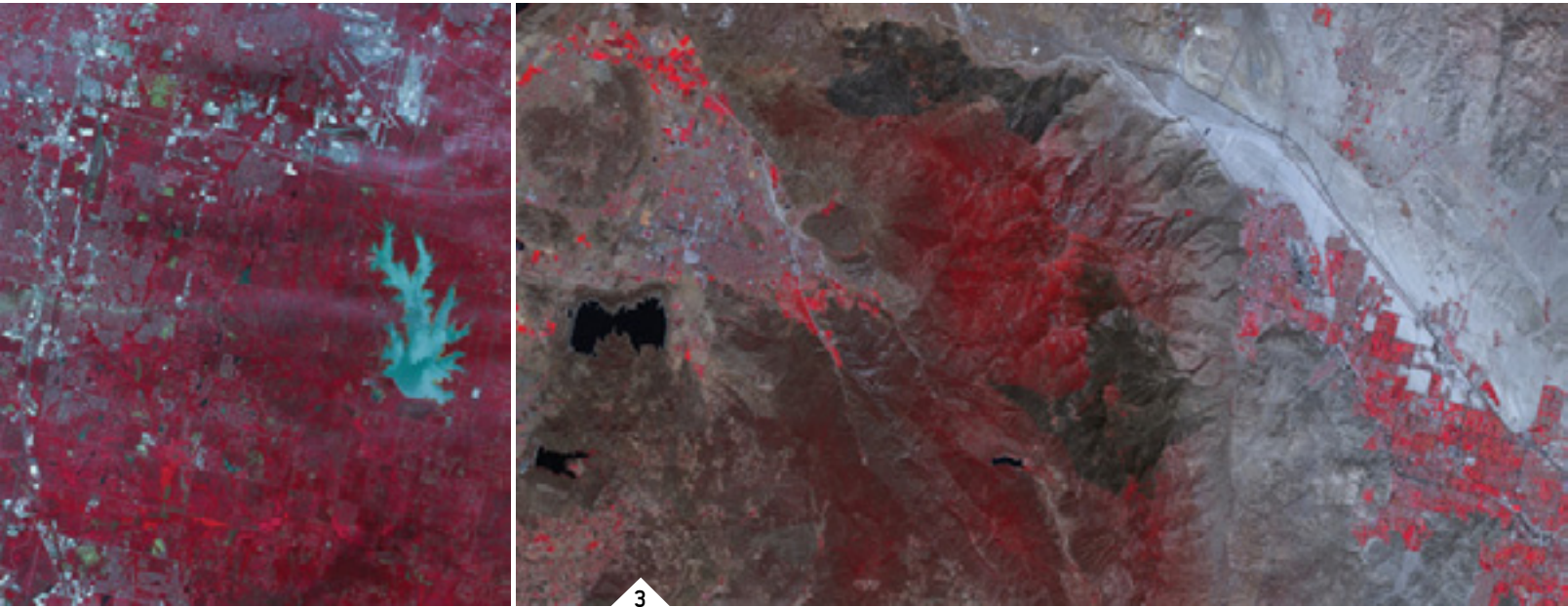
- After instantaneous events, such as earthquakes, a satellite is never more than 24 hours away from assessing the damage.
- In rapidly unfolding situations like this year’s Oklahoma tornado and the Colorado wildfires, multiple satellites can track the change daily.

▼ As occurred in 2004, a constellation can provide multi-image synoptic coverage of a large geographic region in a short period of time.

In less than a decade, the constellation has evolved in both capability and function, its success underscored by the launch of a second generation of satellites. Today, four of the original DMC satellites have been retired, replaced by next-generation Surrey-built satellites with improved spatial resolution and longer imaging swaths. Under DMCii's management, commercial applications

A DIFFERENT SATELLITE BUSINESS MODEL

What's different about the Disaster Monitoring Constellation is that only one of its satellites, UK-DMC2, is owned by DMCii. The others were each purchased from Surrey and are operated by organizations in other countries, including Spain and Nigeria. By investing in a satellite and ground receiving capability, each organization became a member of the DMC consortium, leveraging the advantages of multiple satellites both in terms of shared image data and joint revenue streams.



of the imagery have expanded to include agriculture, forestry, land planning, and environmental monitoring.

While the Disaster Monitoring Constellation is still best known for providing a steady stream of imagery to emergency first responders worldwide through the International Charter for Space and Major Disasters, Surrey believes the constellation is fundamentally changing the economics of space. At a per-satellite development cost of just \$13 million, Surrey built the entire five-satellite second-generation constellation for a fraction of the cost of the recently launched \$855 million Landsat 8.

But the price tag is just part of the DMC success story, according to Dr. John Paffett, CEO of Surrey Satellite Technology US (SST-US), a Colorado-based subsidiary established by Surrey to make its small satellite technology and business practices directly available in the United States. "It's the unique business model of the constellation that makes it commercially viable," said Paffett.

"Each spacecraft has an intrinsic value in its own right, worthy of purchasing," said Paffett. "But when those satellites are operated in a coordinated fashion, the return on investment increases because the value of the entire constellation is greater than the sum of its individual parts."

The business model is purposely flexible so that each owner has autonomy but with the option of a shared commercial revenue stream if desired. The only requirement is participation in the International Charter, with DMCii acting as the manager for the constellation. Its U.K. ground station can directly task and download data from any of the satellites. In times of disasters, imagery from the satellites may be made available at no charge to emergency first responders through a well-established distribution network.

Otherwise, the consortium members are free to do what they wish with the image data collected by their satellite, and they are able to share data with the other operators. Most of the satellites are government funded, and the imagery is provided by the operating

◀ FIGURE 1. Mount Hood smoking volcano, Oregon, U.S., captured Sept. 3, 2011.

◀ FIGURE 2. Track of the tornado in Moore, Oklahoma, U.S., imaged May 22, 2013.

▲ FIGURE 3. Colorado burnscar from wildfires, U.S., captured Aug. 13, 2013.

organization directly to in-country public and private entities for use in natural resource management, monitoring, and planning programs.

Nigeria has primarily limited its data applications to non-commercial projects internally. Spain, however, has taken advantage of the commercial option in the consortium structure to set up an international sales channel through a private remote sensing company called Deimos Imaging. The Spanish firm markets and distributes raw and enhanced image products from the Deimos-1 satellite worldwide—as there is no geographic exclusivity assigned to consortium members.

The benefits of the multi-satellite constellation are fully realized in the commercial operations of the consortium with DMCii serving as the business manager. DMCii's Stephens explained, "We provide a brand for the output of the constellation...and negotiate contracts on behalf of the consortium."

As noted, the rapid revisit and synoptic coverage of a coordinated satellite constellation have significant value in both commercial and government programs related to a variety of applications in nearly every country on Earth. DMCii has

already arranged long-term contracts with the United States, Australia, Brazil, and the Netherlands to receive image data from the satellites on regular schedules.

"Each satellite operator is given the option of participating in these large contracts," said Stephens. "Those who do participate share in the revenue stream generated by the deal."

Paffett at SST-US says there is no exaggeration to the claim that the financially attractive DMC business model has helped to democratize space for countries that might not otherwise be involved. Spain, for instance, has become a player in the international imagery market. And Nigeria, through its National Space Research & Development Agency (NASRDA), is now a sophisticated user of Earth observation technology, particularly for natural resource management.

In the first constellation, NASRDA saw a need and use for imagery but didn't anticipate it would become a revenue stream, Paffett explained. With DMCii

selling image data for NASRDA, its membership brought money back into Nigeria that helped further develop its programs.

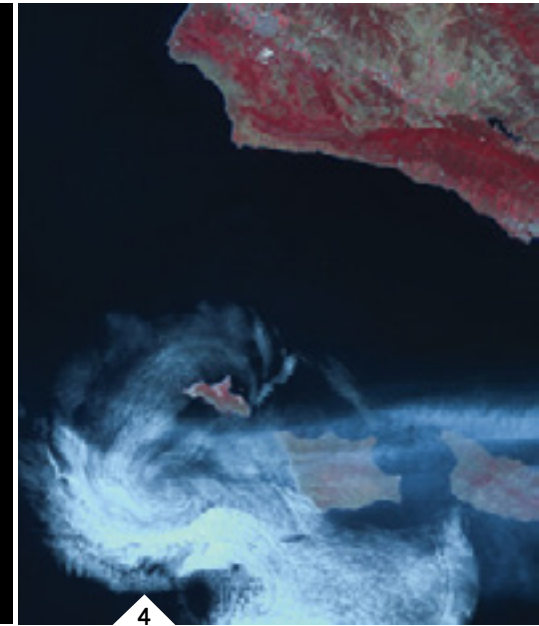
"Less than a decade ago, Nigeria had no space program, but they invested in the first generation of DMC satellites," said Paffett. "A few years later, they came back to Surrey with their own ideas for a higher-resolution imaging sensor suited for mineralogy, hydrology, and land use mapping, which was added to their NigeriaSat-2 spacecraft in the second-generation consortium."

For the sake of continuity, all initial DMC satellites

► FIGURE 4-5.
California Wildfires, USA,
imaged May 2, 2013.

Note:

All images are
UK-DMC2 satellite
images, 2011, SSTL,
all rights reserved,
supplied by DMCii.



used the Surrey SSTL-100 series spacecraft, carrying similar three-band mid-resolution imaging sensors. As an option, however, the satellite can accommodate an additional instrument, as is the case with the DMCii and Nigerian spacecraft.

A SUSTAINABLE FUTURE

Surrey Satellite enjoys a 25-year track record of 41 successful small satellite launches, including Low-Earth Orbit Earth observation and communications spacecraft, as well as Medium-Earth Orbit navigation and an ongoing development of Geostationary communication satellites. In addition to its innovative approach to small satellite technology, the company credits its longevity to a willingness to work with customers in developing satellite programs that are viable from a business perspective.

"That's how we arrived at the constellation business model...the concept evolved and will continue to evolve in response to market changes," said Paffett.

Paffett believes the constellation model could be a solution to the global economic situation where budget limitations are forcing governments, especially the United States, to take a second look at major expenditures like satellite programs. The U.S. budgetary situation is particularly acute because it has launched tremendously expensive navigation, weather, and Earth observation satellites that have become utilities the rest of the world relies upon at little or no cost.

“These programs have to become sustainable,” said Paffett. “One way to do that is for several coun-

telecommunications assets in orbit, but they are not in a position to purchase a satellite of their own,” said Paffett. “In these cases, leased access to satellite services may be the best option.”

Surrey has already moved in this direction offering managed services in which it procures advance agreements from clients to purchase time on planned satellites. Surrey then fronts the development and launch costs in anticipation of the future revenue stream. The company currently has three 1-meter-resolution Earth observation satellites under construction with 100 per-



tries, companies, or government agencies to share the cost of the satellites.”

He adds that not all satellites in a given constellation have to be identical for it to be effective. In fact, participants may be more willing to engage in a consortium if they will have a variety of satellite functionality at their disposal to meet multiple needs. Along these lines, Surrey is launching an all-weather synthetic aperture radar satellite called NovaSAR in 2015 that will participate in the DMC constellation. With funding from the UK government and industry partners, the NovaSAR radar sensor will complement the optical sensors in the existing constellation.

Despite the success of the DMC business model in helping Earth observation organizations stretch their investment dollars further than anyone imagined, Surrey already sees the need to adopt a modified business model to accommodate a different type of organization.

“There are organizations that could benefit from having their own imaging, navigation, or

cent of their imaging capacity leased to customers in advance, with additional capacity sales under discussion.

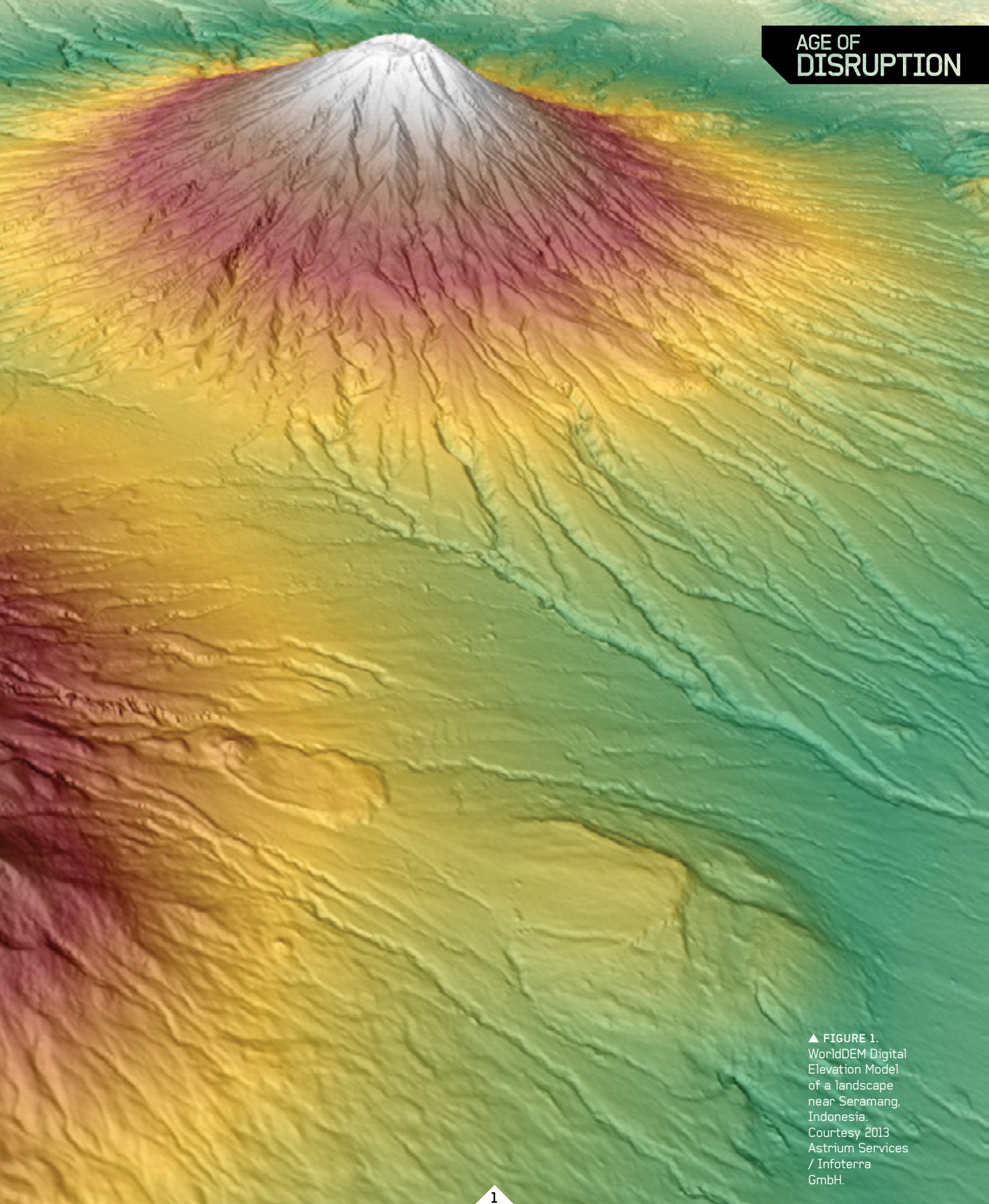
“For government agencies that have no procurement mechanism in place to buy a satellite, leased service is a fast and easy alternative that is practical for remote sensing, communications, or navigation,” said Paffett, adding that this model has long been used by telephone companies and television networks, which lease signal relay capabilities on telecommunications satellites.

“Budget constraints aren’t going to ease any time soon,” said Paffett. “At the end of the day, both private and public sector organizations have to address the issue of sustainability for their satellite programs to continue.”

Paffett says that Surrey has been successful with the DMC constellation business model and managed services concept because both are fundamentally focused on commercial viability—offering the best value solution at the right price. And this may require challenging the traditional operational and technical requirements of big satellite programs. ▲○

Astrium Services' WorldDEM Gets Ready

BY GERTRUD RIEGLER / WORLDDDEM PRODUCT MANAGER
ASTRIUM SERVICES / GEO-INFORMATION / FRIEDRICHSHAFEN, GERMANY
[HTTP://WWW.ASTRIUM-GEO.COM/WORLDDDEM](http://www.astrium-geo.com/worlddem)



▲ FIGURE 1.
WorldDEM Digital
Elevation Model
of a landscape
near Seramang,
Indonesia.
Courtesy 2013
Astrium Services
/ Infoterra
GmbH.

Beginning in 2014, Astrium Services' WorldDEM will provide a global Digital Elevation Model of unprecedented quality, accuracy, and coverage. A multitude of applications such as satellite image orthorectification, thematic mapping, aviation as well as defense and security-related missions will benefit from this unique dataset.

THE WORLD TWICE OVER

The TanDEM-X mission has recently accomplished a major project milestone: the second coverage of the Earth's entire landmass has been finalized. This means that the two satellites TerraSAR-X and TanDEM-X are ready to take the final hurdle of the data acquisition campaign. They are now focusing their full attention on the Earth's challenging terrain areas.

The twin satellites are taking a third and sometimes even fourth look at the high-altitude mountain ranges of the globe, like the Himalayas, the Alps and the Cordilleras in North and South America. The purpose of these additional data takes is to ensure that details that might otherwise be hidden due to radar shadow areas

such as steep terrain, valleys, canyons and gorges are made visible. The combined processing of these various data takes will ensure the global consistency and quality of the final WorldDEM product.

IT'S ALL ABOUT ELEVATION

Pole-to-pole coverage joined with unique accuracy and quality—these are the defining characteristics of the WorldDEM. The WorldDEM is a game-changing disruptive technology providing the first truly global, single-source, high-precision Digital Elevation Model from satellites. The product will feature a vertical accuracy of 2m (relative) / better than 10m (absolute) in a 12m x 12m raster. The accuracy will surpass that of any global satellite-based elevation model available

today. WorldDEM is intended to be the replacement dataset for SRTM and will define a new standard in global elevation modeling.

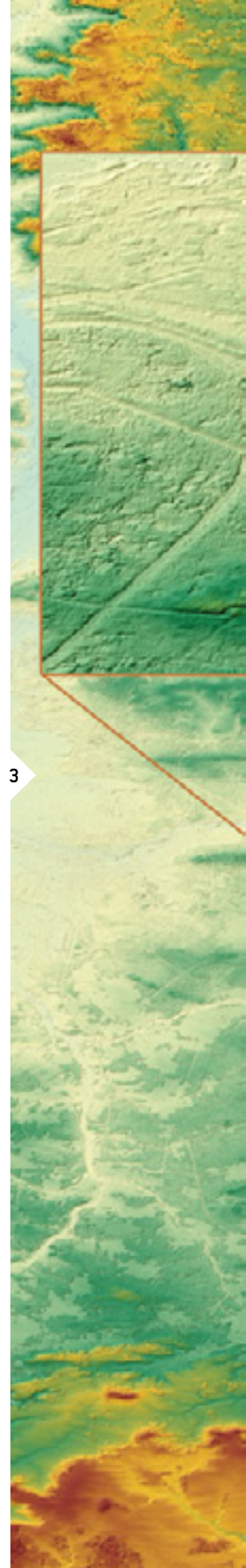
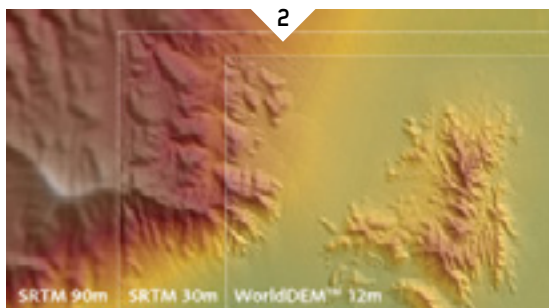
Precise elevation data is the initial foundation of any accurate geospatial product, particularly when the integration of multi-source imagery and data is performed based upon it. Fused data provides for improved reliability, increased confidence and reduced ambiguity. Thus the accuracy of the base DEM is key to reliable information.

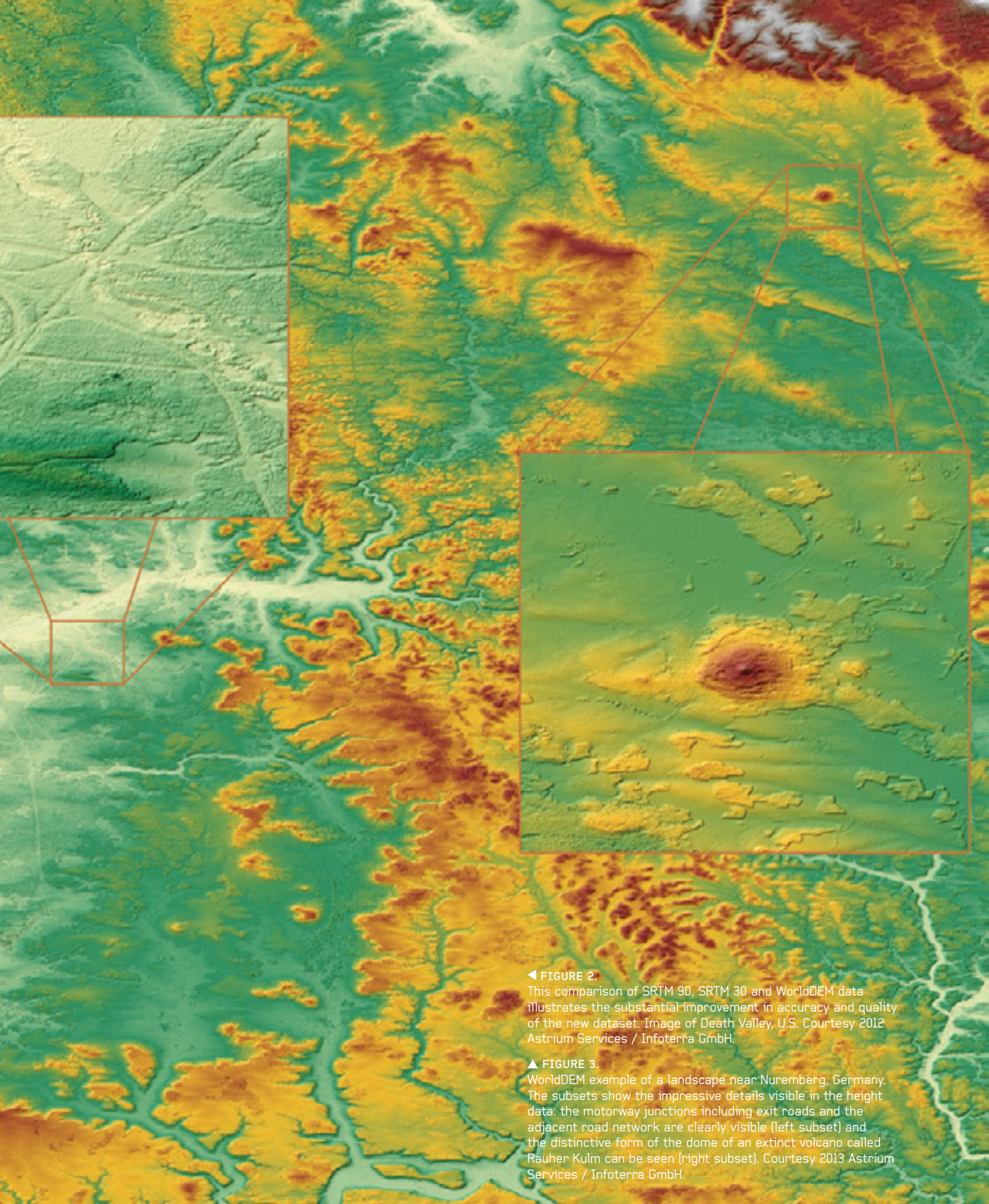
Thanks to WorldDEM, operators of civil and military Earth observation satellites will have a standardized elevation model at their disposal for high-quality image orthorectification—no matter where their acquisition area is located on the planet.

Cartographic authorities around the world will be able to improve or update their standard cartographic maps thanks to this more accurate and up-to-date data source.

Another area where the WorldDEM can make a valuable contribution is aviation. The highly precise and globally available DEMs combined with additional information provide improved input data for collision avoidance systems, ground proximity warning and flight management systems. WorldDEM supports flight path and landing area planning, even in remote and difficult-to-access areas.

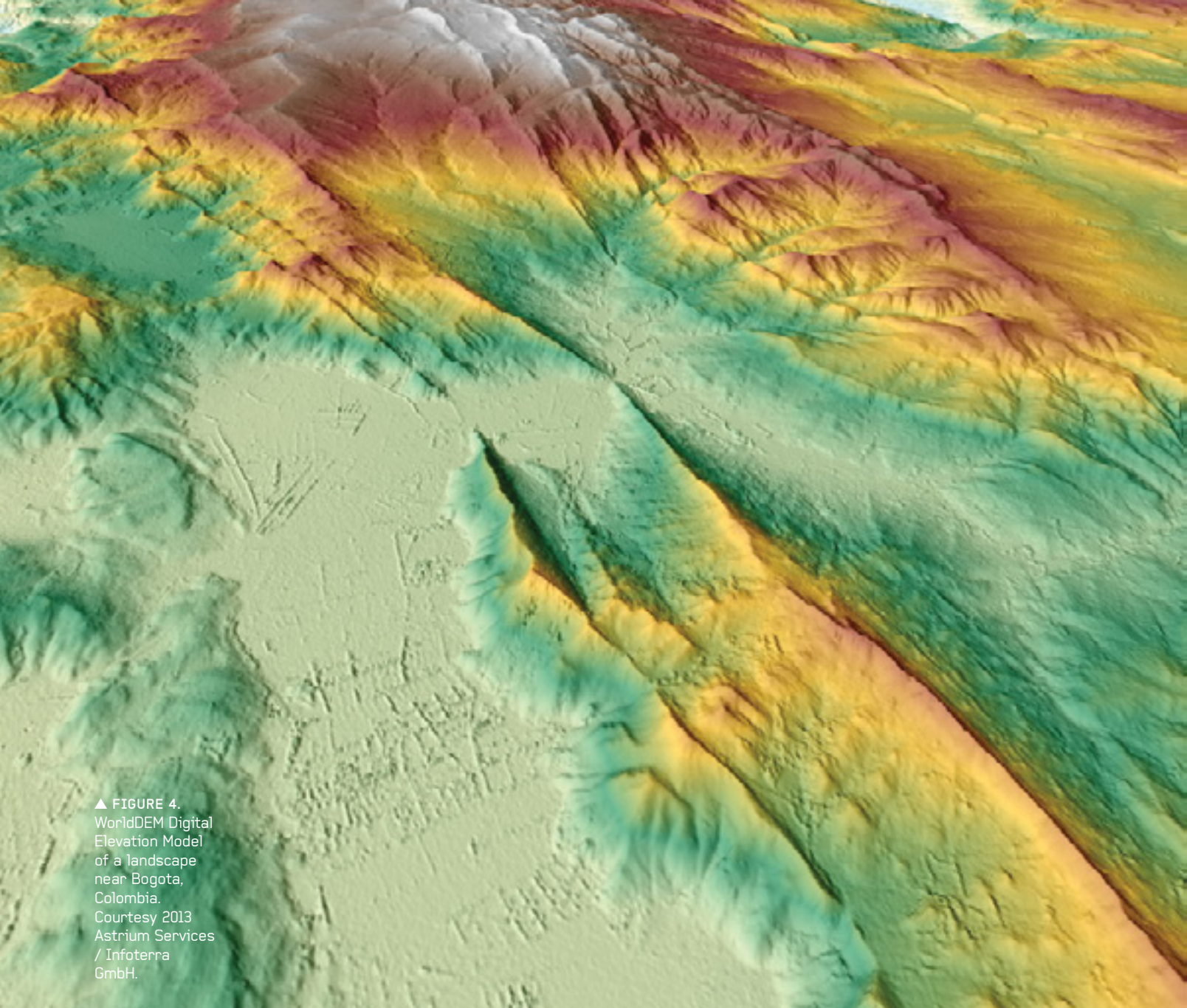
The global availability of the dataset will also support international cooperation and cross-border mission planning. Particularly when the rapid provision of accurate information is of utmost





◀ FIGURE 2.
This comparison of SRTM 90, SRTM 30 and WorldDEM data illustrates the substantial improvement in accuracy and quality of the new dataset. Image of Death Valley, U.S. Courtesy 2012 Astrium Services / Infoterra GmbH.

▲ FIGURE 3.
WorldDEM example of a landscape near Nuremberg, Germany. The subsets show the impressive details visible in the height data: the motorway junctions including exit roads and the adjacent road network are clearly visible (left subset) and the distinctive form of the dome of an extinct volcano called Rauher Kulm can be seen (right subset). Courtesy 2013 Astrium Services / Infoterra GmbH.



▲ FIGURE 4.
WorldDEM Digital
Elevation Model
of a landscape
near Bogota,
Colombia.
Courtesy 2013
Astrium Services
/ Infoterra
GmbH.

importance (for instance in case of emergency situations like natural or environmental disasters), the availability of a standardized, highly accurate DEM will be a major advantage as it enables the provision of reliable information to rescue teams on ground.

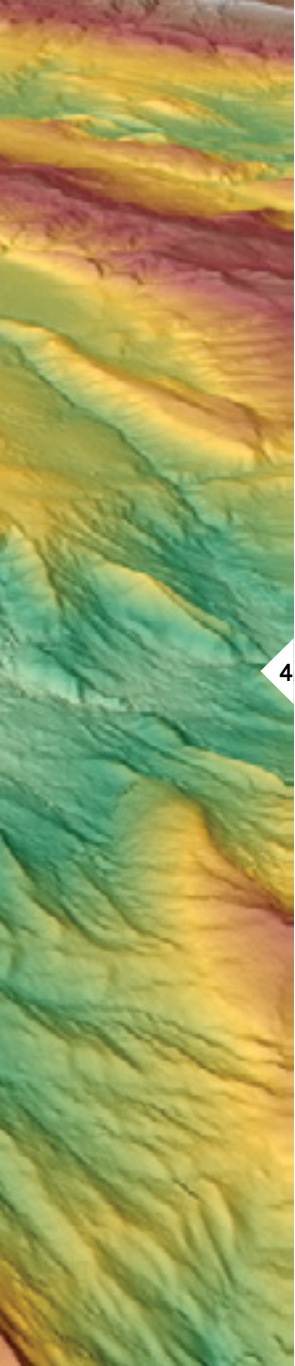
VERSATILE PRODUCT

The WorldDEM is built on the global TanDEM-X DEM as acquired by the TanDEM-X mission, which is performed jointly with the German Aerospace Center (DLR). Astrium Services holds the exclusive commercial marketing rights for the data and is responsible for the adaptation of the elevation model to the needs of commercial users worldwide.

Astrium Services will refine the DEM according to customer requirements, e.g. editing of water surfaces or processing to a Digital Terrain Model (representing the bare Earth's terrain).

Initially three core WorldDEM products will be available:

1. A basic Digital Surface Model that includes the heights of all natural and man-made objects.
2. A hydro-enforced Digital Surface Model with water body features derived from the radar image. Water surfaces of lakes and reservoirs are set to a single



elevation, rivers and canals are flattened with monotonic flow, oceans are set to zero and coastal infrastructure features are removed. This product is ideal for high-quality image orthorectification.

3. The Digital Terrain Model (DTM) represents the bare Earth elevation with all vegetation and man-made objects removed. This product provides detailed terrain information for even the most remote and difficult areas and reveals small-scale terrain structures that are covered by vegetation.

Building on this core WorldDEM offering, Astrium Services plans to provide an expanded portfolio,

weather-independent Elevation10 DEMs all the way to highly precise locally available DEMs at 1m and 4m resolution.

TECHNICAL SOPHISTICATION

Technically the TerraSAR-X and TanDEM-X mission (implemented as a Public-Private Partnership between the German Aerospace Center DLR and Astrium) is a true novelty and already a great success. The two satellites form the world's first free-flying high-precision radar interferometer in space. They fly in a very close formation with distances of as little as a few 100m—a technical feat that has never been tried before and that has now

“The acquisitions are not recorded region by region, but rather in the style of a jigsaw. Seemingly random acquisitions are made in different locations across the globe and piece by piece the jigsaw is completed with the overall picture becoming visible once all pieces are assembled.”

including Global Ocean Shoreline, Waterbody Map, and Global Airport / Harbour Map.

The WorldDEM offering is a logical complement and continuation of Astrium Services' established GEO Elevation product range. The company offers a comprehensive elevation data range derived from both optical and radar satellite data. Leveraging decades of experience deriving elevation products, Astrium Services now offers precise and reliable elevation data for any location on Earth ranging from global coverage to local detail. The DEMs span the entire bandwidth from large-area Elevation30 DEMs at DTED-2 level available off-the-shelf for >70 Million km² worldwide through regional

been working with perfect reliability for more than 3 years. Safe operation of this uniquely close coordinated flight of two satellites at an average speed of 28,000km/h is ensured through a Helix formation of the two spacecrafts.

The data acquisition is performed in the so-called bi-static mode. One satellite transmits the radar signal to the ground, while both satellites record the signal's backscattering. (In a classic i.e. mono-static radar configuration, the same antenna is used for transmission and reception of the signal.) This means that one satellite is only “listening” to the signals that come back from the ground, which means that this one can save battery power and keep

its radar instrument cool. By applying the so-called SAR-Interferometry (InSAR) technique, the phase difference of the two acquisitions is evaluated and the elevation information can be extracted.

The two SAR sensors operate independent of cloud coverage and lighting conditions and thus acquire data absolutely reliably. The worldwide homogeneous acquisition guarantees a global DEM with no break lines at regional or national borders and no heterogeneities caused by differing measurement procedures or data collection campaigns staggered in time.

The concept of the mission is to complete the global homogeneous DEM in the shortest possible time frame. To achieve this ambitious goal, the acquisition

For the third and fourth coverage, an even more complex adjustment was performed: the formation of TerraSAR-X and TanDEM-X was revised in early August. At the start of the mission, TanDEM-X circled around TerraSAR-X in an anti-clockwise direction; after the satellite swap, it is now clockwise. This change of formation was necessary to view complex mountainous terrain from a different viewing angle to eliminate missing information due to radar effects.

For the safe performance of this complicated manoeuvre, the distance between the satellites was first increased to approximately 10km. For the flight path adjustment, TanDEM-X was then rotated 180° so that the thrusters acted in the desired direction.


“The formation of TerraSAR-X and TanDEM-X was revised in early August. At the start of the mission, TanDEM-X circled around TerraSAR-X in an anti-clockwise direction; after the satellite swap, it is now clockwise.”

plan is optimised for time-efficient coverage of the Earth's entire landmass. As a result, the acquisitions are not recorded region by region but rather in the style of a jigsaw. Seemingly random acquisitions are made in different locations across the globe and piece by piece the jigsaw is completed with the overall picture becoming visible once all pieces are assembled.

SATELLITE SWAP

Following the first complete coverage of the Earth's surface (concluded in early 2012), a slight adjustment to the acquisition angles of the satellites was made for the second coverage to eliminate remaining height ambiguities in first coverage data takes. While the first coverage already generated quality levels close to the final dataset specifications, with the second coverage, now dual baseline processing techniques are applied to increase the homogeneity of the global coverage.

Following the successful modification of the flight path, TanDEM-X then started slowly to catch up again with its twin satellite to achieve the nominal distance of a few hundred metres. After the swap, both satellites are now once more able to observe the same ground track on the Earth's surface. The complex manoeuvre took in total three days and was successfully executed by the experts at DLR.

The excellent cooperation and integration of expertise between the partners Astrium and DLR have resulted in an exceptionally smooth preparation and realization of the TanDEM-X mission. The exploitation of the advantages of SAR technology and multiple coverages of the Earth's surface secure a highly homogeneous and accurate product for the marketplace. Customers from private industry and public authorities alike can be assured that from 2014 they can rely on the new highly precise base dataset for a multitude of applications. 



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