# APOGEO SPATIAL

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FORMERLY Imaging NOTES

PROUD MEMBER OF LMA LOCATION MEDIA ALLIANCE

[ Winter 2013-14 / Vol. 29 / No. 1 ]

Image from DMCii shows Poyang Lake, drying up in the eastern China province of Jiangxi. See details on page 4.

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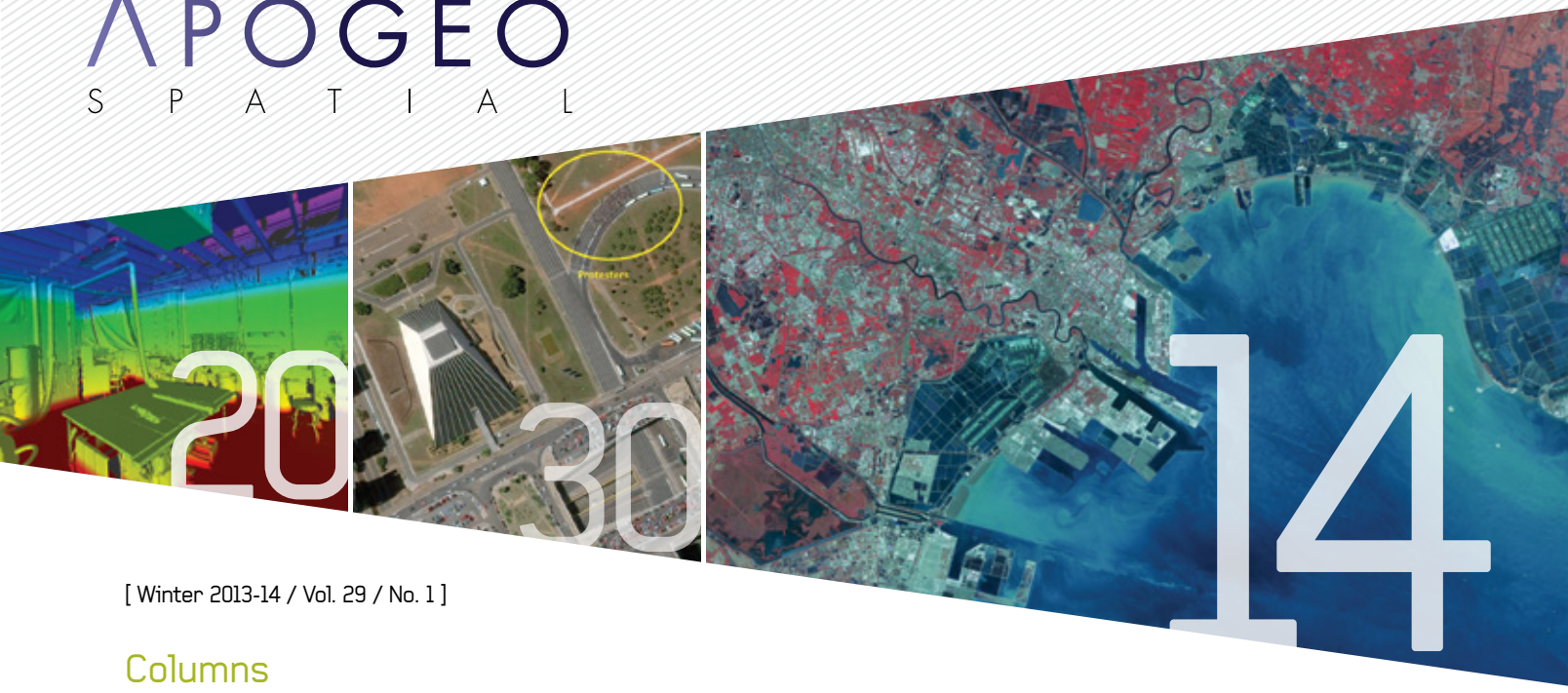


[ Winter 2013-14 / Vol. 29 / No. 1 ]

## Columns



## Departments



## Features

COVER IMAGE

# Jiangxi, China

## POYANG LAKE

REMOTE SENSING DATA IS USEFUL and often profound in its ability to show important changes on the Earth's surface. Images are very powerful, because our minds comprehend the point quickly.

This image on our front cover of east China's Jiangxi province shows Poyang Lake, which is drying up due to the current drought, and to the complications of water management with the Three Gorges reservoir located 500 km upstream. It was China's largest freshwater lake, and now many people are affected, including fishermen needing new income. Scientists found that the artificial regulation of the water levels in The Gorges reservoir contributes to low water levels downstream. (Source: The Guardian, Jan. 31, 2014: http://www.theguardian.com/environment/2012/jan/31/china-freshwater-lake-dries-up)

This image was taken Jan. 21, 2014, and is courtesy of DMC International Imaging. Images are available on www.dmcii.com and www.flickr.com/photos/dmcii. DMCii supplies satellite imagery products and services to a wide range of international customers for agriculture, forestry, landcover mapping and other applications. These examples are from the UK-DMC2 satellite that collects multispectral data at 22-m resolution in the green, red and NIR bands. More images appear on pages 22-23.

APOGEO SPATIAL

*Formerly* Imaging Notes

[ Winter 2013-14 / Vol. 29 / No. 1 ]

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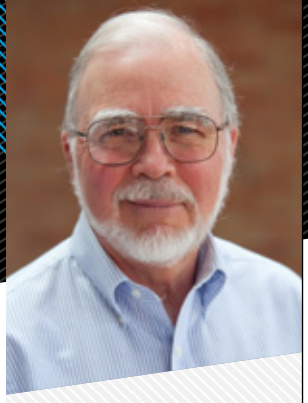

# Building an Earth Observation Network

## A MESOAMERICAN EXPERIENCE

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THE LUSH TROPICAL LANDSCAPE of the state of Chiapas, Mexico, seems an unlikely place to encounter an institution focused on theoretical physics, but the Mesoamerican Center for Theoretical Physics (MCTP), located in Tuxtla Gutierrez, the capitol of Chiapas, offers programs that cover the full scope of theoretical physics. It also seeks to offer more practical science and technology topics of special interest to the region. It therefore proved an excellent host for an intensive international meeting on Earth observations, the first of its kind in the region.

Indeed, in November 2013, MCTP hosted a high-level bilingual practicum focused on the use of space science and technology for the prevention of and response to disasters in Mesoamerica. Secure World Foundation (SWF), the Regional Centre for Space Science Education for Latin America and the Caribbean (CRECTEALC), and the National Oceanic and Atmospheric Administration (NOAA) joined forces with several Mesoamerican organizations to bore in on the potential for making more effective use of satellite data and geographic information systems (GIS) to reduce the toll that natural disasters wreak on people and property in the region.

This was a particularly fitting subject as Chiapas lies in a geographical region subject to more than its share of the world's natural disasters—hurricanes, earthquakes, flooding, and drought are all too common. A major tropical storm or hurricane can leave the residents of the region reeling for weeks afterward from widespread flooding. In fact, on the long drive southeast from CRECTEALC's headquarters in Tonantzintla, Mexico (near Puebla) along the raised highways across the lowlands inland from Veracruz and Villahermosa, we witnessed vivid evidence of the widespread flooding that resulted from rainfall generated by Hurricane Ingrid, which struck eastern Mexico near Veracruz, dropping heavy rains in mid-September.

Even in November, many homes and farm fields remained inundated. Not only does flooding cause extensive property damage, but it also fosters the development and spread of lethal vector-borne diseases, including malaria and chagas by enhancing breeding grounds for their hosts, mosquitos and triatimines, respectively.

This workshop was designed as a capacity-building effort, specifically focused on sharing methods, tools, data sources and software designed to reduce the risk of damage to lives and property from flooding. It was also centered on building a Mesoamerican network of professionals willing and able to share their expertise with disaster management officials in the region. This was a particularly auspicious time to hold such a workshop there because the State of Chiapas had recently set up an integrated program in disaster risk reduction.

In addition to the organizers, experts came from the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) in Panama, the Center for Agronomy Research and Education (CATIE) in Costa Rica, and several institutions in Mexico. Presenters from NASA, USAID, and UN SPIDER joined the workshop from afar.

Presentations and discussion covered a broad range of activities, data sources and methodologies. Because financial resources are often limited in Mesoamerican countries, the workshop emphasized especially the availability of free data and free, open-source software and training in their use. Of particular note were

presentations of the open-source GIS software, Q-GIS and its module on disaster mitigation and response, and the recently developed software, TerraMA² from INPE. Q-GIS is the successor to the venerable GRASS GIS software, developed and enhanced throughout the 1980-90s.

TerraMA² developed by INPE computer scientist, Dr. Eymar Silvio Lopes, is an operational open-source platform designed to monitor and warn of environmental risks in the landscape. The software package can be programmed to generate warnings for a wide variety of environmental risks, including air or water quality, epidemics, seismic activity, fires, floods, drought, tidal movements, and interruptions in the transmission and distribution of energy—in short, any hazard where one has spatial and temporal data over the risk period.

Data ingested can originate from satellites or from a network of ground-based sensors. Model output can be in a variety of forms, including tables and vector or raster maps. The software can be programmed to provide automatic warnings for any areas of risk. Dr. Lopes demonstrated the package and conducted a training exercise on it.

Remote presentations included one on the Famine Early Warning System Network (FEWS NET) in Mesoamerica, which focuses on providing information of famine or flooding for agriculture, the resources of the UN SPIDER program, NASA's Applied Remote Sensing Training (ARSET) program (which offers both web-based and in-situ training), and NASA's support of data and tools for disaster risk management as part of its contribution to the Committee on Earth Observations (CEOS).

On-site presentations included a review of data policy issues and the use of crowdsourcing to speed data analysis and community remote sensing to enhance the effectiveness of rescue efforts. NOAA contributed important information about the CEOS Data Democracy effort to provide data, software and training to developing communities, and about the Global Earth Observation System of System (GEOSS) GEONETCast, a low-cost satellite-based data and product dissemination system.

Most of the inexpensive or free data available are relatively low resolution, excellent for broadscale analysis, but for detailed analysis, higher resolutions and quick access are needed.

Commercially focused startup companies like Newspace, Planet Labs and Skybox are launching systems that they hope will change the entire cost equation of the Earth observing industry, providing relatively high-resolution, extremely timely but low-price data to a broad cross section of customers. As noted in the Fall 2013 issue of *Apogeo Spatial*, these firms expect to offer daily or nearly daily coverage of most of the entire Earth at highly competitive prices. If successful, these companies may well come to the rescue of budget-pressed civil protection organizations.

The ability to obtain low-price relatively high-resolution data would also substantially assist the recovery and rebuilding effort. These phases, which are exceedingly important for affected communities to return to normal functioning, are not currently served by the excellent disaster response efforts of the International Charter: Space and Natural Disasters, or UN SPIDER, which concentrate more on the immediate disaster response period. Nevertheless, the availability of overhead data can speed the recovery and rebuilding process.

Workshop participants were not passive listeners. Discussion, which was one of the key features of this workshop, focused on how to improve the level of knowledge about geospatial techniques and their application to disaster mitigation and response. Even more than 40 years after the launch of the first Landsat satellite, few disaster professionals in Mesoamerica are familiar with the assistance that geospatial data and analytical tools can provide them in enhancing their work. Part of the difficulty is that there exist few case examples sufficiently devoid of confusing technical language to speak directly to the needs of disaster mitigation and response professionals and illustrate how they can use these techniques to enhance the effectiveness of their work.

It also became clear that Mesoamerica lacks an organized network of GIS professionals who focus on disaster mitigation and response. This workshop became the opportunity to start one, which will be hosted at CRECTEALC. CRECTEALC, CATHALAC, and CATIE also offer training courses that can readily be tweaked to provide training in geomatics for disaster mitigation and response. Overall, this workshop raised awareness of the need to improve the availability of disaster mitigation and response resources for Mesoamerica, and started participants on the way to doing so. ∧♂

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# Humanity for Economy or Economy for Humanity?

## WHAT TO TELL YOUR 20-YEAR-OLD SELF

READING MY COLUMNS, YOU MIGHT WALK AWAY with the impression that I am crying "wolf" all the time and do not see a way out of the deleterious path we are on. This would be a wrong impression. When I was much younger, I often went up into the mountains in Corsica, Austria and Switzerland alone in February and March, with no mobile phone to call for help or satellite navigation tools to guide my way, but with enough food to survive should I get stuck for weeks. I exposed myself to difficult terrain, terrifying snowstorms, and decision-making that was truly existential: a wrong decision would have meant death.

During these times I learned to accept facts, and I also learned to always know the way out. Humanity has all the capabilities needed to get out of the situation we are in with a growing population precipitating into densely populated urban coasts, on a warming planet with rising sea levels, diminishing water and food security, and a growing energy usage based on unsustainable sources. We just need to want to get out.

The hardest decisions for me alone in the mountains were the few times when I had to realize that changing weather conditions had brought a lot of new snow, increased the danger of avalanches, or covered all rocks with thick layers of ice, which made it impossible to continue on my path. I had to find the shortest, and sometimes extremely tedious way out. It is hard to give up on a goal. Or to change a lifestyle.

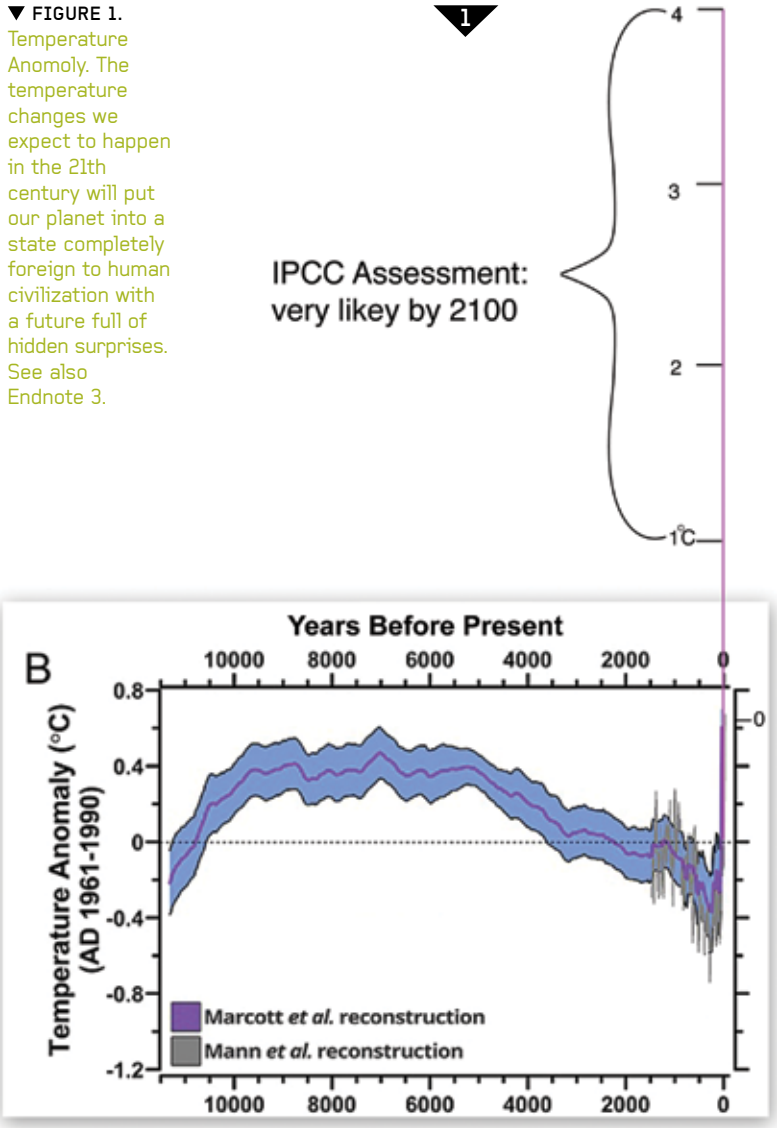
The fifth assessment of the Intergovernmental Panel on Climate Change (IPCC) of our common knowledge on climate change has a cogent message: The planet is on its path to a much warmer state.[1] And this state may not be very convenient for us. Are there signs that we will make the necessary changes in how we are in the world to mitigate climate change to any discernible amount? I am afraid, not too many.

It is embarrassing to find out that at the Nineteenth Conference of the Parties (COP 19) of the United Nations Framework Convention on Climate Change (UNFCCC) in November in Warsaw, Poland, 132 of the poorer countries in the world had to stage a walk out from a session discussing responsibility for the damage caused by climate change in these countries.[2] We are not very serious about changing our lifestyle or taking responsibility for the damage we are doing to the developing world.

In my teaching, I often take an approach similar to a doctor's approach to a patient in a first consultation: I look at the observations and describe what they tell us about the state of the planet and the trends. For those looking for sustainability, Earth observations are what lab measurements are for the doctor who is concerned about the health of a patient. To visualize the extent of the change we are seeing in the "patient" Earth, I combine the temperature changes during the last 11,000 years with those likely for this century and I tell students that I am frightened when I see how far Earth is likely to move out of the "normal."[3] See ***Figure 1***. Students often thank me for the clarifying lectures.

Recently, a student wrote to me, "The question I have been asking myself following

▼ FIGURE 1.
Temperature Anomoly. The temperature changes we expect to happen in the 21th century will put our planet into a state completely foreign to human civilization with a future full of hidden surprises. See also Endnote 3.




your presentation is, what am I to do?" Then she confronted me with an obvious, though surprising question: "What would you like to tell your twenty year old self?"

Of course, I have been thinking a lot about what "we" could do, but I never looked at it from this angle: What would I tell my twenty year old self? It is a very important question, going far beyond me, saying that the party we have been having in the developed world for the last 50 plus years is coming to an end and the twenty-year old ones of today will have to do the cleaning up.

What would I have told my twenty year old self had I been that age in 1930 in Germany? Studying the critical newspapers, books, poems, paintings, and other documents of the 1920-30s, I find it was all there, but most of the twenty year olds of that time did not listen (and in fact those who persuasively described what was coming mostly paid with their lives for it).

Which of the thoughts older and wiser people shared with my younger self helped me to find my way at the age of twenty living in post-war Germany and Europe? At that time, "The Limits of Growth" was published by the Club of Rome (actually exactly when I was twenty), and this book, despite many issues, made one thing clear

"Redefined sustainable development is 'development that meets our needs while safeguarding Earth's life-support system, on which the welfare of current and future generations depends.'"

> "An economy that increases 'wealth' by burning fossil fuels and destroying Earth's life-support systems is like a doctor who practices medicine by killing the patient."

2

▲ FIGURE 2. Planet. People. Economy. The paradigm shift to an economy for humanity: "An economy that meets our needs while safeguarding Earth's life-support system, on which the welfare of current and future generations depends."

to me: we are living on a finite planet.

Later, the data collected by paleo scientists, Earth observations documenting the rapid changes of the planet's surface, and the words by James Lovelock and other insightful thinkers convinced me that the planet is in a precarious dynamic equilibrium and even small causes can lead to dramatic changes in dynamics, climate and sea level. Those who were not afraid of facts and complexities were the ones who impacted me most and got me engaged.

If I were twenty today, what would help me if I heard it from the older ones? "We are on the Titanic after it hit the iceberg! Go find the life-boats!" Or something more like, "We are about to hit the iceberg and here is what we need to do to avoid it." The one thing I always wanted to hear is the truth, the facts, the options, the answers to the "What if..." questions.

Here are some thoughts I would pass on to my twenty year old self:

Hope for a way out is in the fact that humanity is looking for a better future. The Millennium Development Goals are one of the visible signs of the search for a way out. And now, the world leadership is discussing a replacement of the Millennium Development Goals with the Sustainable Development Goals (SDGs). A recent article proposed six SDGs I am sure we all can agree to.[4] The article also redefined sustainable development as "development that meets our needs while safeguarding Earth's life-support system, on which the welfare of current and future generations depends."

The authors illustrate sustainable development by a picture of the planet symbolizing the life-support system, humanity inside of it, and in the center of humanity they place economy symbolized by coins. See ***Figure 2***. The moment I saw this sketch, I thought of a doctor whose sole goal is coins. It wouldn't be a doctor to whom I would want to entrust my life. An economy that increases "wealth" by burning fossil fuels and destroying Earth's life-support systems is like a doctor who practices medicine by killing the patient.

We need a paradigm shift to an economy for humanity, an economy that meets our needs while safeguarding Earth's life-support systems. In this new economy that comprises all our interactions with Earth's life-support system, scientists are the doctors who keep us informed about the health of the life-support system, and Earth observations provide the lab results urgently needed for early detection of any deviation from a healthy state.

This is what I would like to tell my twenty year old self, and my older self as well: go, and fight for the paradigm shift to an economy for humanity, without which humanity has little chance to persist much longer. Go, and do not rest before this transition is accomplished. ∧○

Footnotes:

1 Stoker et al. (eds.), 2013. Climate Change 2013 - The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change - Summary for Policymakers; http://www.climate2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf

2 "Poor countries walk out of U.N. climate talks as compensation row rumbles on," by John Vidal, *The Guardian*, 20 November 2013; http://www.theguardian.com/global-development/2013/nov/20/climate-talks-walk-out-compensation-un-warsaw

3 Marcott, S. A. et al., 2013. A Reconstruction of Regional and Global Temperature for the Past 11,300 Years. *Science*, 339, 1198-1201.

4 Griggs, D. et al., 2013. Sustainable development goals for people and planet. *Nature*, 495, 305-307.

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QUARTERLY LOCATION BUSINESS NEWS

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

## LOCATION ECOSYSTEM

1. Purdue University to Create Hub for Geospatial Data Hosting — 11/27/2013

   Purdue University researchers are launching a four-year project that will allow anyone to input geospatial data and create multilayer maps to help the public and policymakers make more informed decisions on topics such as disaster management, land use and environmental protection. The $4.5 million project is funded by the National Science Foundation and aims to make sophisticated analytical and modeling tools available through the Web and allow sharing. http://bit.ly/1epDvMR

2. GAO: Car Navigation Systems Fail to Disclose Data Uses — 01/08/2014

   In-car navigation services including OnStar and Google Maps are not doing enough to let customers know what data are being collected about their vehicles' location, according to a U.S. Government Accountability Office report. Nine of 10 companies included in the report share location data with third parties but do not give consumers the option to delete data or provide specific information about why it's collected. http://bit.ly/1fl75AT

3. Google Axes "Accidental" Privacy Control Panel for Android — 12/18/2013

   Google's latest Android operating system release eliminated an experimental privacy control panel that allowed users to prevent mobile applications from gaining certain permissions such as access to location data. Google told the Electronic Frontier Foundation the feature was released accidentally and noted the privacy controls made it so some apps didn't work. http://bit.ly/1biuGD6

## INDUSTRY APPLICATIONS

1. U.S. Agency to Undertake Global Map for Predicting Disasters — 11/20/2013

   The National Geospatial-Intelligence Agency is looking to build a map of the globe that combines physical location with demographic, environmental risk factors and political climate data so the U.S. military can better respond to humanitarian disasters and terrorist threats. http://bit.ly/1acQi5A

2. Geo-targeted Ad Growth is Expected to Surge as Marketers Realize Advantages — 11/06/2013

   Spending on geo-targeted mobile ads is expected to reach $725 million this year and more than triple to $2.74 billion by 2017, according to an estimate by BIA/Kelsey. "We're seeing enormous interest in this type of marketing from mainstream brands, far more than we did 18-24 months ago. Brands are realizing that consumers are increasingly using the mobile device to navigate the physical world…" said Alistair Goodman, CEO of Placecast, a location-based advertising provider. http://bit.ly/1gC1jjI

3. Gamers Help Boost the World's Crop Production with Mapping Game — 12/04/2013

   A new game from Geo-Wiki called Cropland Capture lets gamers play a part in helping to map the world's farmland, and potential farmland, by identifying areas on aerial photographs. "We know, for example, in Africa, there are huge yield gaps. This means you could produce much more food in certain places in Africa, but we don't even know where exactly the cropland is," said project leader Steffen Fritz, adding that the results of the game will be the first steps in creating an accurate global crop map. In the first week, gamers surveyed 65,000 square kilometers of land. http://bit.ly/1ik6p1p

## BUSINESS AND STRATEGY PLANNING

1. How Location Analytics are Changing Sales Strategies — 11/20/2013

   Location analytics are providing businesses with several new strategic avenues for improving sales, Linda Hecht of Esri writes. More detailed maps help businesses spot trends by layering demographic, sales and lifestyle information, while map-based analytics can offer precise answers to spatial queries. http://bit.ly/1gC1jjI

2. Viewpoint: Location Functions Shouldn't Take Over a Mobile App — 01/08/2014

   Mobile location data companies often try to promise too much and end up confusing consumers, brands and application developers alike, Esri head of research and development Amber Case said. "When done well, (adding location to an application) is beautiful. But often people want to do too much and it ends up falling apart," she says. "Simpler is better." http://bit.ly/1fl75AT

3. Esri to Open Up Geotrigger to App and Software Developers — 11/13/2013

   Esri will release an application programming interface and software development kit for its ArcGIS Geotrigger service later this month to allow developers to create apps based on the service. Developers can use the API to build a geofence around a Starbucks that sends nearby users a notification or alert that can be sent to utility workers of hazards in a particular area, Esri research and development director Amber Case said. http://bit.ly/MLbp4Q

Sensors & Systems

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/1hMKUph.

| OCTOBER | NOVEMBER | DECEMBER |
|---|---|---|
| NASA Invites Students to Sign Up to Control International Space Station Camera http://bit.ly/1ef6EtP | Geospatial Data Project Lets Anyone Put Almost Anything on a Map http://bit.ly/1faZYMR | International Map Makers Create Maps of Scientific Data http://bit.ly/1e61aTU |
| we-do-IT's LatLonGO Mobile Tablet GIS Solution Achieves SAP Certification http://bit.ly/1d71n30 | GIS Analyst Climbs the Career Ladder with Newfound Credentials http://bit.ly/MsJTcj | Esri Introduces ArcGIS for Electric and Gas http://bit.ly/LmlLai |
| Astrium Services and IHS Sign a Partnership Agreement to Support GeoInt Community http://bit.ly/MduV96 | U.S. GIS Market Will Grow at CAGR of 10.96% in 2016 http://bit.ly/1i9qd7E | U.S. Air Force Awards Lockheed Martin a Contract to Complete Two More GPS III Satellites http://bit.ly/1lleqla |
| Solar Powered Robo Raven Extends Monitoring Missions http://bit.ly/MsHIFD | South Korea Successfully Deploys an Infrared Radar Science Satellite http://bit.ly/1fb1cGA | Precision Farming Market Worth $3,721.27 Million by 2018 http://bit.ly/1llevM4 |
| Orbit Logic Sponsors Balloon Launch of CubeSat http://bit.ly/1dMD8HI | New Outdoor Drone Will Aid Mapping and Monitoring of Radiation http://bit.ly/1iJrdID | Esri Story Map Shows Charles Darwin's Voyage Around the World http://bit.ly/1nhfdse |
| Russian Federal Space Agency Hopes to Remove Satellite Resolution Restriction http://bit.ly/Lmj4pj | Global Map Provides New Insights Into Land Use http://bit.ly/1goKNUc | Skybox Releases First Images from SkySat-1 http://bit.ly/1goMtgy |
| New Book Promises to Demystify Business Cases for GIS and IT http://bit.ly/1fv2rRl | Celebrate GIS Day 2013 with the University Libraries http://bit.ly/1fb1NrL | Amazon Web Services Leverages Amazon RDS for PostgreSQL http://bit.ly/1csSFAp |
| Ordnance Survey Launches OpenSpace SDK for Android http://bit.ly/1e5Zz0d | Lockheed Martin GPS III Satellite Prototype Communicate Successfully with GPS Satellite Constellation http://bit.ly/1bxa8Uh | HP Harnesses Big Data to Drive Environmental Progress http://bit.ly/1mVjBds |
| Popular Mechanics Breakthrough Awards Honor Innovations Including Sensors and Drones http://bit.ly/1ewgSmc | Drones in the Port of Hamburg http://bit.ly/1hLf63W | Polar Geospatial Center Releases New Application with High-res Satellite Imagery http://bit.ly/1e62g20 |
| Grant Enables County to Resume Landslide Mapping http://bit.ly/1mVenhO | Russian Satellite Mission Launches 24 Payloads http://bit.ly/1e6152y | Book: Mapping Disease for a Multidisciplinary View http://bit.ly/1fv6htP |

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EXECUTIVE VIEWPOINT

DR. STUART EVES
LEAD MISSION CONCEPTS ENGINEER
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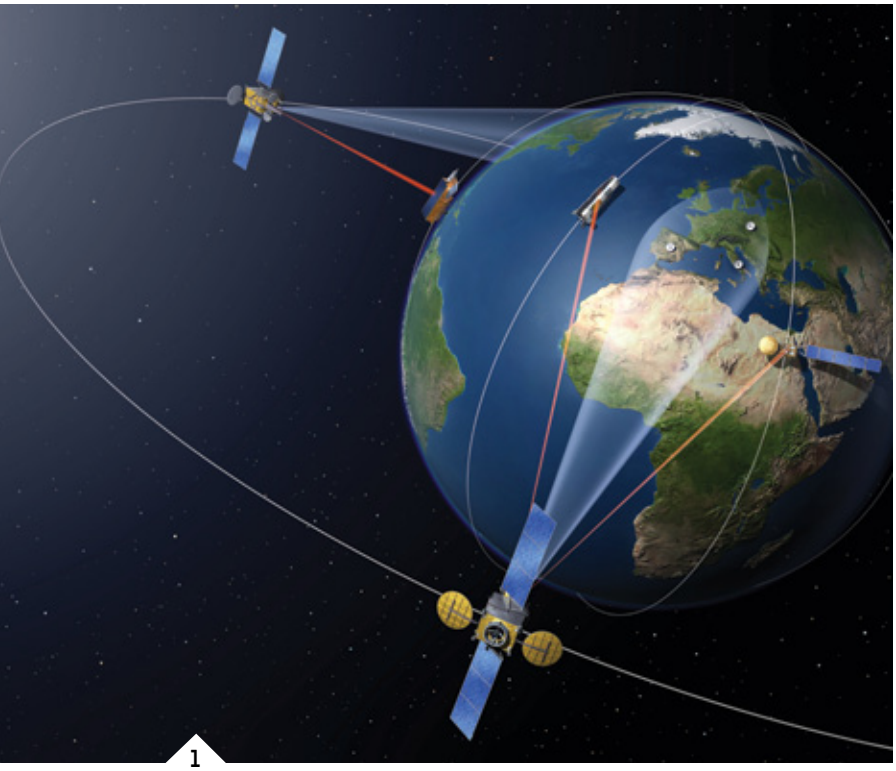
# Move Over Geospatial; Here Comes Hydrospatial



1

▲ FIGURE 1. Artist's concept of EDRS, courtesy of ESA.

As 2014 commences, Moore's Law is alive and kicking. This has significant implications for the design of Earth-observation satellites, and by extension, for the geospatial community, which exploits the data which they collect.

Because of Moore's Law, the satellite hardware required to provide geospatial data is getting smaller and cheaper. This is a consequence of developments in terrestrial components, which are now being incorporated into "on orbit" designs. Data products which previously required a "mainframe" satellite can now be supplied by one of the "laptops" of space, and this has made commercial remote sensing an increasingly viable market.

This trend will continue, as larger satellite memories, more on-board processing, and faster downlink data rates result in increased satellite duty cycles and hence a better return on investment.

More importantly, perhaps, the decreasing costs associated with individual satellites mean that constellations incorporating multiple missions are now an affordable proposition. This clearly results in both significantly greater area coverage rates and much shorter revisit opportunities. Hence, change detection products comparing a given scene with an image of the same location taken the day before (rather than two weeks before), are now routinely possible.

Historically, much of the Earth observation that has been performed from low Earth orbit (LEO) has been targeted at the land domain. However, a quick look at an atlas will convince most people that our planet is mis-named—it should be called "Ocean," not "Earth"—since more than two thirds of the surface is covered by water.

Due to the mobile nature of many maritime targets, satellite surveillance of the ocean clearly has to provide an up-to-date picture. The ongoing improvements to constellation technology mean that observation of the maritime domain can now be conducted in a relevant timeframe.

This will become even easier in the future. As commercial data-relay services from geostationary satellites such as the European Data Relay Satellite (EDRS), become a reality, LEO observation missions will be able to return their data in near-real-time. See ***Figure 1***.

The design of a satellite optimised for maritime surveillance is subtly different from one intended for surveillance of the land. It will typically have wider swath sensors, of course; but some of the expected applications such as bathymetry also call for data collection in different spectral bands to allow the

discrimination of bottom type; and the need for ship detection implies a greater emphasis on the near-infra-red, a band in which the contrast between the ocean surface and the ships is enhanced, improving the probability of detection.

Future missions are also expected to break out of the historical pattern of stove-piped satellites carrying just one class of sensor. It is likely that these future constellations will incorporate "ears" as well as "eyes." Satellites in LEO are already incorporating receivers for the Automatic Identification System (AIS), a mandatory radio-frequency (RF) system designed to enhance the safety of maritime navigation. Combining the output of such RF receivers with the data from imaging sensors opens up interesting possibilities.

Pursuing this analogy, human beings who lack their sense of sight or hearing are generally considered handicapped, and it is likely that our current satellite missions will be regarded similarly in a decade or two.

Developments in the processing and dissemination domains will be required to exploit these very timely data streams. Correlating the position of a ship in an image with its AIS-derived location is not entirely straightforward. However, it offers enormous potential for differentiating between legal shipping and any unwise vessels with criminal intent which fail to recognise that the "high seas" have ceased to be an unobserved and hence unpoliced domain.

It has been calculated that 90% of world commerce moves by sea, and hence there is a global commercial interest in keeping track of movements in the ocean. The problems caused in the maritime domain by illegal fishing, maritime pollution, drug smuggling, illegal immigration, piracy, etc. will only be addressed if there is improved surveillance of the oceans. Move over geospatial, here comes hydrospatial.

**Editor's Note:**
These two Executive Viewpoints contain opinions of the authors, not their respective companies.

EXECUTIVE VIEWPOINT

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# Trends to Watch in Earth Observation

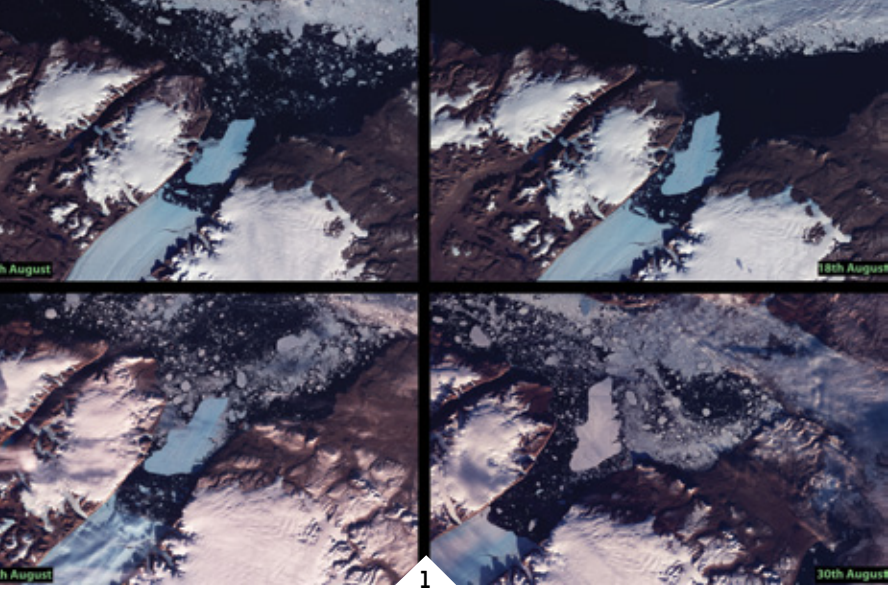
Since the early days of space-based remote sensing for land applications, there have been efforts by governments, particularly the U.S. government, to commercialize Earth observation programs. These efforts have been met with varying degrees of success and have resulted in significant uncertainties around the long-term sustainability and continuity of remote sensing data.

Today, there are four main trends bringing change to the industry, and opportunities for access to space-based remote sensing data, in a more commoditized way. These trends are facilitating the transition toward commercialisation that was envisioned in those early days.

***Firstly, improved low-cost satellites reduce Earth observation space segments costs, which in turn reduce the corresponding data costs.***

***Secondly, constellations facilitating high revisit rates are becoming more commonplace.*** This is partially due to the fact that the Earth observation industry is becoming more creative in forming constellations. Traditionally, constellations were formed either through government and industry cooperation (e.g., DMC), or through big programs that funded the entire constellation (e.g. RapidEye and the upcoming Radarsat Constellation Mission).

These models will carry on with continued success; however, innovative ways of assembling constellations are coming about. For example, satellites are no longer financially prohibitive for commercial entities wishing to procure a satellite for their own imaging needs and to offer it as part of a constellation along with satellites owned by various industrial partners. Alternatively, there is a trend toward satellite capacity sharing (e.g., NovaSAR), creating an opportunity for a larger stakeholder base that can spread the costs of commercial constellations.

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▲ FIGURE 1. Melting of Petermann Glacier, Greenland, during August of 2010, taken with the UK-DMC2 satellite.

▶ FIGURE 2. Image of harbour in Binhai, Tianjin, China acquired Oct. 2, 2013, courtesy of DMCii.

***Thirdly, access points are being created to consolidate data from many sources in various innovative ways in support of a range of user types.*** In some cases, governments are initiating their own portals for access to geospatial data, including remote sensing data. This type of initiative has been very successful in the Netherlands and in particular in Australia, where the government is making data available to all government users on open licenses as part of a 'Data Commons' concept. Further to governmental initiatives, intergovernmental access points are linking wider groups of users to various datasets (e.g. GEOSS data portal).

Commercial data providers and distributors are also providing access points to consolidated data offerings. DMCii, for example, will soon be a one-stop-shop for a wider range of data products, including very high-resolution multispectral data and S-band SAR data, alongside its flagship 22-m multispectral data product. Through this growing constellation, DMCii is itself growing with a wider offering of rapid access to low-cost, high-quality data products. Access points to data are also allowing buyers to select their particular areas of interest, rather than procuring full scenes. This is a leap forward in improving data processing times.

EXECUTIVE VIEWPOINT

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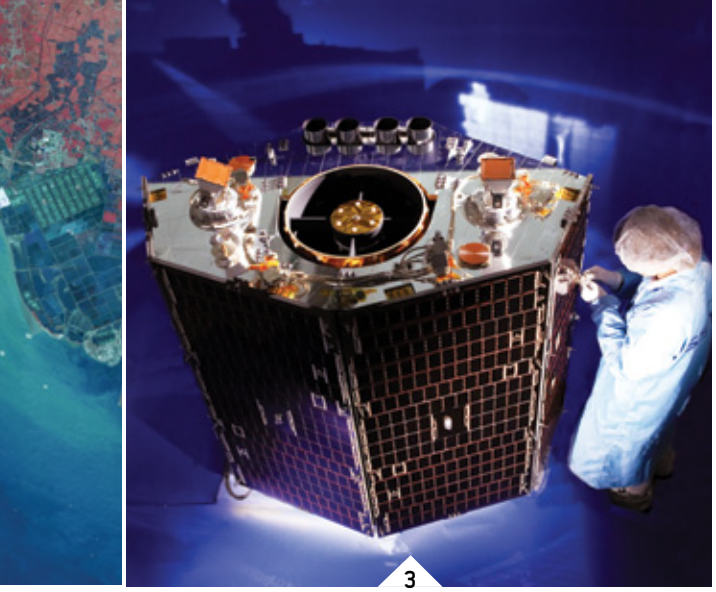
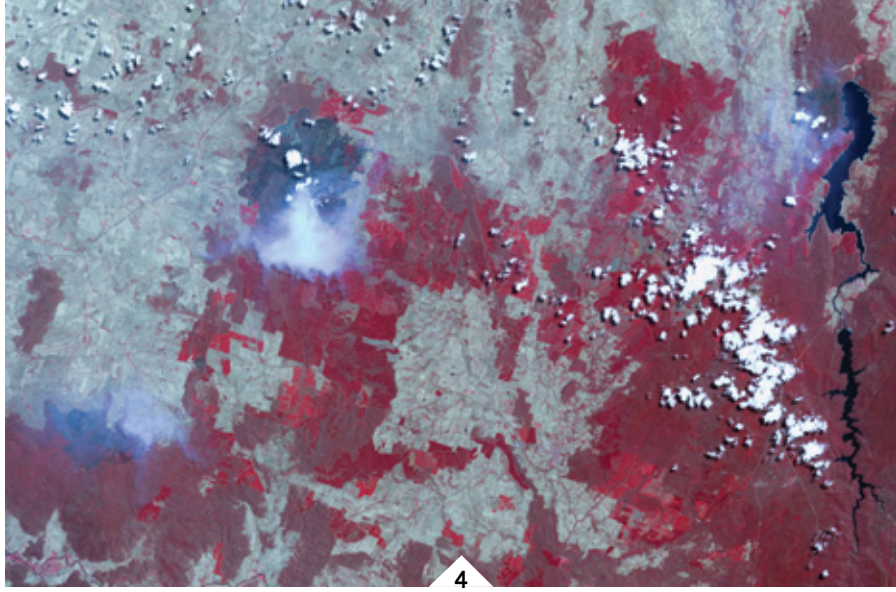
# Esri's Imagery Strategy 2014

Esri's main technology platform, ArcGIS, has evolved over the last decade into a comprehensive imagery system. It includes access to global, multispectral, and multi-temporal imagery; provides advanced imagery management capabilities; and has hundreds of built-in imagery processing and analysis tools. ArcGIS works with almost every sensor and data format, and is supported on almost every application, device and platform. Our vision for 2014 is to continue to lead the industry with technology that makes it easier for our customers to use imagery for better comprehension of their environment.

With the vast amount and variety of sources collecting imagery, the problem has shifted from acquiring imagery to being able to quickly discover and use the appropriate imagery for a project. Esri has been actively engaging customers, partners and imagery data providers to understand the different types of imagery required and how people want to use imagery. We've taken that knowledge and over the last six years, significantly increased the amount





◀ FIGURE 3.
NigeriaSat-2 satellite, built by SSTL.

▲ FIGURE 4.
Bush fires in Woomargama National Park, New South Wales, Australia, Jan. 22, 2014, courtesy of DMC International Imaging.

***Fourthly, cloud computing is at the forefront for facilitating the development of and access to Earth observation applications and data.*** The basic principle applied for applications development is that the cloud can be used to bring developers to the data rather than bringing data to the developers. This concept is expected to spur applications development by reducing developers' software and storage infrastructure overheads. Advances in cloud computing should give a wider community access to remote sensing data and facilities in order to advance cutting edge applications development.

Yes, these trends are changing the industry but, of course, major government initiatives (e.g. GMES, Landsat) will continue to provide baseline datasets, which are particularly useful to applications developers and academics. These programs however do not, and will not, support the service level requirements of commercial service providers that will draw on remote sensing data. These requirements for higher service level will be handily met by data providers who are well positioned to offer the rapid revisit times needs for commercial services.

My suggestion is that you watch this space. Exciting times are ahead where better access to consolidated, cheaper data will spur all sorts of services that will draw on space-based Earth observation data.

of imagery available over the cloud through ArcGIS Online. This includes imagery managed / curated by Esri, such as our World Imagery basemaps, dynamic Landsat 8, Landsat GLS and elevation image services. This makes the world's imagery accessible to everyone, with easy integration of imagery into Web maps and applications, desktop tools, and mobile platforms.

People want imagery that is easy to find and easy to use, but also coupled with analytics that help them solve problems. On the analytics side, our core strength is providing world class analytic tools that make it easy to understand and interpret imagery. We have over 40 years of experience building analytic tools that range from basic to advanced. Included in our core platform are thousands of tools dedicated to analyzing, improving and interpreting imagery.

Imagery data providers are also looking for easy ways to manage and make their imagery accessible, and they have adopted the ArcGIS platform. ArcGIS makes it easy to manage imagery, from single scenes to the largest collections. Several imagery providers have standardized on ArcGIS as a management platform for their imagery, while others are coupling that with access to their imagery through our ArcGIS Online cloud.

As we move forward in 2014, we will continue to evolve our technology to help our customers achieve their goals. Expect to see even more imagery available through ArcGIS Online, additional Web applications and templates, and tools that further simplify image analysis and processing.

We believe that the future belongs to the simple and the quick, and our vision is to transform the work required to complete complicated tasks into a process that is easier to use and intuitive.

EXECUTIVE VIEWPOINT

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# Envisioning Year 2020 From the DigitalGlobe Perspective

As we begin year 2014, it's important to examine how the geospatial industry has evolved not only in the past year but in the last several years in addition to how the industry will likely evolve in the years to come. I'll start by discussing why the development of commercial Earth-imaging satellites has been one of the most important advancements in the geospatial industry.

Geospatial technology using Earth-imaging satellites has reshaped our view of the world, improving national security, logistics and navigation, mapping, natural disaster tracking and transparency in human rights issues. With highly accurate cameras on satellites orbiting the Earth, the commercial Earth-imaging business grew out of Cold War military applications for reconnaissance missions that photographed classified military installations.

Today, high-resolution imagery from commercial satellites serves worldwide demand for measuring and monitoring the Earth for security, emergency response, environmental assessment, natural resources, real estate, agriculture and news reporting purposes. DigitalGlobe has a long history of providing imagery for disasters and crises across the globe, ranging from war crimes in the Sudans, to the recent flooding devastation in Colorado, to the typhoon in the Philippines (see ***Figures 1-2***). Ultimately, imagery from commercial satellites helps protect and improve the lives of millions of people every day.

After further examining the history of the geospatial industry, we've been most surprised by the advancement of geospatial analytics, which turns images into answers using the data from commercial satellites. Many assume that DigitalGlobe and other satellite providers have automated tools to search through the massive number of images taken each day by satellites circling the Earth, but that's not quite the case yet. It still comes down to the people and the analysts to identify what's most important and to provide context and insight to satellite imagery. Insight provided by combining imagery, geospatial analytics and all-source intelligence can make a significant difference in evacuation planning, disaster response and recovery, and change management worldwide.

These enhanced geospatial analytics capabilities have enabled DigitalGlobe to routinely develop predictive analytics models that process hundreds of layers of geospatial data to identify the physical, cultural, and social factors that can assist various military, intelligence, and law enforcement activities. Understanding the geospatial factors that correlate with nefarious activity allows our customers to put their resources in the right place at the right time.

Now, as crowdsourcing comes of age, it reinforces what has always been true: the power of people makes the ultimate difference. With the acquisition of Tomnod, Inc., a geospatial crowdsourced intelligence pioneer, we're able to add crowdsourcing analysis and deliver even more value to customers—at great speed. This has enabled DigitalGlobe to take another step in moving beyond providing only raw data to now being able to deliver insight and analysis that can be

▶ **FIGURE 1.** Before the typhoon: Tacloban City, Philippines, captured Feb. 23, 2012, courtesy of DigitalGlobe.

▼ **FIGURE 2.** After: This image of Tacloban City was taken Nov. 10, 2013, showing damage from Typhoon Haiyan. Image courtesy of DigitalGlobe.


integrated with the imagery.

As we look ahead to year 2020, we realize the geospatial industry may not exist as we currently know it with primarily location-based information and imagery, but it will exist in some form and will have grown significantly. Geospatial technology will likely be focused on managing the massive amount of data that's too difficult to process using on-hand database management tools or traditional data processing applications. The ongoing challenges over the next several years will most likely include capturing, curating, storing, searching, sharing, transferring, analyzing and visualizing geospatial big data. The large and complex data will demand cost-effective, innovative forms of information processing for enhanced insight and decision making.

DigitalGlobe is equipped with the expertise and enabling technologies required to process and exploit geospatial big data. This allows us to quickly discover patterns that may exist across hundreds of layers of spatial data and then process that data on the fly to deliver timely insights. We plan to continue extracting information from our imagery to solve some of the greatest challenges that our government and commercial customers will face in the years to come.

By 2020, DigitalGlobe aspires to be the indispensable source of information about our changing planet. We expect to manage a living digital inventory of information about the surface of the Earth, and our customers and users will be able to reach into that living inventory and ask a discrete question about the Earth and the answer they need. We don't believe our customers will need a degree or background in GIS or mapping but instead will be responsible for making decisions tied to a place on the Earth's surface and managing change of that place. ∧○

# lidar

## Software Catching Up, Alternative Technologies Emerge

BY MATTEO LUCCIO / CONTRIBUTOR / PALE BLUE DOT LLC
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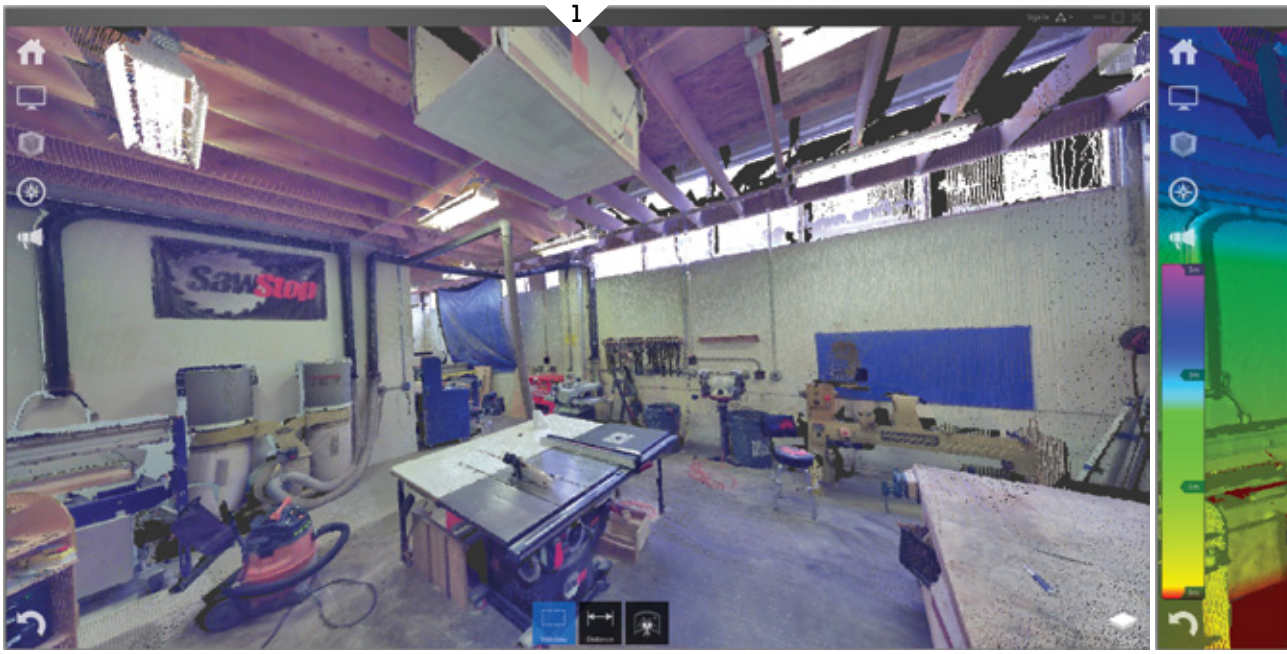



▶ FIGURE 1. Using Autodesk ReCap Pro, point clouds no longer look like abstract groups of points; they are fully functioning 3D models.

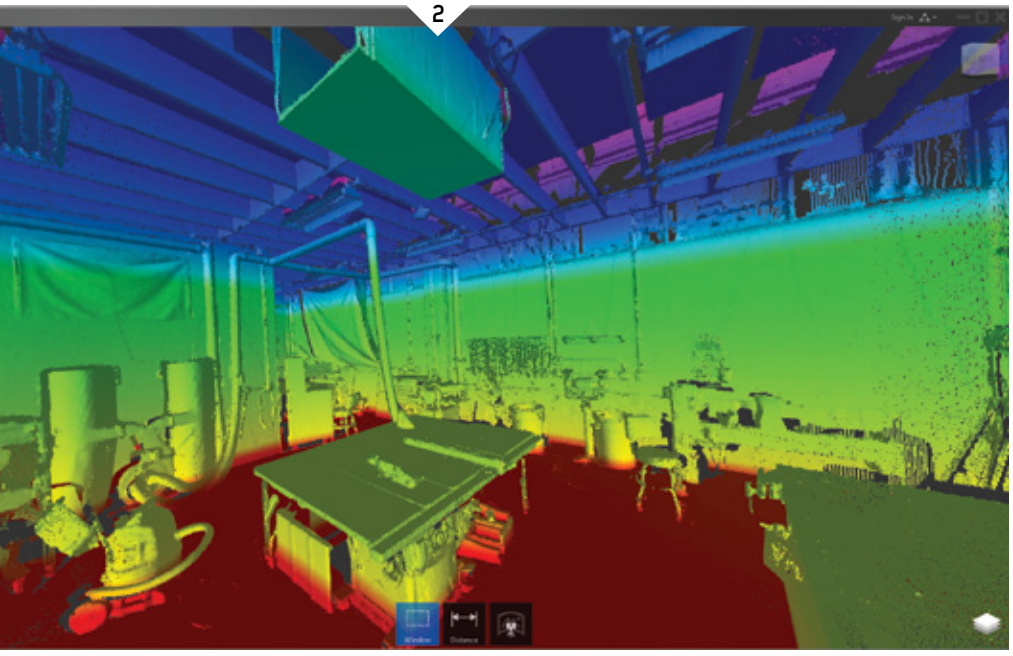
▶ FIGURE 2. Autodesk ReCap Pro shows various height levels through color coding.

Throughout its history, lidar has been one of the very few technologies in which the exponential growth in the hardware's ability to collect data has outpaced software's growing ability to process and visualize that data—largely because it is an unstructured point cloud, unlike raster data, which consists of rows of pixels. Software is catching up, however, offering new ways to manage, edit, and visualize point-cloud data.

At the same time, traditional lidar is being challenged by two new and potentially alternative technologies: multi-ray photogrammetry and Flash Lidar, which also generate point-clouds. The former can be used to increase the performance of both light and cheap consumer-grade cameras and of large high-end aerial sensors. Both may soon make 3D sensors small and light enough to be deployed on small unmanned aerial vehicles (UAVs).

## SOFTWARE CATCHING UP

Sensor manufacturers are not in the software business; therefore, the software they produce to support their devices tends to be expensive, hard to use, and lagging behind customers' needs, argues Elmer Bol, Director of Reality Capture at Autodesk. Therefore, the workflow to obtain useful data from lidar scanners is often complicated and this, more than the cost of the sensors, limits their use.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### *AUTODESK*

Bol and a couple of his friends recognized this problem and founded Alice Labs to create tools to dramatically simplify that work flow. "If we want to increase the number of scanners sold by a factor of ten, we need to make sure that the entire workflow is simplified for any user, not only for professional surveyors," he says. Three years ago, Autodesk acquired Alice Labs. A couple of years earlier, it had acquired REALVIZ, which led to the development of Photofly, a module that powers its consumer-oriented 123D Catch software that creates 3D mesh from photos. Last year, Autodesk released Photo on ReCap 360, a professional-grade cloud service for creating high-resolution 3D mesh and photo-based point clouds. ReCap 360's RealView enables users to share laser scans with other Autodesk 360 accounts for viewing in a Web browser.

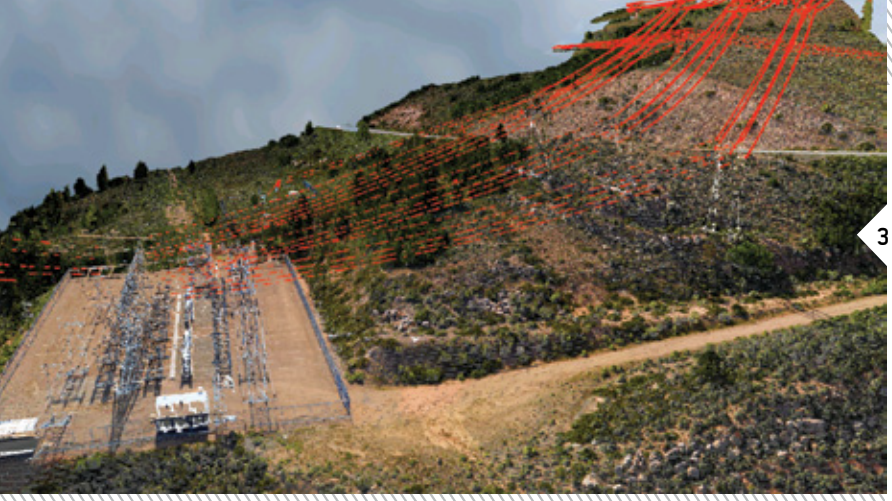
With the acquisition of Allpoint Systems, the company expanded its capabilities for laser scanning workflows with targetless scan-to-scan registration in its ReCap Pro desktop software. Recently, it released a new scan-to-scan registration feature in ReCap Pro that allows users to automatically snap together scans continuously using feature recognition, instead of survey targets. "It dramatically simplifies the process of registering together laser scans to create a single model," says Bol. "Our goal is to make that an in-field work flow. I can teach anyone to register laser scan data in minutes without the need for survey expertise."

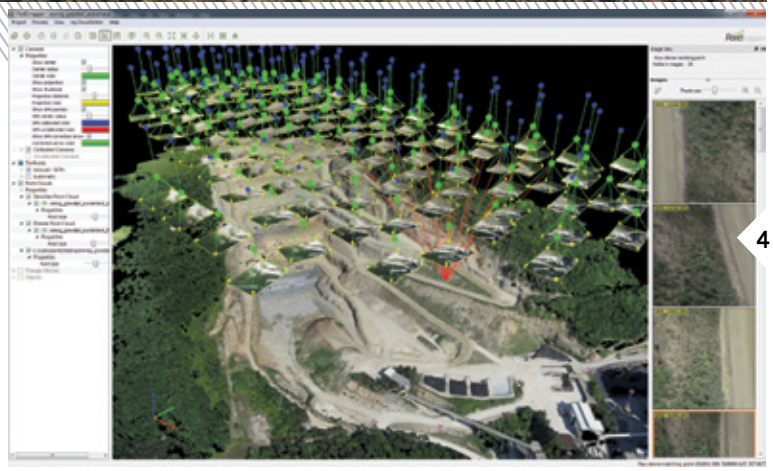
Point clouds can be pretty rough, he explains, and might need some cleaning or other editing. ReCap, a free data preparation tool that ships in all of Autodesk's software suites, allows users to import any kind of scan data, visualize it, and edit and clean the data. See ***Figures 1-2***.

### *EUCLIDEON*

Euclideon, founded in late 2009 as a gaming company, soon demonstrated its middleware 3D graphics engine, called Unlimited Detail. Unlike traditional polygonal game engines that drive on a computer's GPU (graphics processing unit), it renders 3D points called atoms using only a computer's CPU, explains Derek van Tonder, the company's Technical Business Development Coordinator. The following year, aided by a large government grant, Euclideon began to develop its first commercial geospatial software offering, Geoverse.

Merrick & Company, Inc., a U.S. engineering, architecture, planning, and geospatial services company, was an early adopter of Geoverse and soon became a distributor. "Euclideon came to us with a very simple





▲ FIGURE 3. 3D view of electrical substation and transmission lines, courtesy of Merrick.

▲ FIGURE 4. Pix4D's rayCloud editor combines the 3D points of a point cloud with the original input images, resulting in this image of a quarry.

question," says Bill Emison, Senior Account Manager in Merrick's Geospatial Solutions division. "Do you have more points than you know how to manage and visualize? We said yes, so they showed us their solution and it became quite a treat. The rest is history. Their background in the video-game industry has served them well because they know how to render very large datasets very efficiently." According to Josh Beck, a software consultant in the same division, Merrick staff found the product to be a great resource for both quality assurance and marketing, by allowing them for the first time to efficiently visualize huge datasets, internally as well as for their clients and potential clients.

Competing technologies just parse the data and are limited in the number of points they can display at certain scales, Beck explains, because they load the data into a computer's RAM. By contrast, "Geoverse allows us to visualize all the points, no matter how many, from just a typical work station or even a five-year-old laptop." Users can load "three terabytes of data in less than a second," he claims, and then pan it in real time.

The key to Geoverse's performance is its novel form of indexing. "It is like a Google or Yahoo search algorithm for 3D points," says van Tonder. "We find exactly one 3D point for every pixel on the screen." See ***Figure 3***.

At the International Lidar Mapping Forum (ILMF) in Denver in February, Euclideon's CEO Bruce Dell will present a keynote on new technologies and the future of scanning, with Christoph Fröhlich, CEO of Zoller + Fröhlich.

## ALTERNATIVE TO LIDAR: MULTI-RAY PHOTOGRAMMETRY

### *PIX4D*

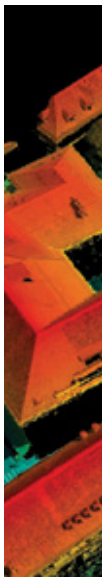
Traditionally, photogrammetrists reconstruct 3D information using two images and a stereo display. At ILMF, Dr. Christoph Strecha, CEO of Pix4D, will present a new approach to reconstructing 3D information with increased accuracy from several images, based on multi-ray photogrammetry. It is the basis of the company's new release of Pix4Dmapper. This concept, he predicts, will be standard in a couple of years. "If you want to put a sensor on a very light-weight UAV or on mobile phones," he points out, "you are always restricted in price, weight, and energy consumption. Given these restrictions of the sensor, multi-ray photogrammetry is the best approach we have." See ***Figures 4-5***.

One way to increase accuracy is to build better sensors, but that makes them too heavy for small UAVs, Strecha argues. That, for example, is the route that Microsoft took by buying Vexcel, an Austrian company that builds very good cameras, and using them to capture cities and build beautiful, highly accurate 3D models. The alternative is to use smart algorithms.

"There's a growing market in extracting 3D information from consumer devices and that's what we're addressing," he says. "We are focusing on integrating images that have been taken from the air looking downward with oblique ones. This is especially interesting for modeling cities, where you not only want to get the roofs but also very detailed information on the façades. It is very challenging to generate simplified models directly from captured data: this is a car, this is an entry, this is a window, and so on. Multi-ray photogrammetry will give a lot of added value because you are not just measuring point clouds, but you are able to automatically also integrate them into an existing database."

### *MICROSOFT*

While multi-ray photogrammetry is not new, it has been helped along by digital cameras, says Jerry Skaw, Marketing Manager for Microsoft's Photogrammetry Division. It is based, he explains, on a dense-matching process that starts with a flight pattern that has 80



percent forward overlap and 60 percent side overlap, as opposed to traditional flight patterns that have an overlap of only about 60 percent forward and 20 percent on the side. "This provides enough redundancy so that you get the same points on the ground and up to twelve different images," Skaw explains. "Consequently, you have a more robust and highly automated dense-matching process." See ***Figure 6***.

Microsoft's UltraMap software ingests imagery from the company's UltraCam sensor and stitches together the sub-images created by its different CCDs. Next, it does radiometric corrections, color-based color balancing, and aero-triangulation. Then the software extrapolates precise exterior orientation data to generate per-pixel height values and outputs very dense point clouds.

"This process is very automated and these point clouds are much denser than lidar point clouds," says Skaw. "Ours are on the order of or greater than 300 points per square meter." From there, users can generate a digital surface model (DSM), which derives the same vertical accuracy as the ground-sample distance at which the images are taken, and export the DSM or the point cloud in LAS format. They can also generate a digital terrain model (DTM), but that's not exportable. From there, the DSMs and DTMs are used to generate ortho photos. See ***Figures 7-8***.

"There are huge efficiency gains with flying one of our cameras and using our software to create point-clouds," Skaw argues. "You can fly faster, you can do much more overlap, and you end up with a much larger usable swath." These advantages are particularly important for very large collection areas, such as for national mapping and mining. Also, by collecting more data than lidar, multi-ray photogrammetry produces better DSMs and, therefore, better ortho photos.

## ALTERNATIVE TO LIDAR: FLASH LIDAR

### *ADVANCED SCIENTIFIC CONCEPTS*

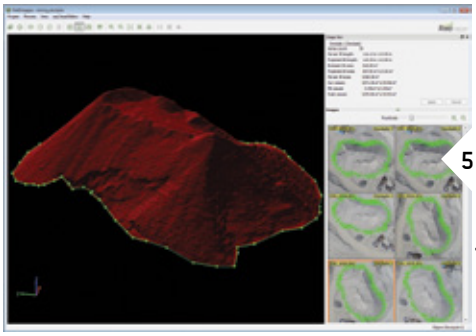
Advanced Scientific Concepts (ASC) developed 3D Flash Lidar cameras on the basis of much core research around the readout ICs (also known as ROICs), which are "the brain" of the focal plane array, explains Thomas Laux, ASC's Vice President of Business Development and Sales. Flash Lidar cameras operate and appear very much like 2D digital cameras. Like the latter, they have rows and columns of pixels on their focal plane arrays, but with the additional capability of measuring the 3D "depth" and intensity.

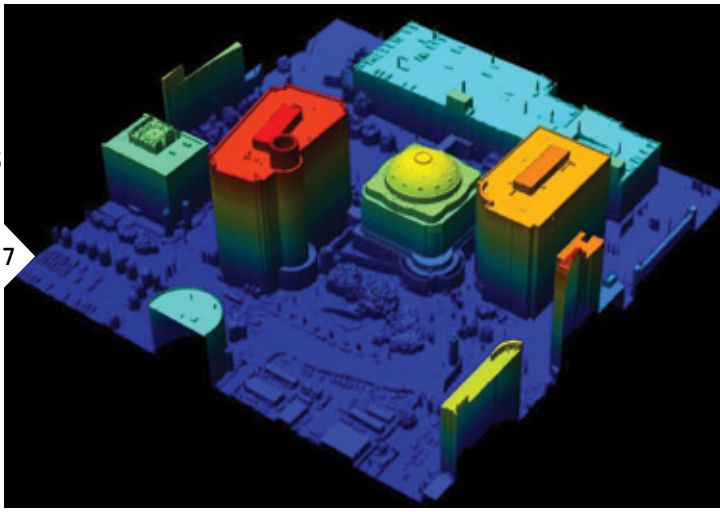
A pulsed laser illuminates the objects in front of the camera and each pixel independently records the time each pulse takes to reach the objects and return to the sensor. With each flash (frame), ASC cameras capture 16,384 data points, allowing them to capture scenes at a high dynamic rate. They are solid state, therefore they have no mechanical parts that wear out, do not require routine calibration, and are smaller, lighter, and more durable than laser scanners.

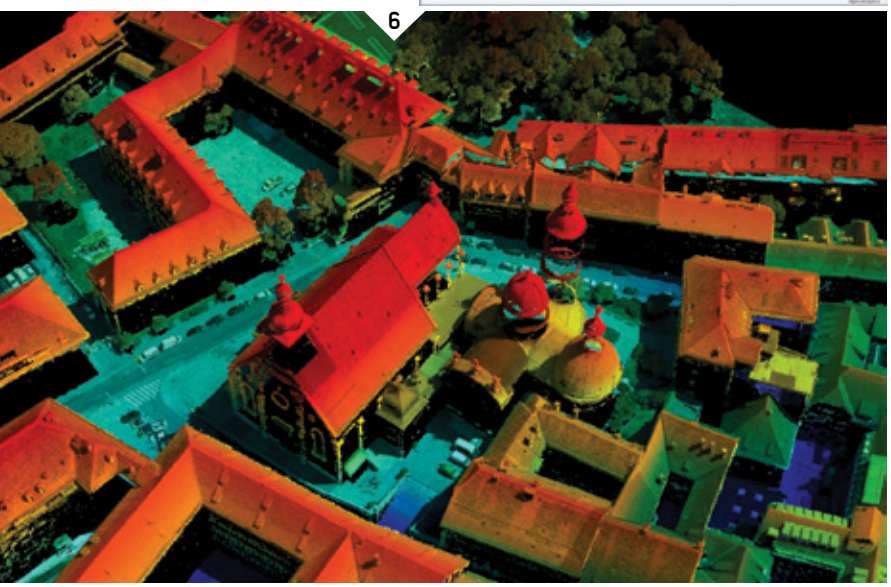
Because they measure distances directly, Flash Lidar cameras can provide absolute range data on the

▼ **FIGURE 5.** Object annotations for a stockpile volume measurement in Pix4Dmapper.

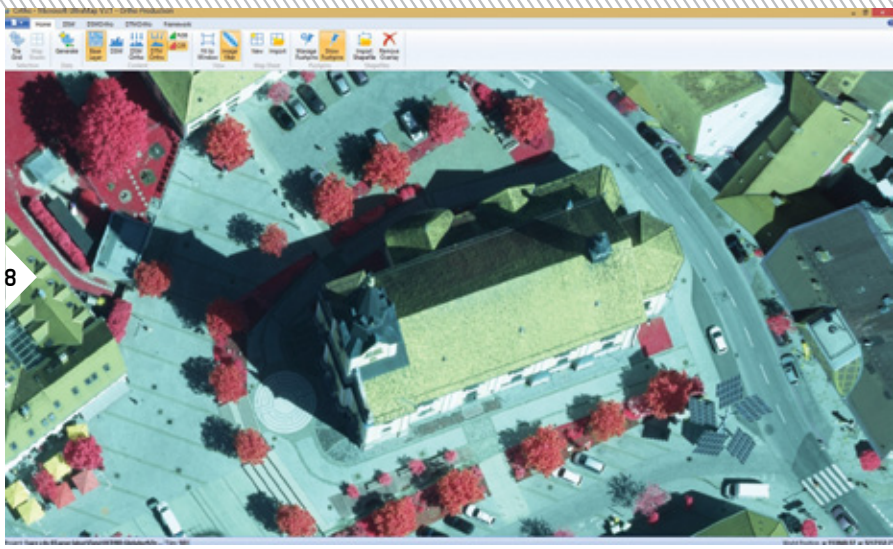
▼ **FIGURE 6.** Very high-density point cloud from dense matching of cathedral in Graz, Austria, taken with UltraCam Xp at ground sampling of 6 cm, is exportable to LAS file format, courtesy of Microsoft.



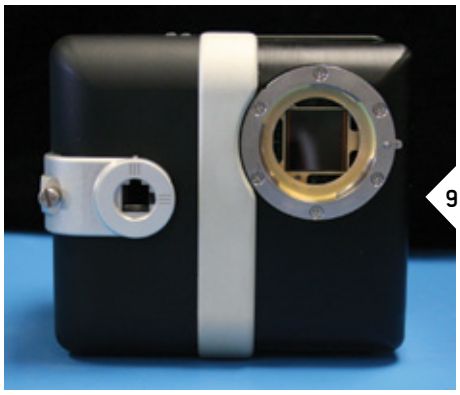

▲ **FIGURE 7.** The DSMs generated in the UltraMap Dense Matcher module inherit the accuracy of the dense underlying point clouds and can be exported in tiles as 32bit floating GeoTIFF for use in downstream workflows.



▶ **FIGURE 8.** From the DSMs and DTMs UltraMap OrthoPipeline module automatically generates final DSM- and DTM-based orthomosaics in optional TIFF & TFW and GeoTIFF file formats.

fly, as well as the speed at which they are approaching another object and its image. "This technology is now emerging into a wide range of applications," says Laux. "It has been of keen interest to some application areas like NASA, for ranging or imaging rather long ranges and knowing the absolute range from a target—for example, for autonomous rendezvous and docking with the International Space Station—but also for landing on various planetary locations like the Moon, Mars, and asteroids."

Flash Lidar cameras are also used for mapping and are being researched as a way to image into and through obscuration—such as dust, fog, or smoke. These are very critical areas with regards to moving machines, especially autonomous ones, such as UAVs used for aerial mapping or to transport cargo. For imaging into and through water, ASC typically uses its raw or continuous-sample mode (CSM), while for other applications it uses a range-and-intensity mode.



▼ **FIGURE 9.** Advanced Scientific Concepts Inc.'s TigerCub 3D Flash Lidar camera with Zephyr laser weighs less than three pounds. Image courtesy of ASC.

Ten or 15 years ago, Laux points out, one of these cameras plus the processing unit would probably have weighed 15 or 20 pounds. "Now, we're talking about all-in with, let's say, a 12 millijoule laser capable of imaging well over a kilometer and a TigerCub camera that weighs less than three pounds," says Laux. See ***Figure 9***. "We have a new one that weighs less than a pound. "

"The same unit is being targeted for going into mines, either for autonomous operations on big trucks or underground. You put these cameras on vehicles or sensors and then you do an explosive blast keeping people safe. You can manage all this stuff remotely, without putting humans at risk."

Over the next three to five years, Laux predicts, numerous companies are going to use this technology to create whole new application areas. "Scanning lidar systems have proven that time-of-flight is of value to humans. Now we're poised to watch this emerging technology just 'blow off all the doors.'"

### *BALL AEROSPACE AND TECHNOLOGIES CORP.*

Ball Aerospace and Technologies Corp. has been studying ASC's Flash Lidar device and uses it as a component in its Total Sight Flash Lidar system, which also contains visible and/or MWIR cameras to provide contextual imagery and a single board computer to process the data. "We fuse the color imagery with the data coming out of the ASC lidar camera in real time, on a frame-by-frame basis," says Roy Nelson, Sr. Advanced Systems Manager at Ball. "We also fly an Applanix INS unit in our box and we georegister all of the lidar data in real time. So, we have built a lidar system, not just a camera, where lidar is now Laser Imaging, Ranging, and Detection." See ***Figure 10***.

Ball has developed the signal processing and the software to perform this fusion in real time, compiling the metadata for each frame rather than for each pixel. "That reduces the amount of metadata and it also allows you to do significant processing on the frames," Nelson explains. "Before the next frame of data is taken, we process all of the data from the previous frame. So, on the ground, you see a 3D full-motion video image and it is fully geo-registered. At the same time, we are creating a LAS file, in parallel. At any given time, the user can snip the LAS file and use it as a full Level 3 data product."

While the current scanning systems have been optimized over the years to provide very accurate data on static targets, Nelson says, the value of Ball's system is in providing time-critical information in real time when the conditions on the ground are rapidly changing. "Flash Lidar rolls at 30 frames per second and it is an array-type sensor, so it is nothing more than a highly accurate 3D camera. It provides full motion video in 3D." Ball is now looking at re-packaging its unit to fit within the space constraints of small UAVs.

### *SABRE LAND & SEA*

None of the lidar scanners currently on the market are small and light enough to fit on the smaller and lighter UAVs that are exploding in popularity on the civilian market. "They have been doing laser scanning for years with unmanned helicopters capable of carrying more than 100 kilograms, but with those you are up near the costs of a manned helicopter," says Stephen Ball, the founder and CEO of Sabre Land & Sea. "You might as well just fly a Robinson R22 two-seat helicopter with a pod on it, instead of using a $250,000 UAV to carry a $500,000 lidar scanner. We wanted to build a system small enough, light enough, and cost-effective enough for the UAV market." He is targeting UAVs under 20 kilograms and integrating into aerial mobile mapping what he learned during more than 10 years in the terrestrial mobile mapping sector.

While the weight of the laser scanner itself is the biggest challenge, the required components also include the GPS/IMU navigation system, the processing hardware, and the power source. Sabre is developing a pod with these components into which it can integrate any manufacturers' sensor. They are starting with a FARO scanner, which is a high-precision laser scanner that was designed for static-based scanning on the ground.

"We have successfully integrated it for the airborne environment, but it is still too heavy," says Ball. "We have now managed to reduce the weight of the SABRE pod in order for it to carry lasers from other manufacturers, such as Velodyne and Ibeo." To stabilize the platform in high winds, SABRE developed its own electric-powered, multi-rotor aircraft. The payload can also be separately stabilized, using a double-gimbal and a gyroscope. See ***Figure 11***.

Besides weight, a few additional hurdles still need to be overcome before lidar can be routinely deployed on small UAVs, Ball argues. The first one is the combination of cost, reliability, and insurance. "Even if we make a laser scanning system that costs $80,000," says Ball, "are they going to put it on a light-weight UAV that you can buy off the shelf for $20,000? For small UAVs, it's an insurance and confidence issue." The second hurdle is the lack of a small UAV that is reliable in a broad range of weather conditions. The third one is regulatory: in the United States, UAVs may not be operated commercially except under a Certificate of Authorization (COA) from the Federal Aviation Administration, which is hard to obtain. The agency is required by law to issue regulations for commercial UAV use of the airspace by 2015. The final hurdle is that data acquisition and processing needs to be easier.

## CONCLUSIONS

Demand for 3D imagery continues to grow rapidly, for consumer, business, and government applications—including creating 3D maps for navigation, modeling as-built construction, and planning emergency response. However, the way we collect, process, and visualize this data is changing rapidly, both from hardware and software perspectives. Large and heavy laser scanners may soon give way for many applications to small and light sensors that use emerging technologies. ∧♂



▲ **FIGURE 10.** Scan of Denver, Colorado, courtesy of Ball Aerospace Corp.

◀ **FIGURE 11.** Multi-rotor UAV prototype landing on auto-pilot, courtesy of Sabre Land & Sea.

# Geospatial

## Continuing to Balance Principles, Tools and Job Skills

BY MATT BALL / EDITOR / *SENSORS & SYSTEMS*

From the very early days of geographic information systems and allied tools and technology, there have been ongoing questions on the best ways to train practitioners. Geospatial skill development relies on both tools and science, and needs a strong foundation of concepts as well as an understanding of the software and hardware that are used in professional practice.

Two market research reports, commissioned by Google, came out last year, one by Oxera on the worldwide economic impact of geospatial services (http://bit.ly/19VZElW), and the other from the Boston Consulting Group (http://on.bcg.com/M0ERms) on the market for the geospatial services industry. The reports reveal the economic contributions of the geospatial industry as well as growing employment prospects. While the profession continues to grow, the definition of geospatial practitioners is also expanding as witnessed by these reports. A slightly different conception of the geospatial industry overall takes in new uses, services, and more flexibility in the toolset.

"The core geospatial industry is thriving," said David DiBiase, director of education, industry solutions at Esri, and long-time educator and former director of the Dutton e-Education Institute at Penn State University. "But there is also an innovative frontier beyond core that is more consumer- and business-oriented than traditional applications. Software and application development is a core competency at the frontier."

Despite the growing need for geospatial skills, there are recent graduates who are still sitting on the sidelines because they don't have practical experience. In a growing market like geospatial, finding qualified personnel is difficult, and yet acquiring core skills and competencies is essential for employment.

### DEFINING COMPETENCIES

A big advancement in defining the skills needed at the different phases of career advancements has been the Geospatial Technology Competency Model (GTCM). Geospatial has been numbered among industries with a set competency since it was identified as a high-growth industry by the U.S. Department of Labor back in 2003. See ***Figure 1***.

"The GTCM is widely known, and has good adoption in the two-year community college sector," said DiBiase. "Among the four-year colleges and universities, it is known, but hasn't had the same impact."

The GTCM can be used as an assessment to gauge the workforce needs and the gaps that university programs and other educators may want to address, as well as by students who are given the opportunity to assess their own knowledge and gaps. The National Geotech Center where the GTCM originated received a new round of funding by the National Science Foundation, and the key activity that they will deliver is the review and revision of the GTCM.

"The GTCM addresses the educational elements that individuals need to have in order to enter this field," said Dr. Jan Van Sickle, principal at Van Sickle LLC and professor at Penn State Online. "It also illustrates a multidisciplinary approach, but it has

very little to do with technology; it has to do with fundamental knowledge."

## CONSIDERING GEOMATICS

Coordinate systems, cartography, geodesy, surveying, remote sensing, photogrammetry, GPS/GNSS, LiDAR, navigation, GIS—most practitioners don't have the complete understanding of these related technologies. Conveying this broader view of geomatics science is the aim of the new Geomatics Engineering program within the College of Engineering and Applied Science at the University of Colorado Denver (UCD). The field of geomatics started more than 6,000 years ago with surveying, cartographic science, and geodesy, and then added photogrammetry, remote sensing, and GIS as these technologies emerged. There are only a few geomatics program in the United States, and this new program aims to fill an expertise gap by training geomatic engineers, researchers and scientists.

"GIS is driving too much toward only GIS, and is disregarding a big part of the geomatics world," said Dr. Apostol Panayotov, assistant research professor, College of Engineering and Applied Science, UCD. "We value what GIS did and continues to do, but they can't change the world in their light. The new science arrived, and has become part of geomatics, but it's not tearing apart the science of geomatics."

The new program retains a master in GIS and a GIS certification as well as a masters and Ph.D. in geomatics. Students can pick up their own specialization, and there are plans to address varied disciplines such as oil and gas, mining, environmental, and space exploration.

"The program at UCD is following the geomatics program models of the programs at the University of Calgary and the University of New Brunswick, which are the oldest geomatics programs in North America," said Panayotov. "Developing narrow specialists like GIS analysts and surveyors creates silos and limits their knowledge in only one area of geomatic science. The goal is to provide broader and comprehensive geospatial education, which will develop well educated geoscientists and professionals."

In Europe, there has never been the division between GIS and geomatics, but that's the norm in the United States. In order to focus on the broader global opportunities, it's important to factor in how the rest of the world learns these skills. There may be experts in individual disciplines in the United States, but if they don't talk to others, there are deficiencies.

Starting a new program from scratch requires resources from vendor partners and industry employers. The geomatics program at UCD has successfully launched, and has garnered a great deal of interest

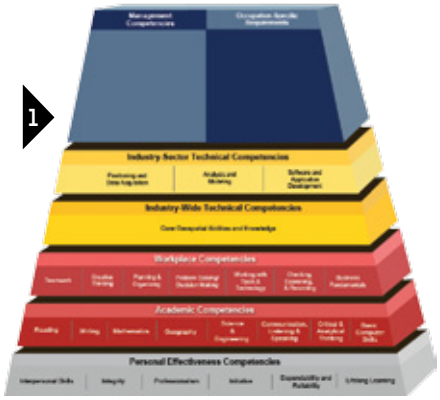
**Editor's Note:**

This article also appears in our partner publication *Sensors & Systems*:

*http://bit.ly/1hTORJg*

A related article called "Advocating for Geography Education" appears on the *Sensors & Systems* site as well:

*http://bit.ly/1ekOumQ*




▲ FIGURE 1. The Geospatial Technology Competency Model, also referred to as the Geospatial Education Pyramid

from prospective students. The program hopes to build on this momentum by connecting with funding sources that share this broader vision. Breaking down the traditional narrow geospatial tracks in order to train the next generation of geospatial generalists will help push broader adoption as well as technological innovation.

Why now, and why in Colorado? The Front Range—sometimes called "GIS Alley"—has one of the highest concentrations of geospatial government agencies and businesses in the world, and knowledgeable professionals are here to instruct. The demand is also high in Colorado, with greater connection to job opportunities for students. The program plans for completely online coursework in order to take advantage of the expertise of the local workforce while reaching out globally.

## MOST MARKETABLE SKILLS

The typical approach is to categorize programs into groups such as photogrammetry, geodesy, surveying, and GIS, and these are considered separate and distinct categories. The reality is that all of these, and more, are part of an overarching geomatics science. The history of specialization in one tends to mean that you don't have enough information on the others, and the broader picture is often left to be acquired on the job.

"It is rare to nonexistent to have programs that address the pertinent areas of modern geospatial practice," said Van Sickle. "It is typical for universities to be behind technological advancements in any field, and that's partly the reason they don't correlate well with current practice. There's another more important reason, and that is that the geospatial work has changed fundamentally."

Most of the work that have objectives that benefit from geospatial solutions span across a range of tools and disciplines. While collaboration is more achievable through online means these days, there are many questions and answers along the way toward answering the overall objective.

"How do you address the bigger problems if you're just a surveyor, just a photogrammetrist or just a GIS person?" asked Van Sickle. "For instance, I'm not in favor of teaching a surveying course to young students today because I feel that I would be preparing them for unemployment. Surveying is still needed, but how much better to have someone who knows those principles, and photogrammetric principles, and geodetic principles, and GIS principles? That young person will have a glorious future with unending possibilities."

"If someone asks about a particular tool, my attitude is that teaching the principles involved to full comprehension is more important, because if a tool changes, and it inevitably will, they will be able to adapt and move on," continued Van Sickle. "If I teach a particular tool, and they don't understand the principles, then they can't adapt, and they will quickly become obsolete."

## DYNAMIC TECHNOLOGY EVOLUTION

In the traditional GIS occupations, we think of professional and sophisticated desktop GIS software and image analysis tools as the norm. The trend in much of the software world has been away from this heavy-duty software toward apps that are focused on specific tasks. Along with the trend, there has been an explosion of those that are developing the applications.

"Any geospatial program needs to have a substantial component of software design, programming, data management architecture, and database administration," said Van Sickle. "The best way to prepare students for the real world is for them to come out of school with a robust geospatial understanding and programming skills."

"Esri now talks about ArcGIS as a platform—a foundation upon which users build custom applications that address their organizations' needs," said DiBiase. "This creates a challenge for the education sector, because not many academic programs are preparing students for application development opportunities."

While there is a never-ending battle to provide students with the technical competencies that they need, The Chronicle of Higher Education released a survey on the role of higher education in career development, surveying more than 700 employers about what they found lacking in the preparation of recent college graduates, including scientific and technical fields. They reported that skills like problem solving and the ability to manage multiple priorities, and communication skills were most lacking. Many employers rated these "foundational competencies" at least as important as technical skills.

"In the rush to keep up with the expanding technology ecosystem, my worry is that we may neglect some of these foundational competencies that employers say are the most important," said DiBiase. "Educators need to strike a balance between technical competencies with the equally important foundational competencies like communication and problem solving skills and business fundamentals. Weak foundational competencies combined with a lack of job experience put recent graduates at a real disadvantage in the geospatial job market."

The failure of higher education to ensure marketable skills and to balance the skills with specialized discipline-specific competencies is being addressed through an increasing emphasis on internships with workplace experience as part of the formal education process.

## FLEXIBLE OPTIONS

There are formal and informal sides to all education today. Looking at the formal side, there are a number of two and four-year programs, and graduate school. The post-baccalaureate and practice-oriented programs, such as certification in specific software tools, are also seeing great growth, with working adult professionals out to advance their careers. There is also a large uncoordinated movement for volunteered geographic education, where individuals pursue their own interests.

There is a real drive for most technology practitioners to pursue an education outside of the formal education process. If you look at YouTube for tutorial videos, you find a broad array of videos that are focused on teaching geospatial concepts or software functionality. Similarly, there are also massive open online courses (MOOCs) where university professors open up their coursework for free to a broad audience. Today's practitioners are teaching themselves through these volunteered resources, as well as augmenting their education through more flexible online study options.

"It's a gratifying time for me, having started online learning at Penn State back in 1998," said DiBiase. "There was quite a backlash from those who felt that it would cheapen the quality of a university education, but not many think that anymore. Most online education consumers have the same expectation of learning as face-to-face learning, with the added value to study in the time and place of your choosing. The potential to get a good education online is every bit as good as in a classroom, given teachers who care and know what they're doing." ∧o

## A Sampling of Online GIS Certificates and Masters Programs

American Sentinel University
http://www.americansentinel.edu/
Colorado State University
http://www.online.colostate.edu
Delta State University
http://www.deltastate.edu/college-of-arts-and-sciences/biological-and-physical-sciences/mas-git/
Elmhurst College
http://public.elmhurst.edu/adult/gis
Esri Virtual Campus
http://training.esri.com/gateway/index.cfm
Birkbeck University of London,UK
http://www.bbk.ac.uk/gisc/index_html
Fresno State
http://www.fresnostate.edu/cge/giscert/
Johns Hopkins University
http://advanced.jhu.edu/academic/environmental/gis/
Northwest Missouri
http://www.nwmissouri.edu/socialsciences/msgis/index.htm
Penn State
http://www.worldcampus.psu.edu/GISCertificate.shtml
Ryerson University, Toronto, Canada
http://ce-online.ryerson.ca/ce/default.aspx?id=2584
Salisbury University
http://www.salisbury.edu/geography/msgism/index.html
UNIGIS International
http://www.unigis.org/
University of Colorado, Denver
http://bit.ly/1lqm4RC
University of Denver
http://universitycollege.du.edu/gis/degree/certificate/geographic-information-systems-online/degreeid/31#courses
University of North Dakota
http://distance.und.edu/degree/?id=geoinfoscience2
University of Redlands
http://www.redlands.edu/academics/school-of-business/1231.aspx
University of Southern California
http://gis.usc.edu/
University of Toronto
http://bit.ly/1emyqEO
University of Washington
http://www.outreach.washington.edu/pmpgis/
University of West Florida
http://uwf.edu/gisonline/
Vancouver Island University, Canada
http://www.viu.ca/adgisa/

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◀ ▶ FIGURES 1-2. This image of Kyrgyzstan was the high-res image used by UNOSAT to create the annotated image on the right, courtesy of DigitalGlobe.

# Satellites Show Promise in Preventing Atrocities

BY MATTEO LUCCIO / CONTRIBUTOR
PORTLAND, ORE. / WWW.PALEBLUEDOTLLC.COM

Currently, about a dozen government and commercial Earth imaging satellites circle the Earth daily. They take thousands of pictures that governments, private companies, and non-governmental organizations (NGOs) use for purposes as varied as monitoring wheat production, looking for point sources of pollution, and displaying images on Google Earth.

Long before the launch of the first Earth imaging satellites, some envisioned using them to help prevent wars and atrocities by detecting, proving, and publicizing acts of military aggression and large-scale violations of human rights. Now that these imaging capabilities are well established and the quantity and quality of the available satellite imagery is steadily increasing, we are better able to understand its benefits and limitations for these purposes.

## POINTING THE CAMERAS

Satellites cover vast swaths of the Earth's surface every day, but not all of it. Additionally, searching the huge amounts of imagery that they collect for evidence of preparations for attacks is an overwhelming task even for large intelligence agencies, let alone for NGOs. Therefore, a critical component of any Earth observation mission is tasking the satellites—that is, instructing them to maintain or vary their orbit, and where to point their cameras along their path. This requires some knowledge of where to look.

UNOSAT (the U.N. Operational Satellite Applications Program within U.N. Institute for Training and Research, or UNITAR) maintains a hotline staffed around the clock by duty officers. Launched thirteen years ago to make the benefits of satellite remote sensing and GIS available to its sister U.N. agencies, U.N. member states, and their citizens, UNOSAT works exclusively in response to requests, usually from U.N. agencies. "We have been working on internal conflicts where there's a humanitarian aspect," says Einar Bjorgo, the agency's manager, who points out that it has not yet worked on detecting military build-ups and preparations for trans-border attacks.

"Typically, we first get a request from a humanitarian actor to understand what the internal situation is like, because in these situations there is little or no access to the field for security reasons. So that is exactly where satellite imagery can come in and play a very important role: to be the eyes of the U.N. and the international community as to what goes on during conflicts. Often, either during or after the event, we are requested to do specific assessments related to potential human rights violations. We provide our objective, neutral, image-based scientific analysis. That is then compared against interviews and media reports and volunteer information, etc," Bjorno stated.

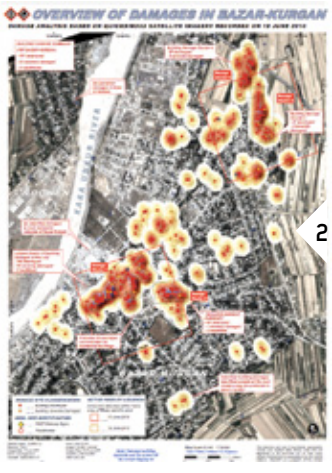
During the Kyrgyzstan conflict, a couple of years ago, UNOSAT received reports of ethnic violence, Bjorgo recalls. "We used very coarse satellite imagery to see whether there was fire detection, because there were reports of houses being burned. Indeed, we did see fire signals in an urban environment. Then we were able to program much more detailed satellite images and

Sensors & Systems

**Editor's Notes:**

Portions of this article also appear in our partner publication, *Sensors & Systems*: http://bit.ly/1gzoNWC

A related article on the Satellite Sentinel Project appeared in the Spring 2011 issue of *Imaging Notes*.

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do damage assessment and ongoing monitoring of this situation." See ***Figures 1-2***.

While it is difficult to use satellite imagery to detect the movements and actions of small units, at times attacks can be predicted by imagery showing encampments or amassed equipment, such as trucks. Often, however, this can only be done after the fact. For example, if open-source information about atrocities indicates a pattern of attackers burning down villages, imagery can be used to detect burnt villages that were intact in previous imagery. "In cases like Sudan, it's a little bit of chicken-or-egg," says Jim Stokes, Vice President of Commercial Insight Solutions at DigitalGlobe, where he leads a team of imagery, geospatial, and oceanographic experts that deliver information on a subscription basis. "Prior bad events help us understand future bad events."

"Some of our ongoing customers give us information they have to help drive our collections," says Andy Dinville, DigitalGlobe's Senior Manager for Intelligence Solutions. "For instance, we've worked with the Satellite Sentinel Project in Sudan to try to understand from their sources some of the things that are going on to help point the camera on the satellite at some of the places where there are express concerns of human rights violations occurring or attacks or harassment activities going on." See ***Figures 3-4***.

DigitalGlobe also monitors events around the world, such as typhoons, and tries to anticipate where they will have the greatest impact, so as to maximize its chances of collecting valuable imagery.

Often, knowing where to point the cameras on commercial satellites depends on tips from governments, according to Tim Brown, Senior Fellow at GlobalSecurity.org, an independent research organization. "Say that Syria intervened in Jordan or Turkey or across the Golan Heights into Israel. Using open-source satellites to detect that sort of activity, publicize it, and deter it, really depends more on cross-cueing from the extensive resources of the U.S. and allied intelligence community. Preparations for missile attacks from Syria into Israel or preparations for a build-up along the Golan Heights for an invasion into Israel from Syria are not things that the commercial satellite system is really able to handle on its own. We are not going to discover it because some international NGO detects a build-up. Rather, there are going to be leaks from U.S. intelligence and administration officials to the *New York Times* or the *Washington Post*, saying that we detected evidence of a Syrian build-up and then, once that gets out, human rights organizations and commercial satellite providers are going to start focusing their resources on trying to determine whether it is actually happening and, if it is, to document it."

## ANALYZING THE IMAGERY AND MAKING MAPS

Acquiring the right imagery from the right place at the right time is only the first step. Next, it has to be analyzed and used to make maps. UNOSAT conducts its own satellite image analysis, mapping, and reporting. Additionally, as part of UNITAR, it trains people who work in national ministries, U.N. agencies, and NGOs on the use of the technology for disaster reduction and for humanitarian response. "Very often there's too much focus on access to the actual images and the raw data, while what a lot of people need most of the time is the derived information, such as the extent of a flood," Bjorgo says. "So our mission is to build capacity and to deliver this expertise."

Over the past couple of years, the relatively few

## "Left of Boom"

In the war in Afghanistan, more than 60 percent of U.S. casualties have been due to improvised explosive devices (IEDs). U.S. efforts to counter IEDs have focused overwhelmingly on the explosion–for example, by spending billions of dollars to develop and deploy electronic jammers–and on mitigating its effects. However, as early as 2003, Army officers spoke of the need to disrupt insurgent cells before bombs are built and planted. In military parlance, this was referred to as shifting the focus from "right of boom" to "left of boom"–that is, from actions and activities following the explosion to those preceding it on a timeline.

The latter expression was popularized by a series of articles by *Washington Post* staff writer Rick Atkinson, titled "Left of Boom: The Struggle to Defeat Roadside Bombs," which appeared in the paper in the fall of 2007 and later in a book by the same title. The expression "Left of Boom" has since been used more broadly to refer to activities or programs aimed at preventing crises or catastrophic events. In the context of this article, it refers to the use of remote sensing to obtain early warning of an impending military attack or mass killing with the aim of helping to prevent it.

commercial satellite image vendors have increasingly begun to also provide services. However, what sets UNOSAT apart from them, according to Bjorgo, is that since its inception the agency has been working with a full range of commercial, scientific, and governmental satellite sensors, so it has a very wide technical expertise. "Also, because we're not commercial, because we're a U.N. program, we are in very close contact with the user community in the field; we really understand their need. Not working for profit at all allows us to develop together with them more sustainable solutions."

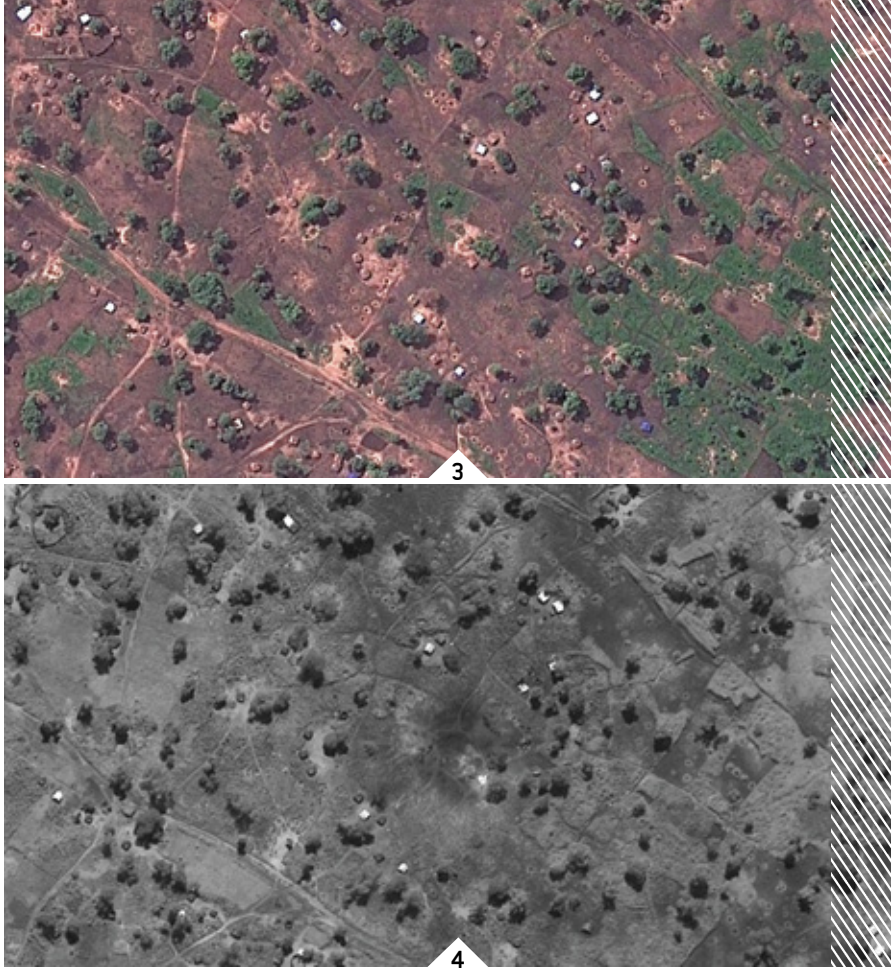
Depending on cloud coverage and other conditions, from the moment it receives a request, UNOSAT can take from one to three days or longer to produce an image. "Once we have the image in-house, if it's really urgent, we typically print out the first product within six hours. That's just a quick overview. Then we can make our refined, more detailed product the next day. Normally, if we can get an image within 24 hours of the request we're really quite happy. The important thing is to make the images available very, very fast and in formats that are easy to use—not what we saw ten years ago, when the formats were highly proprietary and you received the images on a CD in the mail a few weeks after the event was finished."

Bjorgo acknowledges that remote sensing "cannot do everything" and this is where the combination of field assessment and remote analysis comes in. "We play our part and our field colleagues play their part and together we now have a much better system in place than before."

## DATA FUSION

Currently, the biggest challenge in using satellite imagery to detect and monitor military activities and human rights violations is efficiently managing and exploiting the vast amount of data that are being collected. "We're trying to help fuse the data sources that exist, and specifically, of course, do some of the things that we at DigitalGlobe can do to add perspective to some of the data that we assemble," says Dinville. "On a daily basis, there is an ever-growing mountain of data out there. There are webcams, social media sources, ever-growing media feeds, and almost anyone can publish data and make it readily available to a broad community."

DigitalGlobe collects satellite imagery from around the planet at least at half-meter resolution and georeferences it using standard geospatial datasets, such as roads and administrative boundaries. The imagery's resolution is sufficient to show individuals and the size of crowds, whether in Tahrir Square or on the Washington Mall. By fusing data from social media with satellite imagery, "you can take a snapshot in time of those locations," says Dinville. "We are working with all of those types of data to try to provide more awareness and what we hope to be a more objective assessment of what's happening on the ground."




▲ **FIGURES 3-4.** Evidence of airstrike outside of Jau, Unity State, South Sudan, appears in the center of the bottom image, taken Sept. 8, 2013. Before image was taken June 12, 2013. Both are courtesy of DigitalGlobe.

"With the volume of satellite imagery that we're able to collect on a daily basis, our challenge is to process that daily load, turn it around, and make it available rapidly," says Dinville. "We use crowdsourcing to get it in the hands of the right people, to observe, to evaluate and to monitor some of these events that provide derived information." This crowdsourcing includes both experts and non-experts, he explains. "If I'm looking at military equipment, I certainly need a military analyst to try to help support that. But if I'm looking for a lost ship off the coast of Australia, frankly, I need any set of eyes that have had any experience looking for something that doesn't look like open water."

Enormous advances in recent years in the ability of computers to analyze quickly large data files from satellites have greatly increased the ability of analysts to rapidly assess change, Stokes points out. "Change is really the key to all this. Something's there yesterday

and it's not there today, or something that wasn't there yesterday is there today, associated with these global atrocities. We're much better able to detect that in a much shorter window of time." Furthermore, the huge advances in data production, data download, cloud analytics, and image archives, he argues, have greatly improved the ability to understand that change. "Fifteen years ago, you really couldn't do that and today I can, within minutes, look at ten different images from ten years and tell you what's changed."

DigitalGlobe has a growing analytical capability that was part of the legacy GeoEye organization, and they continue to invest in that business. DigitalGlobe Intelligence Solutions combines Earth imagery, deep analytic expertise, and innovative technology to deliver integrated intelligence solutions. Analysts currently support security missions embedded with combatant commands, special operations and other U.S. government mission partners as well as a growing list of NGOs like the Enough Project and the Satellite Sentinel Project.

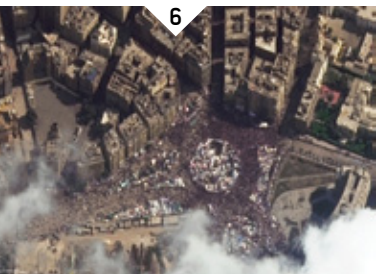

▶ **FIGURE 5.** This image taken June 15, 2013, by WorldView-2 captures a crowd protesting the Brazilian government's decision to raise bus fares. Courtesy of DigitalGlobe.

## CLASSIFIED VS. UNCLASSIFIED

The resolution of half a meter or better of open-source commercial imagery is sufficient to recognize the presence of people on the ground—for example, refugees, protesters, or military personnel—as well as vehicle types. "For instance, across Africa, we can recognize U.N. vehicles bringing relief supplies to an internally displaced persons (IDP) camp," says Dinville. "The combined analytic capability of unclassified satellite imagery at its current resolution and information available through open-source means are more than adequate to expose 'Left of Boom' activities," says Stokes, using a military term for the precursors to an attack. See ***Figure 5***, and box on page 32.

UNOSAT uses the full range of open source imagery, from both government satellites and commercial providers. This can be a challenge, says Bjorgo, because of the number of data formats and new developments. From commercial satellite companies, it acquires mostly very high resolution imagery. Increasingly, UNOSAT buys imagery, due both to its improved finances and to the fact that the commercial companies have dropped their prices.

▼ **FIGURE 6.** This image shows Cairo's Tahrir Square on February 11, 2011, the day Hosni Mubarak gave up the Egyptian presidency, when an estimated 300,000 protesters gathered in downtown Cairo, Egypt. Courtesy of DigitalGlobe.




The imagery available for free on Google Earth is "stale," Brown says. "It gets updated more frequently in some areas, but if you want to see yesterday's photo of where the Syrians were shelling a town outside of Damascus, you have to pay money for it."

## HAVE SATELLITES CHANGED BEHAVIOR ON THE GROUND?

The ability of UNOSAT and of NGOs such as the Satellite Sentinel Project and Human Rights Watch to monitor ongoing atrocities and regional problems around the world is unprecedented. "It is extremely different from what it was during the breakup of Yugoslavia and the Russian intervention in Chechnya," says Brown. "Satellites now provide a much greater ability to monitor and document what is going on."

Ultimately, however, do governments and rebels behave differently because they are aware of being "watched" by satellites? It may be too soon to tell. When Iraq invaded Kuwait in 1990, leading to the first Gulf War, there were not enough commercial satellites to capture the event and the current constellations of Earth observation satellites still barely existed when the United States invaded Iraq in 2003. "Satellites have not yet been used to document a cross-border intervention," Brown points out.

While Bjorgo can point to humanitarian disasters in which governments used satellite imagery to make important decisions—such as planning food assistance in Pakistan or relocating refugees out of shelters built in areas prone to flash floods in Haiti after the earthquake—he cannot cite any examples of governments changing their military behavior due to it. "One can speculate," he says, "but it would only be that."

According to Dinville, however, DigitalGlobe's work in Sudan and, more recently, in Egypt provides some examples of behavioral changes brought about by satellites. "Both Sudan and South Sudan are being watched," he says. "The satellite imagery that we've used has at least helped illustrate and illuminate actions by both parties to help make them understand that they can't just do whatever they want and have no consequence. As we collected imagery over Tahrir Square, we saw more people joining the protests and the military backing off a little bit because they knew that they were being watched. The more we can monitor these events and get the information out rapidly, collaborating with reliable information sources to document these events, the more it will have an impact." See ***Figure 6***.

Brown is skeptical. The real question, he says, is leveraging all that data and turning it into deterrence for actors who are violating international norms and using it as evidence to prosecute war crimes and crimes against humanity. The effort to document what the Syrian government has done is unprecedented, he points out, yet despite images of carnage, destruction, and mass graves from both satellites and sources on the ground, the Syrian government remains committed to maintaining control.

"In spite of all this technology and all of this effort, it has not deterred or dissuaded Assad. I think it is admirable, but I don't know whether it is actually going to work. I haven't yet seen a case in which satellite imagery has deterred a regime from using a military capability or compelled a regime to stop using one." Ultimately, he believes, "a ground photo taken with an iPhone of a mass grave or of burnt corpses in a village is much more capable of moving public opinion than a photo from even the most advanced spy satellite."

UNOSAT recently signed an agreement with the International Criminal Court that enables the latter to rely on UNOSAT expert analysis for the cases that are brought to it. Bjorgo expects this collaboration to become "almost routine for any upcoming war-crime cases, as long as imagery can bring something to the table." See box to right.

While the use of satellite imagery began nearly sixty years ago, its use as a tool to help prevent, document, and prosecute war crimes and crimes against humanity is still in its infancy. Its effectiveness for this purpose will depend on the collaboration of private satellite companies, governments, and NGOs in building a system that international tribunals will accept as reliable and impartial.

## Establishing Satellite Imagery as a Tool for International Criminal Prosecution

The analysis of satellite imagery, once the sole province of governments, can now be a great tool for NGOs to use in support of international judicial bodies to hold perpetrators of crimes against humanity to account. However, to accomplish this goal repeatedly and effectively, NGOs need to build a system, prove its neutrality, and establish legal precedents, according to a journal article by members of the Satellite Sentinel Project. "The techniques of analysis and compilation of satellite data for documentation of humanitarian crises," they write, "should be developed into a structured discipline" because this "would maximize efficiency and increase reliability."

While non-profit human rights groups have been essential to raising funds, increasing awareness, and recruiting volunteers for these projects, they point out, their agendas can bias their findings and greatly reduce their credibility in court. "Therefore," they argue, "if such projects were to be employed in greater numbers and their work submitted to international criminal courts, the establishment of a third-party verifying organization would be necessary."

Finally, while satellite imagery has been submitted to and considered as evidence by the International Criminal Court (ICC), it has not been formally admitted as evidence by the court. A first case in which the ICC accepted this kind of evidence would establish a crucial legal precedent—making it more likely that satellite imagery would be admitted as evidence in the future, encouraging its use as an investigative tool by the court's chief prosecutor, and encouraging the formation of other independent data analysis projects.

**Source:**

Ben Yunmo Wang, Nathaniel A. Raymond, Gabrielle Gould, and Isaac Baker, "Problems from Hell, Solution in the Heavens?: Identifying Obstacles and Opportunities for Employing Geospatial Technologies to Document and Mitigate Mass Atrocities." *Stability: International Journal of Security & Development*, 2013, 2(3): 53, pp. 1-18, DOI: http://dx.doi.org/10.5334/sta.cn

# Airbus Defence and Space Expands Sensor and Service Offerings with an Eye on Mission

## Geo-Intelligence Division at Airbus Defence and Space (formerly Astrium)

*Through its Geo-Intelligence programme line, Airbus Defence and Space (formerly the GEO-Information division of Astrium Services) has been significantly increasing its Earth observation capacity for some time, including a diverse array of sensors at different resolutions, as well as commercial radar imagery that can capture data at night and through clouds.* Sensors & Systems *(S&S) editor Matt Ball recently spoke with Bernhard Brenner, executive director Geo-Intelligence programme line, about the company's diverse data collection platforms and upcoming plans. The conversation ranged from satellite capacity, opportunities in the commercial market to deliver solutions and services, and the overall market prospects for their data and services.*

**S&S** *I was fascinated by your work history at another Airbus Group (former EADS) company, having managed Eurocopter operations in both South America and Southeast Asia. Do the similarities between helicopters and Earth observation go beyond having a view of the Earth from above?*

**BRENNER** Another parallel is that when you sell a person a helicopter, they're not always interested in the helicopter. They are interested in the mission. I think the same thing is true of satellites. Many of our customers are not interested in satellites; they're interested in the mission and the results coming from this data.

I think it is important that we remain focused on what the customer wants to do with the images, and how we can deliver them. We want to be both market-oriented and mission-oriented.

Editor's Note: This story was originally published in November 2013 with Location Media Alliance partner *Sensors & Systems*: http://bit.ly/1fkZl43

**S&S** *Airbus Defence and Space is investing heavily in the market, with so many satellites getting ready to launch, and so many already in orbit. You're in an impressive position compared to the rest of the market, although there seems to be a great number of new competitors emerging lately.*

**BRENNER** We are indeed completing our optical constellation with SPOT 7 soon on its way and our radar capacity with PAZ, the Hisdesat satellite, expected for 2014. This gives us high reactivity and faster access to any target every day. We also have a unique acquisition capacity both with Pléiades 1A and 1B, and SPOT 6 & 7. For instance, SPOT 6 & 7 will be able to acquire six million km²/day. In addition, the combination of optical and radar satellites gives us a unique position on the market.

Now it's up to us to demonstrate to our market. We are number two in the world, and I think there are many opportunities for us in this market. We have the assets and the expertise to strengthen our position and get a good market share in the very high resolution market.

**S&S** *On the very high resolution segment of the market, there's such an international push now to remove the resolution restrictions. Do you think that may resolve to allow you to commercially sell the best quality imagery that you capture?*

**BRENNER** There is more demand always for very high resolution, but you can get a very high resolution with airplanes and with drones. I think the market is pushing for very high resolution. Whatever is the demand, we of course obey the restrictions and laws fixed by governments with regards to security and sovereignty considerations.

**S&S** *On the SPOT and Pléiades satellites you have a nice combination of resolution, including very high resolution. Is there any gap right now in terms of your optical capacity?*

**BRENNER** Indeed, while SPOT 6 and SPOT 7 will provide a wide view over a large area, Pléiades 1A and Pléiades 1B will be able to offer, the same day and for the same zone, products with a narrower field of view, but with an increased level of detail. You can imagine how useful this capacity is for our customers whether they are in the defence, institutional or commercial sectors.

**S&S** *Your radar offering has some nice advantages. What are some of the ways that you're providing solutions with a combination of optical and radar imagery?*

**BRENNER** TerraSAR-X and TanDEM-X are very successful so far. For example, we utilize radar and optical for forest mapping to discriminate difficult land classes. Also in cloudy equatorial areas, radar elevation models complement the optical elevation coverage.

You might know that we are working on the WorldDEM™ project to be commercially available later this year. The complete coverage of the Earth will soon be finished. It has been completed twice, and will be done a third time—and even a fourth time—if necessary in order to meet our quality requirements. The multiple visits are particularly important for difficult terrain such as in mountainous regions. This is a product that is definitely unique, and that will establish a new standard for digital elevation modeling.

**S&S** *You're in a bit of a unique position at Airbus Defence and Space, as a different division of your company is building satellites, including the upcoming series of satellites for the EU's Copernicus (formerly GMES) satellites. Is there some crossover between the two groups?*

**BRENNER** We succeeded in the sale of some satellites (I'm sorry, but I can't tell you which ones) because of our offering on the services side. Sometimes, the customer is more interested in the soft skills of how to operate and what to do with the satellite rather than the hardware. Sometimes to prepare the arrival of their own satellite the customer asks for some services immediately. This is the beauty of our group (Airbus Group), and within Airbus Defence and Space, that we can meet the customer with both strengths: hardware and how to operate the satellite.

In many countries it is difficult working with the requirements of various departments that may not be satisfied with the output of data. Different departments and ministries have different objectives. The beauty of our group is our ability to handle both sides, and to tailor output to different needs.

This is true for Copernicus as well. Our interest is much larger because we are building some of the satellites, and also can make use of the data. Airbus Defence and Space operates the optical and radar-based satellites—SPOT, Pléiades, TerraSAR-X and TanDEM-X—that supply data for Copernicus services. But we also play a major part in the construction of the Sentinel satellites that will complement the data from the Copernicus Contributing Missions.

**S&S** *On the services and solutions side, I understand that you've added some cloud capacity to help deliver imagery.*

**BRENNER** We will never focus only on data; we will always focus on solutions and services as well. One of the services is to stream data and offer cloud services to improve the delivery of data to the customer. We are technology and platform agnostic. In

Bernhard Brenner
Executive Director
Geo-Intelligence programme line
Airbus Defence and Space (formerly Astrium)

the end, we just want to enter new markets, and this can be reached through ArcGIS from Esri, from Google Earth and Google Map Engine, or through our own platforms like Get GEO and DataDoors. Our target is to take full advantage of all the platforms and routes to market.

**S&S** *Your materials discuss being the fastest to the desktop. Is speed a growing advantage for satellite imagery?*

**BRENNER** Speed is of the essence, definitely. The freshness and reactivity of the data is important, and this is the feedback we have been getting from Pléiades customers. For example, we added Google as a customer in September based largely on speed. I don't know if we are the fastest–and of course accuracy is important–but we can deliver direct tasking of Pléiades imagery within one hour of the original request.

GeoStore, our imagery portal on the Internet, facilitates ordering and also includes an option for instant tasking. This is a new innovation aimed at empowering the customer, because it allows our customers to task the satellite of their choice as it passes over their area of interest–essentially "having the joystick."

**S&S** *Were you impacted at all by the sequestration or U.S. government shutdown?*

**BRENNER** Unfortunately, not really, at least not as much as some of our competitors. We'd like to be more impacted, because it would mean that we do a lot of business with the U.S. government.

To take your question more generally, we are quite balanced in our market across the world between continents. One third of our business is with Asia, one third with North and South America, and one third in Europe and the Middle East. This balance is also achieved in terms of customer segments. We feel pressure on budgets in Europe too, but we are able to compensate and find other areas of growth. So far, we have done quite well, thanks in part to our distribution worldwide, with 34 receiving station partners and 140 resellers worldwide.

**S&S** *What is the picture in terms of your balance of commercial and government clients and services? Are you focused on delivering vertical market solutions to any particular industries?*

**BRENNER** We want to grow in commercial markets. We have defense, institutional and commercial markets. In the institutional market, we are quite strong. We have defense customers in many countries, but a potential to do better. Commercially, the oil and gas market is interesting notably because we have the unique combination of optical and radar imagery as well as value added services. We have a strategic agreement with Spatial Energy in Boulder, and we are working very well together.

**S&S** *Are there other vertical markets that you're poised to address? I know that DigitalGlobe has an international fishing product. Are there similar solutions that you foresee?*

**BRENNER** We checked our portfolio, and the answer is in defense, oil and gas, maritime activities, and we also want to satisfy the internal needs of our huge group, formerly known as EADS, now called Airbus Group.

In the last few years, we've done big solution deals with our aviation and space companies, where there is a huge internal demand for this kind of data. We won a big border control project with the former EADS Cassidian division, and our satellite data was a big part of that solution.

**S&S** *You have a lot of products, and a good diversity across the globe. As a final topic, I'd like to touch on the promise of the overall market versus current market performance. There is an increasing level of competition, but is the competition cutting into profits or stirring more interest in the data and solutions overall?*

**BRENNER** That's an interesting question. You can imagine that I'm amazed every day by what I learn. Even people that have been in this industry for a very long time are quite amazed to see new kinds of customer requests. I think it's just fascinating what you can do with the intelligence coming out of satellite data. In some markets, we match the expectation. In other areas, we are surprised to learn of new requirements and we try to meet them. That's the beauty of this industry, which is quite dynamic. There are always new things popping up. ∧○

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