

A P O G E O

S P A T I A L

ELEVATING GLOBAL AWARENESS

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Interference *p. 10*
by Victoria Samson

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the Weather Data Gap *p. 30*
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Earth Observation Priorities 2014

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“Radio occultation data is considered by NOAA and others as an effective gap-mitigator because it not only improves the (weather) model forecasts on its own, but also calibrates data from other satellites, thereby improving the forecast impact of other satellite data and improving the overall forecast.”
– Anne Hale Miglarese, CEO of PlanetiQ *p. 30*

“It turns out that the long sought after Killer App in the commercial imagery industry isn't an app at all—it's improved service delivery powered largely by Web and cloud-based solutions.”

– Dennis Jones, Chair of the Earth Observation Industry Alliance *p. 16*

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NOTES



MADAGASCAR

The Tambohorano Wetlands on the western shoreline of Madagascar has been home to over 80 species of birds, of which 20 are endemic to Madagascar. Mudflats surround the mainland and Lake Mandrozo is natural, with very clear water. Seasonal rivers contribute to maintaining the wetlands. Image taken by Landsat, Oct. 9, 1994. Image courtesy of U.S. Geological Survey, Earth Resources Observation and Science Center.

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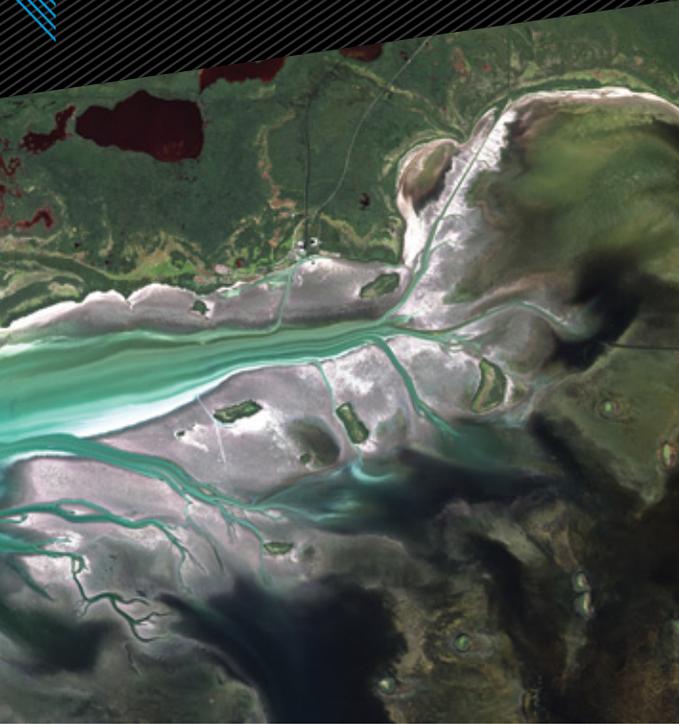
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By Matteo Luccio, Contributor



Florida Everglades

THIS IMAGE SHOWS Everglades National Park, in Florida. The area is the largest subtropical wetland ecosystem of its kind in the United States. The National Park protects the southern 20 percent of the original Everglades.

It is a World Heritage Site, and an International Biosphere Reserve. Contrary to popular belief, the area is not a swamp; it is a slow-moving river.

The area encompasses a combination of habitats that together make up an extraordinary and valuable ecosystem. The Everglades are home to 67 threatened or endangered species. One out of three Floridians rely on the Everglades as their water supply.

Earth observations are absolutely critical for managing the Earth's ecosystems, protecting endangered species, and managing our threatened water supply. On page 20, we provide a summary of the Earth Observation Priorities 2014, from the Alliance on Earth Observations. This report shares what is being done, and what there is yet to do in this critical area.

Image captured by WorldView-2 on Jan. 5, 2014, courtesy of DigitalGlobe. 

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Formerly **Imaging** NOTES

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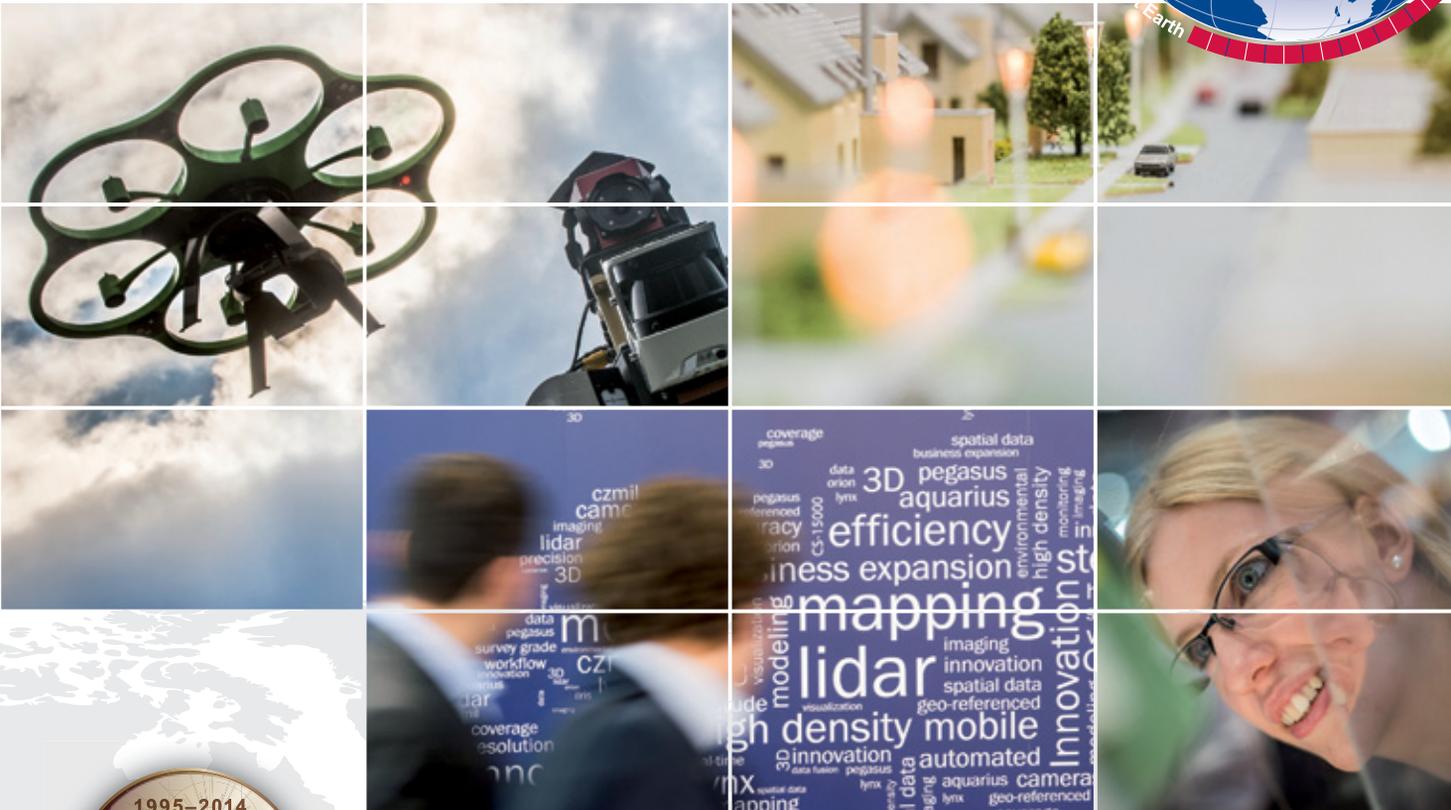


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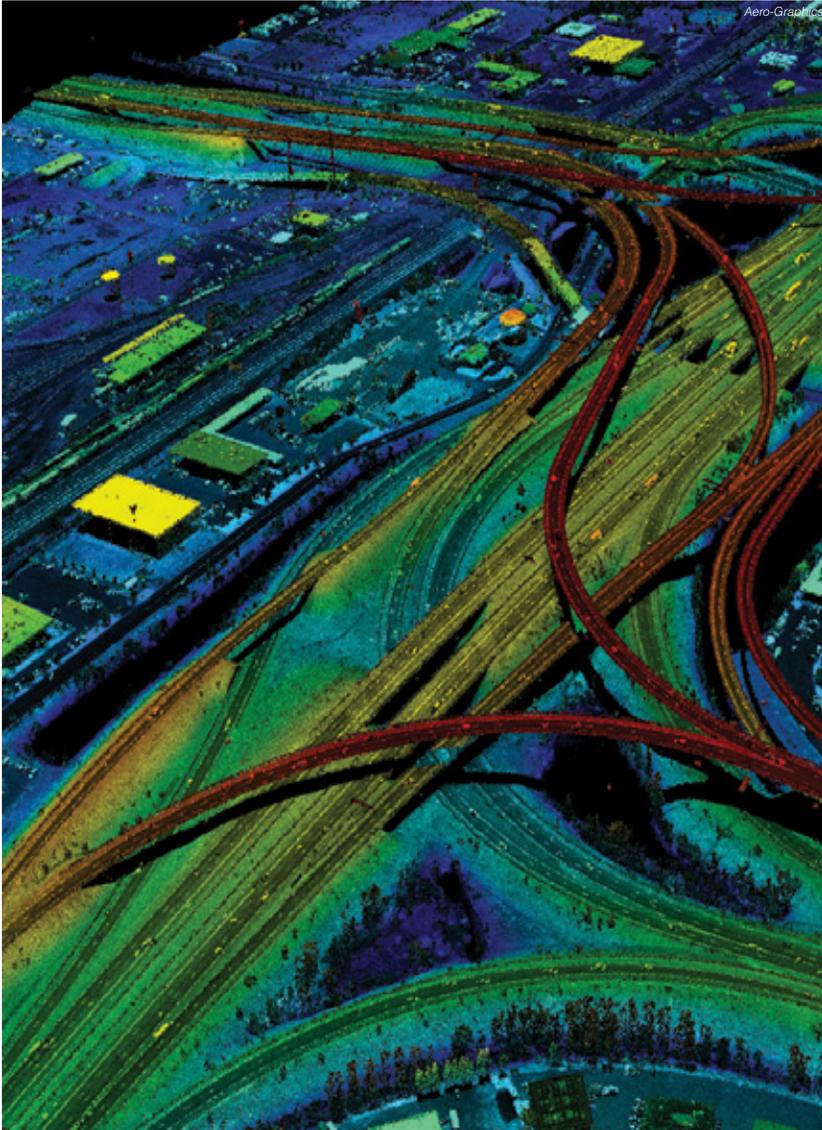
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Earth Observations Must Remain Priority

DEAR COLLEAGUES,

With the re-launch of *Imaging Notes* as *Apogeo Spatial* over a year ago, we recommitted to communicating with you how geospatial data and tools are critical to solving some of the world's biggest, interconnected problems, related to the Earth's changes, for long-term sustainability. The American Geophysical Union (AGU), and companies such as DigitalGlobe, have similar missions. DigitalGlobe is "seeing a better world." The AGU "galvanizes a community of Earth and space scientists that collaboratively advance and communicate science and its power to ensure a sustainable future."

In June, I attended the AGU's Science and Policy meeting, which emphasized the continued need for policymakers to understand the importance of Earth science. The AGU Presidential Citations for Science & Society were awarded to Sen. Barbara Mikulski (D-Md.), chairwoman of the Senate Appropriations Committee; Dr. Eugenie Scott, former Executive Director for the National Center for Science Education; and Dr. Naomi Oreskes, a science historian who uses reason to fight climate change denial, and co-author of the ground-breaking book, *Merchants of Doubt*, which looks at how the tobacco industry attempted to cast doubt on the link between smoking and lung cancer, comparing it to those who would cast doubt on climate scientists.

Dr. Oreskes is a professor at Harvard University. In her 2004 paper published in *Science*, "Beyond the Ivory Tower: The Scientific Consensus on Climate Change," Oreskes analyzed nearly 1,000 scientific journals to directly assess the magnitude of scientific consensus around anthropogenic climate change. 97% of scientists agree that humans are causing climate change, yet only 41% of the public agrees. Only one in 10 Americans realize that there is 97% agreement among scientists. It is time to realize that the responsibility of the press to "tell both sides of the story" is only relevant when there are two sides. In this case, there are not.

On the same note of policymakers understanding the importance of Earth science, the newly released "Earth Observations Priorities 2014" is summarized on page 20, noting that Earth observations are essential in solving many global problems. Download the full report at <http://strategies.org/environmental-information/alliance-for-earth-observations/>.

Our regular column, "On the Edge" also addresses the importance of Earth science in studying climate change. The author, Hans-Peter Plag, PhD, has just formed the Mitigation and Adaptation Research Institute at Old Dominion University (www.mari.odu.edu). See page 12.

The current administration is making progress, releasing the first ever U.S. National Climate Assessment in May 2014. In addition, The White House Climate Data Initiative was announced in March, and Esri and Microsoft (among others) are providing technology and expertise. They are creating portals for communities and citizens to access and use the expansive data from NOAA and USGS, on www.climate.data.gov, and www.resilience.maps.arcgis.com/home.

In order to better predict severe weather, flooding and drought, PlanetIQ is launching commercial weather satellites. CEO Anne Hale Miglarese shares on page 30 why this makes sense for the federal government and other customers. All eyes are on the potential weather data gap, which could occur anytime, most likely in 2017.

In this issue on page 18, we recognize the next generation of remote sensing leaders, the winners of the DigitalGlobe Foundation Scholarship, who are at the university level, and the Thacher Environmental Research Awards, who are high school students.

Also, our sister publication *LBx Journal* is continuing our weekly enewsletter of the best news from around the Web related to location in the language of business, with *LBx LITE: Business Game Changer* (location information, technology and economics). Opt in, or add your email to the list at www.lbxjournal.com (click top right).



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Radio Frequency Interference

A THREAT TO SPACE SUSTAINABILITY

OVER THE LAST SEVERAL YEARS, the long-term sustainability of the space environment has been a growing concern for the space community. Much of the discussion on space sustainability has focused on physical threats to satellites, such as crowding in highly used orbits and the growing population of space debris.

The concern is that these threats may jeopardize humanity's ability to use space for the many benefits it currently provides and new benefits we have yet to even see. Secure World Foundation envisions the secure, sustainable and peaceful uses of outer space contributing to global stability on Earth; as such, we have played an active role in trying to increase awareness of these issues and promote multi-stakeholder dialogue on finding cooperative ways to address them.

Yet there is another, invisible piece to the space sustainability problem that poses just as big of a challenge—radio frequency interference (RFI). All satellites need to communicate with ground stations or each other in order to provide their services and nearly all of this communication takes place over the radio frequency part of the spectrum. There are a range of natural and human-generated threats that could interfere with the ability of satellites to effectively communicate over radio frequencies, and dealing with the challenges of RFI is an important part of the space sustainability conversation.

As part of our efforts to expand the dialogue on RFI and space sustainability, SWF co-sponsored an invitation-only breakfast salon on May 21, 2014, at the Space Foundation's 30th Space Symposium in Colorado Springs, Colo., where a selected panel of experts brought a wide variety of perspectives to discuss both deliberate and unintentional RFI, and the current mechanisms and legal issues for dealing with them. The discussion was held

under Chatham House Rule, meaning that the remarks were not for attribution.

Although the panel was drawn mainly from the satellite telecommunications community, the issue of RFI is increasingly important to those of us interested in Earth observation as well. There is growing concern that terrestrial competition for frequencies critical to radar imaging, for example, might create even more problems for remote sensing than jamming causes for the telecom industry. Given all that could be at stake, it will be wise to keep an eye on the whole range of the RFI problem.

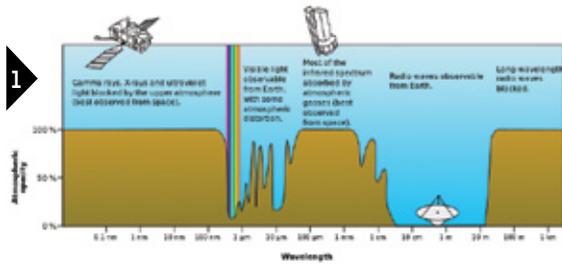
The first speaker of the panel began by pointing out that telecommunication satellite services depend upon freedom of information “regardless of frontiers,” a basic principle that dates back to the 1948 Universal Declaration of Human Rights and is emphasized again in the 1966 International Covenant on Civil and Political Rights. After having established this, he argued that intentional RFI through the deliberate jamming of satellites limits the freedom of information and, more and more often, is being used as an “aggressive soft war weapon.”

The speaker believed that the International Telecommunication Union (ITU) could help deal with deliberate RFI by working to improve the identification of where the jamming signal is coming from, also known as geolocation. In his view, geolocation could help “name and shame” actors that are allowing deliberate jamming to occur on their national territory. Finally, the speaker suggested that increasing transparency

by creating a database of incidents could only help discourage future deliberate RFI events.

The second speaker discussed what industry is doing about identifying the source of RFI (primarily unintentional). One industry group takes data from its members, including radio frequency (RF) contacts payload teams, as well as puts out alerts on RF incidents and generates a database of historical RF incidents. The database is being expanded in 2014 to include payload data and the automatic generation of information that allows rapid interferometric geolocation of interference sources. The goal here is “preemptive, proactive timely RFI mitigation.”

The data provided allows for the industry group’s members to undertake geolocation of RFI incidents; the speaker noted that there are



◀ FIGURE 1. Electromagnetic Spectrum showing Earth's atmospheric transmittance (or opacity) to various wavelengths of EM radiation.

legally binding conditions put on the use of that data so the members can be confident that their data is secure. The speaker highlighted a new utility that is being demonstrated during the 2014 World Cup: the Carrier ID database (CIDB), which associates Carrier IDs generated by ground segment transmitters to their authorized satellite operators, easing the way to geolocate and mitigate RFI for participants (e.g., in case of mis-pointed transmitting antenna).

The final speaker discussed potential enforcement options for dealing with intentional RFI. Article 45 of the ITU Constitution, which directs stations to operate in a manner that does not cause harmful interference to others, and ITU Radio Regulation No. 15.1, which forbids stations from carrying out unnecessary transmissions, lay the groundwork to prevent deliberate and harmful interference. However, as the speaker noted, there is not much of an enforcement mechanism, as the ITU—and the international community in general—depends upon compliant operators owning up to RFI. If

they refuse to do so, or if nations refuse to admit that jamming is coming from their territory, there is not a lot that can be done at present.

Nevertheless, the speaker hoped that perhaps the satellite communications industry can take a page from the intellectual property community’s handbook and use trade obligations as a powerful enforcement mechanism. For example, the United States and the European Union could make compliance with ITU’s efforts to prevent RFI a condition for developing countries to receive favorable trade preferences under the Generalized System of Preferences. The speaker also suggested that countries could sue foreign nations through the harmed countries’ domestic court systems for cases of deliberate RFI. In the United States, this effort would be shaped by the Foreign Sovereign Immunity Act, which has an exception clause for an action “in connection with a commercial activity.”

Finally, he suggested that perhaps, under the International Emergency Economic Powers Act, individuals, including government officials, could be sanctioned for allowing deliberate RFI that affected U.S. national or economic security. While the ITU’s efforts could be strengthened, the speaker asserted that governmental efforts, once spurred to action, could provide different options for enforcement mechanisms against deliberate RFI. Note that more on this issue can be found at the blog, LawofSchaefer (<http://lawofschaefer.com/>).

In their remarks and through engagement with the audience, the panel demonstrated that deliberate jamming is increasingly an area of concern for some satellite operators. On a positive note, however, the discussion highlighted that a number of different ways exist to handle RFI, some of which may not have been pursued in the past. Furthermore, with the satellite industry taking proactive steps to handle unintentional RFI, it is clear that a norm is emerging of what constitutes responsible behavior for actors and stakeholders in space. Given that rules of the road guide much of the behavior on orbit, it is encouraging that many stakeholders are willingly participating in the discussions and shaping guidelines that one hopes will allow for the long-term sustainable use of outer space. ▲◊



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The Credibility of Science

ACKNOWLEDGING WHAT WE DO NOT KNOW

THE LAST WEEKS HAVE BEEN FULL of surprising scientific discoveries. In a way, it reminded me of my experience when I was young and hiking alone in mountains in the winter time. Every day brought new situations, new challenges. Predictions of what would happen during the next days were impossible, and being prepared for the unexpected was essential for survival.

In the planning of our cities, infrastructure, economy, communities, etc., we trust that we have a fairly reasonable picture of what might happen in the future. Very little attention is on redundancy that could help us if the unexpected happens. Like many before us, most members of our modern society trust that we have nearly complete knowledge and do not worry about, and do not prepare for, “hidden risks.”

To better understand the importance of acknowledging knowledge gaps, let us look at the challenge of sea-level rise (SLR). Since the beginning of this century, we have seen a rapid development of our knowledge about what is contributing to the current global SLR, and how global sea level may change in this century. The assessments of the Intergovernmental Panel on Climate Change (IPCC) always include trajectories for global sea level during the 21st Century. There are some changes from report to report, but the main picture remains the same: global SLR during the 20th century was larger than in previous centuries, the rate of SLR continues to increase, and by the end of the century, sea level will be significantly higher than today.¹

Around the beginning of the 21st century, several scientific studies attributed most of the global SLR during the last few decades to an increase in the heat content of the oceans, which results in warmer water with a larger volume, hence a rise in sea level.² Another fraction of the SLR was attributed to melting glaciers. The contributions from the Greenland Ice Sheet (GIS) and Antarctic Ice Sheet (AIS) were considered to be minor.

The Gravity Recovery and Climate Experiment (GRACE) satellite that started in 2003 provided excellent observations of mass movements in the fluid envelope of our planet. As early as in 2005 and 2006, the analysis of the GRACE data showed that both the GIS and AIS were losing mass and contributing to SLR, and in 2009 it became clear that these contributions are accelerating.³ Subsequent analyses confirmed the accelerating trends.

Last November, the National Research Council (NRC) published a report on Abrupt Climate Change Impacts⁴ and considered the known threat of a collapse of the West Antarctic Ice Sheet (WAIS), which would cause a global SLR of about 4.5 m. The report concluded that the probability of this collapse starting in the 21st Century as very low. However, a few months later, in May this year, two articles were published providing evidence that the WAIS collapse has started and its retreat is irreversible: the WAIS is melting and will contribute some 4.5 m to global SLR.^{5,6} The question is only how fast this will happen.

Both the IPCC assessment and the NRC report express high confidence that there is no instability that could lead the GIS to contribute rapidly to SLR. However, in May we also saw an article that changed this view: the discovery of deep submarine valleys reaching far inland under the GIS⁷ introduces the possibility of rapid melting of much larger parts of the GIS than previously thought possible. And, before the end of May, another article made the threat from the ice sheets more tangible: Several meltwater pulses



during the last deglaciation 20,000 to 9,000 years ago raised global sea level rapidly, sometimes more than 15 meters within 300 years.

It was generally thought that these pulses came from the melting of the large ice sheets in Scandinavia and North America. The article published in May links the pulses for the first time to major contributions from the AIS.⁸ What has happened in the past could happen again. We still do not know why these pulses started and why they stopped. However, they happened at a time when changes in ocean heat content and air temperature were much slower than today. Under today's rapid transition out of the Holocene, meltwater pulses from the AIS or GIS cannot be excluded.

This brief review of how our knowledge changed over the last decades can be taken as an indication that there are still many knowledge gaps. And these gaps are bridged by assumptions and opinions that have a high probability to turn out wrong (as they did over the last two decades). In the discussion of climate change impacts, we often denote knowledge gaps as "epistemic uncertainties" and we do not explore the full range of what might happen. We display an almost "willful

blindness" to the worst case, and call those who don't alarmists. The response of the large ice sheets to the on-going global warming is a very good example of this normalcy-biased approach to what could turn into an existential challenge for our civilization: learning to live with, and live in, a variable, transient coastline and coastal zone.

In most parts of the world, coastal settlements are organized and coastal infrastructure is designed based on the fundamental assumption that sea level does not change much over time and the coastline is basically fixed. Opening our minds for the possibility that rapidly melting ice sheets could cause rapid increases in sea level and large horizontal progressions of the coastline would require a paradigm shift for the way we live in the coastal zone. We would have to find new ways of how we define private real estate, how we plan the urban coast, and how we design our coastal infrastructure for services such as transportation, communication, power, water, food, sewage, and health.

It does not look like we are ready for this paradigm shift. Many of us rather attach low probabilities to the range of sea level rise that would require fundamental (and expensive) changes, and most of

▲ FIGURE 1. Using sandwalls and sandbags to protect infrastructure against the rising sea is not a viable form of adaptation.

► **FIGURE 2.** Frequent “nuisance flooding” in Norfolk, Va., is increasingly causing logistical problems and economic damage.



► **FIGURE 3.** In a transient coastal zone, the built environment might have to be built so that it can be moved as the coastal zone migrates inland. Photo credit: Larry Atkinson.



us are not open to look at worst-case scenarios to fully comprehend the risks. In particular, quantitative “hard” scientists have problems communicating knowledge gaps—they are supposed to know, not to not know. How we “fill” the knowledge gaps depends on our personal context, our value system, our preferences. Since self-reflection is not a particular strength of natural scientists, we do not analyze how our psychological, social, and political preconditioning impacts our handling of knowledge gaps.

Not considering the worst case and ignoring the huge risks associated with the tail of the risk spectrum carries the danger that things could turn out much worse than what the many assessments on global to local levels consider likely or plausible. Combining the IPCC assessment with the most recent findings about the large ice sheets, we can be rather sure that things will turn out much worse than many of us thought a short time ago.

Who wants to be responsible for our coastal cities not being prepared, if several meters of SLR takes place within a few decades? This would not only drown the coastal cities and infrastructure, it would take away a major share of global productivity, eliminate huge areas of high-value real estate and wealth, destroy much of the coastal defense infrastructure in many countries threatening national and global security, degrade coastal ecosystems, pollute coastal waters and the oceans, impact food and water security, create new health risks, and force unprecedented migration of coastal populations to higher grounds, competing with those already there. A rapid sea level rise could easily turn into a “weapon of mass destruction” (WMD). If that happens, will society turn against the scientists who did not warn assuredly about the threat that is there beyond doubt?

When there was a small chance of Saddam Hussein being in possession of WMDs, the U.S.

Vice President Dick Cheney didn’t want to take a chance, no matter how small the probability. He based himself on the “one percent doctrine,” which basically states that if there is a 1% chance that someone has WMDs, it has to be handled as if it was a 95-100% chance.⁹ Let’s apply this to SLR: based on the most recent scientific discoveries, there is at least a 1% chance that the ice sheets through their contribution to SLR will turn into WMDs, and we should handle this as a 95-100% chance and plan accordingly.

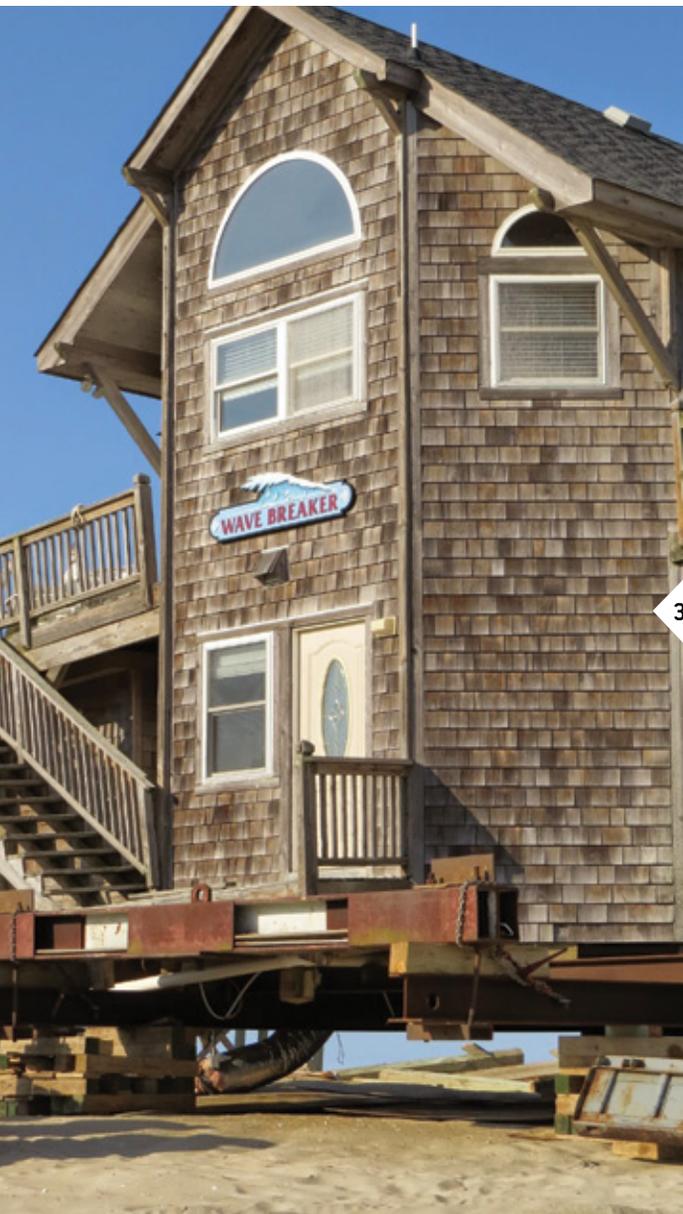
To address successfully the challenge of the “SLR WMD,” we need to better understand the risk associated on local to global scales with every additional meter of SLR. At my university, we have established a “Mitigation and Adaptation Research Institute” (MARI), not least with the mission to assess the risks associated with the tail end of the climate change and sea level rise spectrum as a basis for risk reduction.¹⁰

Hampton Roads in Virginia with its complex socio-economic structure and a high rate of SLR (about 5 mm/year) is a “natural climate change and sea-level rise laboratory” for the nation and beyond. More and more of the low-lying area is getting close to the tidal range, or into it, and frequent flooding impacts the population and economy increasingly. For example,

► **FIGURE 4.** The Amundsen Sea region is the most unstable part of the WAIS. Although it is only a fraction of the whole WAIS, the region contains enough ice to raise global sea levels by 1.2 meters (4 feet). Source: NASA.



a church located on the coast has opened parking areas during high tide to avoid flooding. The mounting risk of extreme flooding combined with insufficient options for horizontal and vertical evacuation creates a general feeling of not being safe.



MARI is working with a wide range of societal stakeholders to co-create the practice-relevant knowledge needed to reduce the risks and to enjoy the benefits of living in the coastal zone. MARI is a positive step aiming to provide the knowledge not about what will happen, but about what might happen and to develop options that would allow the coastal communities to thrive in a transient coastal zone. Learn more at www.mari.odu.edu. 

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Commercial Imagery's Age of Innovation

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Over the past decade, the commercial satellite imagery industry has experienced its share of turbulence. U.S. companies, after experiencing steady growth and increasing U.S. Government demand, spurred by two wars in the Middle East, were jolted by the combination of the global financial crisis, the U.S. budget ordeal and sequestration. In 2013, the U.S. Government cut its commercial imagery budget in half, prompting the merger of the two major commercial imagery companies, GeoEye and DigitalGlobe.

In a span of less than a decade, U.S. industry had consolidated from three companies into one. The merger signaled an end to the National Geospatial-Intelligence Agency (NGA's) widespread investment in commercial remote sensing systems, data, products and services. Despite recent rhetoric at GEOINT 2013(4) in April from the Director of National Intelligence and NGA Director Long about the virtues of commercial imagery and how important it is to DOD and the Intelligence Community, the Golden Goose is out of eggs, for now. James Clapper, Director of National Intelligence, said that 90 percent of the NGA's underlying intelligence now comes from companies like DigitalGlobe. But he said companies should not rely on the government to underwrite new satellite programs (quoted in Reuters, May 23, 2014).

It is in vogue in Washington today to quote Churchill's famous line (lifted from a New Zealand physicist): "We are all out of money. Now we must think." Great ideas often emerge from crisis or difficult circumstances. The denial of one aspect, or diminished prospects in a market, often forces new thinking and a consideration of alternative forms of business and operations. It also focuses attention on

developing other markets and new approaches to markets that have been overlooked and underserved.

Out of Washington's self-described Age of Austerity has emerged perhaps the Age of the Constellation or the Age of Innovation in commercial imagery systems. The recent successful launches by Skybox Imaging and PlanetLabs and Urthecast as well the pending development of systems by BlackSky Global and OmniEarth have ushered in a fresh set of ideas—from operations to products—in how to unlock the hidden potential in the global marketplace for geospatial products. In addition to video collection, source data is expected to further diversify with new companies emerging to provide 12-band multispectral and at least two companies contemplating hyperspectral offerings.

If these ventures are successful in launching all the satellites and all the capabilities they have advertised, it would represent a massive expansion of satellite imaging capacity that dwarfs today's traditional U.S. and foreign commercial systems. The transformation from high-priced imagery product to global-scale commoditization of high-resolution pixels would be complete. Each company promises to continue in Surrey's well-established focus of changing the economics of space. Advances in composites and miniaturization and other key technologies allow these companies to field "good enough" systems at a fraction of the cost of the traditional providers like DigitalGlobe and Airbus.

The ability to offer imagery data at bargain base-ment prices, the theory goes, will unlock pent up demand from users who have traditionally viewed commercial imagery as too expensive, too difficult to obtain and largely unreliable. The long sought after Killer App in the commercial imagery industry it turns out isn't an app at all—it's improved service delivery powered largely by Web and cloud-based solutions.

Editor's Note:

This editorial was written just prior to the long-awaited change to the commercial remote sensing license, allowing U.S. companies to sell imagery at better than .5-m resolution.

The one wrinkle to this theory is just that; it's based on a theory. The problems these companies are trying to address through less expensive products and a Web 2.0 delivery model are real and have persisted since IKONOS was launched in 1999. While great strides have been made in penetrating commercial markets, the defense and intelligence market remains the fundamental underpinning of success for commercial imagery providers. According to market analysis and consulting firm Euroconsult, the overall market for imagery data tops \$2 Billion and is expected to grow steadily for the next decade. Defense users globally comprise over 60% of this total market. The massive capacity expansion promised by these new systems at affordable price points should position these companies well in the traditional defense market. The Director of NGA is on record, most recently at the 30th National Space Symposium in May, that persistence is the Holy Grail of the geospatial community.

Constellation and video companies provide something approaching persistence without bankrupting the treasury. Still the promise of cheaper pixels is alluring and the fact that many of these innovative companies are exposing APIs for applications development may produce new products that can be monetized and further their reach into existing and untapped commercial markets. Again, Euroconsult has estimated that commercial markets—based on growing use of data for location-based services and increased need for monitoring and analytics solutions—will continue to grow at a fairly robust pace in the next decade.

The new companies and new concepts should come as no surprise. The very establishment of the high-resolution commercial imagery industry resulted from similar threats to traditional defense budgets. In the early 90s, with the Cold War won, the Pentagon signaled to its base of prime contractors that they should not rely on defense funding to sustain them. They needed to diversify into new markets.

In the reconnaissance/surveillance arena, companies like Lockheed Martin and Raytheon took these threats seriously and formed Space Imaging, the company that pioneered the commercial sub-meter resolution IKONOS satellite (which by the way is still healthy and flying at the ripe old age of 14). Other companies like DigitalGlobe, and OrbImage emerged. When the predicted commercial market did not rapidly appear, these companies matured based largely on a robust partnership with the U.S. Department of Defense.

However it was a partnership based on shared government and industry risk. While no one expects the DOD to restore commercial imagery funding to pre-2013 levels, the amount of new investment from outside sources presents an enormous opportunity for the U.S. Government or any government for that matter. Wall Street and Silicon Valley are pouring money into these new companies at a surprising rate given current economic conditions. Governments can leverage these investments to procure new products and services at less expense and less, or no, risk than previously. Government needs for reliable, high quality, unclassified imagery data and products have not slackened. The advent of these capabilities could—and should—prompt a reconsideration of budget priorities for NGA, NRO, and other agencies and departments globally. “The capabilities the commercial space has now and the even better capabilities on the near horizon are a critical part of the [intelligence community’s] strategic plans,” Clapper said in a May 21, 2014 interview with *Space News*. “We all want commercial space imagery to do well.

I have a lot invested in it, personally and professionally.”

Governments, and the U.S. Government in particular, should also reconsider their policies and regulatory regimes. While these new capabilities and diverse source offerings create new regulatory and policy challenges, governments should strongly support investment in these new technologies and concepts of operation to ensure that these companies can compete—in government and commercial markets. Governments have traditionally balanced national security and economic interests in making regulatory policy. The balance has tipped too far in the national security direction. Imaging satellite systems are proliferating—not just in North America, but globally. Capabilities are improving here and abroad as demand increases. The creation of a new, more industry-friendly national commercial imagery policy accompanied by a loosening of the government’s regulatory grip would continue to foster this growth to ensure companies have every opportunity to be successful in this transforming market. ▲

The long sought after Killer App in the commercial imagery industry it turns out isn't an app at all—it's improved service delivery powered largely by Web and cloud-based solutions.

Thacher Environmental Research Awards

High School Students Use Space Data and Imagery for Projects

THE THACHER ENVIRONMENTAL RESEARCH CONTEST IS AN ANNUAL COMPETITION

founded by the Institute for Global Environmental Strategies (IGES), and honoring Peter Thacher, a former IGES board member and leader in promoting the use of remote sensing. The Thacher Contest challenges students grades 9-12 to use geospatial tools and data to create innovative research projects. Winners of the contest receive cash prizes of \$2,000, \$1,000 and \$500.

GRAND PRIZE WINNER is **Zachary Weishampe**, for his paper, "Remote Sensing of Water Quality Trends of Central Florida Lakes Over 30 Years: Headwaters of the Everglades & St. Johns River Systems."

Zachary is going into his sophomore year at Paul J. Hagerty High School this fall. He writes, "I have always enjoyed science courses and learning how nature works. My father, a biology professor at the University of Central Florida in Orlando, Florida, and my mother, an elementary gifted math and science teacher, encouraged me. Starting at a young age, science interested me. In 5th grade, I liked going on the 'mud walk' tromping through alligator-infested wetlands of Seminole County."

In 6th grade, he received honorable mention at the State Science and Engineering Fair of Florida for an experiment to determine the effects of cigarette filters on a common freshwater crustacean. In 7th grade, he placed 3rd in the Seminole County Science and Engineering Fair in the Earth and Space Science Category. His project identified how hurricane path characteristics related to model prediction accuracy. This past year, his Experimental Research teacher, Ms. Zietlow, helped him to focus his research project, which used Landsat Thematic Mapper imagery to examine water quality trends in central Florida lakes. He placed 3rd in the State Science and Engineering Fair in the Environmental Science category. This summer, he is a volunteer camp counselor at the Orlando Science Center. During his freshman year, he was also on the varsity high school soccer, cross country, and track teams.

2ND PLACE WINNER is **Soo Yeon (Sean) Lee**, for his paper, "Exploring the Influence of the Aerosols on Regional Precipitation Through the Case of Wildfires: Observation of the Deepening Effect of Aerosols."

Sean, a senior this fall at the Stevenson School in Pebble Beach, Calif., was inspired by his inability to see a single star from his hometown of Seoul, Korea, due to air pollution. Sean conducted research exploring the effects of wildfires on aerosols and precipitation in the southwestern U.S. Using Moderate Resolution Imaging Spectroradiometer (MODIS) imagery and precipitation maps, Lee was surprised to discover that where there was an increased atmospheric aerosol count, there was also a slight increase in precipitation rates. He is planning on continuing his study in Environmental Engineering at University of Iowa this summer. When he is not thinking about engineering, he loves reading mystery books and playing Sudoku.

3RD PLACE WINNER is **Destiny Burnett**, for her paper, "How Is Vegetation Health Affected When It Is Disturbed By Human Development?"

Destiny, a senior this fall at Patrick Taylor Academy in Gretna, La., was curious about the impact her school had on local vegetation in nearby wetlands. Using geospatial software, Destiny analyzed Near-Infrared (NIR) Composite, Middle Infrared (MIR) Composite, and Normalized Difference Vegetation Index (NDVI) data from 2001-2011, noting areas not only lacking vegetation, but also observing that areas with remaining vegetation appeared unhealthy. She is active in Student Government Association and National Honor Society, and she is President of the Patrick Taylor Book Club. In her spare time, she enjoys reading, listening to music, writing, and bettering her high scores in Dance Central. Destiny plans to attend Louisiana State University in Baton Rouge for her bachelor's degree; her major remains undecided amongst anthropology, psychology, and creative writing. ^o^

Zachary Weishampe



Soo Yeon (Sean) Lee



Destiny Burnett



DigitalGlobe Foundation Scholarship Winners

University Students Recognized for Excellence in Geography

THE DIGITALGLOBE FOUNDATION SCHOLARSHIP IS COMMITTED TO PROVIDING RECOGNITION AND FINANCIAL ASSISTANCE TO OUTSTANDING UNDERGRADUATE STUDENTS

in the field of Geography, including Geographic Information Systems (GIS), Remote Sensing, Spatial Analysis, Cartography, Aerospace Engineering, etc. The award recipients won on a variety of factors, including merit, motivation, involvement in campus or community activities, as well as a passion for GIS and plans to pursue a career in the geospatial sciences.

Eric Ong

GEORGE MASON UNIVERSITY

Eric will be a junior at George Mason University, majoring in Geography with dual minors in Intelligence Analysis and GIS. Eric has made the Dean's List multiple semesters. After graduation in May 2015, he plans on a career in geospatial intelligence. Eric graduated from Westfield High School in 2011 and concurrently completed courses through Chantilly Academy, where he took classes in GIS and Engineering. Eric is a certified lifeguard and emergency first aid responder and has extensive experience working at municipal and university aquatic facilities. In August 2014, Eric will be traveling abroad as a scholarship recipient to Beijing where he will participate in the 2014 International Agro-Geoinformatics Conference.

Patrick Wittick

PENNSYLVANIA STATE UNIVERSITY

Patrick, from Downingtown, Penn., is a Schreyer Scholar, and will be a senior in Aerospace Engineering this fall. He is working on an Honors thesis developing a computer simulation to model the dynamics and control of a spacecraft following the capture of an uncooperative asteroid. Patrick is a member of Sigma Gamma Tau, and has been involved as a member of Penn State's Lunar Lion XPrize team on the Guidance, Navigation, and Controls subsystem for the past two semesters. He worked as an engineering tutor during his junior year and currently does vibration analysis work as an intern for KCF Technologies, Inc. in State College. He plans to attend graduate school to obtain a Masters degree following graduation.

Chris Tombasco

PENNSYLVANIA STATE UNIVERSITY

Chris is from Sugarloaf, Penn., and is also a Schreyer Scholar. He will be a senior in Aerospace Engineering this fall. For his Honors thesis, he is determining the minimum mass of an asteroid needed for a gravity assist to have a significant effect on the velocity and trajectory of a spacecraft. He is looking at how many asteroids of adequate mass exist, primarily in the asteroid belt, and how often they are in the proper place to be of use in a gravity assist. Chris has been chapter president of his fraternity, Delta Kappa Epsilon, is a member of Sigma Gamma Tau and has been involved in THON through Finance Committees for the past two years.

Ken Eggering

UNIVERSITY OF COLORADO

Ken has a dual background in Geography and Geology. He has undertaken ambitious projects in his classes, has a research internship at a campus research center, and studies in three of the award's cognate areas: GIS, remote sensing and cartography. Three of Ken's projects for class include his work with the City of Leadville, Colorado, to use GIS to assess sidewalk safety for school children; his GIS programming project to relate gun violence with demographic characteristics; and his remote sensing/cartography internship project for INSTAAR (Institute for Arctic and Alpine Research) modeling sediment plumes on the Greenland ice sheet. He plans to use his award funding to undertake geospatial field work in Peru this summer in support of indigenous communities. After completing his degree this fall, Ken wants to work as a GIS analyst in Colorado. ^o



Earth Observation Priorities 2014

A Report by the Alliance for Earth Observations

INTRODUCTION

Within the borders of the world's third largest country resides the most dynamic and technologically advanced economy on the globe. From smartphones and cars to supercomputers and nanotechnology, the United States is a global leader in innovation. As a vast country with a diverse landscape of mountains, deserts, plains, coasts, wetlands, lakes, and forests and an equally diverse populace, the U.S. must rely on its technological innovation to guide a secure future for the more than 318 million people that make this nation their home.

Nowhere is reliance on technology and innovation more apparent than in the area of understanding and predicting weather and climate on time scales that range from hourly to decadal. From the submersibles deep in the ocean, to ground-based instruments, to satellites in space, today's U.S. civil Earth observation capabilities may seem robust. However, despite monitoring the planet with an estimated \$5 billion annually spread across 17 Federal agencies, the U.S. still faces many challenges. While satellites are operating well past their designed life span, there is a lack of integration across programs, no comprehensive strategy exists to ensure future systems are adequately robust to meet new needs, and approaches to engage and grow the private sector have yet to be defined.

Progress has been made. For example, the White House and Congress have recognized the value of our nation's weather satellites and have improved development with stable and consistent funding and oversight. The Office of Science and Technology Policy has developed a *National Strategy for U.S. Civil Earth Observations. The Implementation Plan for the National Strategy*

for the Arctic Region and National Ocean Policy Implementation Plan have recognized the key role of observations and outlined necessary actions for the federal government to pursue. The U.S. House of Representatives passed the Weather Forecasting Improvement Act and Congress recently reauthorized the National Integrated Drought Information System program. The recent release of the *National Climate Assessment* also drives home the important message regarding the need for improved environmental information, which results from space-based, airborne, and *in situ* ocean, land, and atmospheric observations, research, and modeling.

This report seeks to further identify key priorities and recommend actionable steps, and was informed by numerous reports, such as the Government Accountability Office's *2013 High Risk List* and the *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey*.

PRIORITIES

Earth Observation Priorities 2014 focuses on five critical topics: Weather and Climate, Drought, Water Resources, the Arctic, and Economic Competitiveness.

Related to these priority areas, the Alliance recommends that Congress provide stable funding for Earth observation programs across the federal government recognizing the interconnectedness of these programs, the importance of mitigating and reducing the risk of data gaps, the goal of restoring superiority in weather forecasting, and the economic benefit of long-term investment to the nation.

Specifically, Congress should:

- Better protect American lives, property, and the economy by supporting the FY2015 budget requests for weather and climate satellites and surface-based observation programs (JPSS, GOES-R, NASA's Earth Science Research missions, the DOD Weather System Follow-on and the National Mesonet Program).
- Equip Americans to better understand and respond to drought by providing funding as authorized to maintain and improve the National Integrated Drought Information System (NIDIS) and

Editor's Note:

This is a summary. The complete report is available at <http://strategies.org/environmental-information/alliance-for-earth-observations/>.

The weather data gap is also addressed in an article about PlanetiQ, on page 30.

by providing consistent funding and oversight for a continuous medium-resolution governmental land imaging program.

- Advance U.S. freshwater monitoring and forecasting by continuing to fund the National Streamflow Information Program at an appropriate level.
- Protect U.S. interests and implement expanded Earth monitoring capabilities in the Arctic to better understand and predict changes in the most rapidly changing region in the world and how those changes affect not only the Arctic, but the entire globe.
- Drive U.S. innovation, create jobs, and grow the economy by adopting public-private partnership business models where feasible to augment national systems with commercial data sources, hosted payloads for dedicated sensors, and new innovative measurement capabilities, and to provide the private sector with greater access to existing government data sources.

The President should direct federal agencies to continue to work toward an integrated Earth observation system of systems that leverages the unique capabilities of each participating agency. In addition:

- The Office of Science and Technology Policy should complete the *National Plan for Civil Earth Observations* and ensure that individual agencies immediately begin implementation.
- Pursue innovative commercial space-based solutions to augment the core government Landsat program and seek innovative acquisition strategies from commercial providers to ensure affordability and access to higher-resolution imagery than can be obtained from government civil Earth imaging satellites.
- Enable access to older data from the government's National Technical Means imaging systems.
- Support and actively facilitate the *Implementation Plan for the National Strategy for the Arctic Region* and the *National Ocean Policy Implementation Plan*.
- Support a U.S./Canadian agreement regarding Arctic communications and weather satellite capability.
- Optimize U.S. policy and Cate-

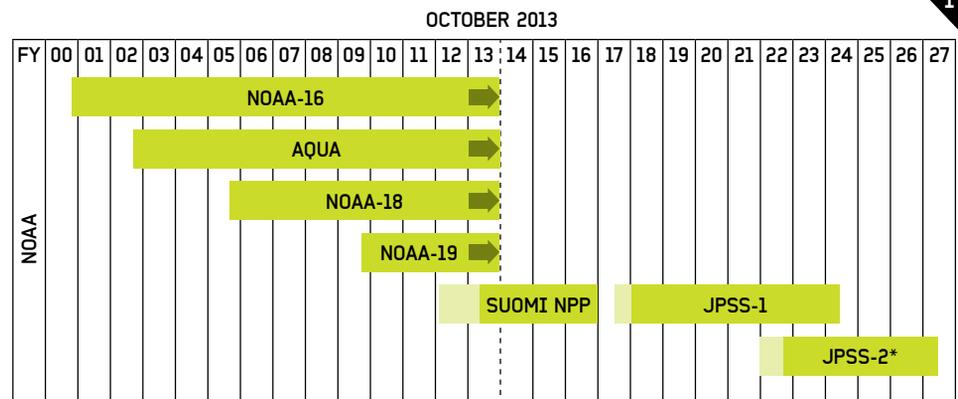
gory XV of the U.S. Munitions List so that commercial-class U.S. remote sensing companies are able to successfully compete against foreign suppliers.

- Establish a centralized mechanism by which commercial solutions can be considered within the federal Earth observing enterprise, thus spurring innovation and reducing costs.

The Alliance for Earth Observation's unified commitment towards developing a second-to-none world-class Earth observation enterprise means non-federal action as well. In 2014, the Alliance will:

- Continue to reach out to stakeholder groups across sectors to bring together data collectors with data users to facilitate improved engagement and dissemination.
- Continue to work across various sectors and disciplines to support U.S. programs, leverage U.S. investment in Earth observations, and provide the highest quality research and development capabilities.
- Utilize the breadth of expertise and experience of the Alliance members to continue to inform the public and policy makers about the key components of an Earth observation system and to demonstrate support for these components.
- Support the President and Congress in their efforts to sustain necessary programs and to promote innovative new policies.
- Participate as an active member of the Earth observations enterprise to provide innovative strategies and ideas for future systems and capabilities.

Current Polar PM Orbit Architecture



JPSS: Joint Polar Satellite Program
 Suomi NPP: Suomi National Polar Partnership
 Post Launch Test
 Operations past present

*Program funding provided through FY2025. The follow-on program will provide funding for operations post FY25.

▲ FIGURE 1
 The U.S. current and planned civil weather satellite system, showing potential gap in 2017.

PRIORITY 1: WEATHER AND CLIMATE Better protect American lives, property, and the economy by reducing the risk of data gaps, restoring superiority in weather forecasting, and increasing understanding of climate change

The impact of weather on our daily activities, as well as on broad sectors of the U.S. economy, is astounding. Major storms can cause billions of dollars in damage and wreak havoc on the economic viability of a community. In 2012, Superstorm Sandy was responsible for approximately \$65 billion worth of damage and 159 deaths. Nearly as destructive, but not as widely reported, was the impact of the heat wave and accompanying drought that affected a large portion of the U.S. during 2012. It is estimated that the heat wave and drought were responsible for \$30 billion worth in crop damage and 123 deaths.¹

U.S. Weather Satellite Systems. Despite the importance weather forecasting has on the lives, property and economy of U.S. citizens, the U.S. currently faces a weather satellite data gap potentially lasting 15-40 months beginning as early as 2017. Major satellite acquisition programs to replace aging satellite systems are currently in development. The Joint Polar Satellite System (JPSS) is being developed to provide global environmental data critical to weather forecasting. The data and imagery to be collected by JPSS aid NOAA and the U.S. government in developing timely and accurate public warnings and forecasts. JPSS will host the same next-generation weather instruments that are currently in operation on the precursor satellite, the Suomi National Polar-orbiting Partnership (NPP). JPSS-1 is not expected to launch until 2017. The Government Accountability Office has noted that the potential gap in weather satellite data constituted one of the high-risk government programs in 2013.

Figure 1 on page 21 depicts the current and planned civil weather system as detailed by the NOAA NESDIS Independent

Review Team's One Year Assessment. The report indicates that current NASA and NOAA satellites are operating beyond their designed life span and the on-orbit architecture becomes very sparse in the forthcoming years. In addition, the Defense Meteorological Satellite Program (DMSP), designed to cover the nation's needs for the AM orbit, recently launched the second-to-last in its series. The final DMSP satellite (F-20) is ready for launch; yet the DOD has only recently requested funding to implement the follow-on program. Even as such, the Weather Satellite Follow-on (WSF) program is being designed to meet only the highest priority DOD weather requirements but will not have the same capability as DMSP. Urgency is increased by imminent gaps (i.e., in ocean surface vector winds for tropical cyclone intensity, and some space weather gaps) that will not be met by DMSP capabilities, or other US capabilities.

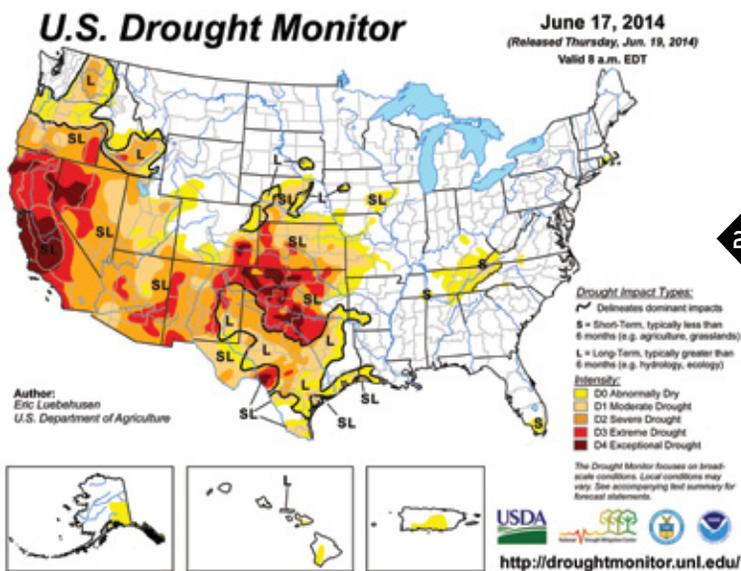
NASA Earth Observation System. NASA also operates a fleet of Earth science research satellites that contribute to our weather and climate prediction capabilities, all of which are operating well beyond their designed lifetime. The fleet of both satellite and airborne platforms provides integrated and long-term global observations meant to provide a coordinated and improved understanding of Earth's environment as one system.

A 2012 review of NASA's Earth Science program, *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey* found that within the next 6 years the number of NASA and NOAA Earth observing instruments in space will be only 25 percent of the current fleet. As the report states, "rapid decline in capability is now beginning and the needs for both investment and careful stewardship of the U.S. Earth observations enterprise are more certain and more urgent now than they were 5 years ago."

National Strategy for Civil Earth Observations. The same 2012 National Academies report suggested that an inter-agency framework for sustained global Earth observation systems should be developed. The Office of Science and Technology Policy released a *National Strategy for Civil Earth Observations* in April 2013. While such a framework was an essential first step, the White House needs to complete the process by finalizing the *National Plan for Civil Earth Observations* that will fill in the necessary details for a coordinated federal Earth observation program that allocates roles, responsibilities, and resources needed to maintain a national Earth observation system.

Reliable and accurate weather forecasting and prediction capabilities cannot be compromised and actions need to be taken to:

- Ensure long-term U.S. capabilities in weather and climate data continuity by guaranteeing critical satellite systems



remain on track with appropriate funding and continued oversight. This includes fully funding the FY2015 NOAA requests for both JPSS and the GOES-R satellite systems, accelerating acquisition of JPSS-2, and fully funding the FY2015 request for both the critical NASA Earth Science Division missions and the DOD Weather Satellite Follow-on program.

- Embrace cost-effective alternatives for sustaining and enhancing the long-term supply of critical weather and climate data by considering commercial acquisition strategies, commercial data sources, hosted payloads for dedicated sensors, and new innovative measurement capabilities and public-private partnership business models where feasible and appropriate. This includes continued budgetary support for the National Mesonet Program and expanded ground-based observation capabilities.
- Complete the *National Plan for Civil Earth Observations* and ensure individual agencies immediately begin implementation.

PRIORITY 2: DROUGHT Equip Americans to better understand and respond to drought by optimizing drought data and information for improved forecasting capabilities

The ability to monitor and forecast drought conditions in the U.S. impacts every American. The cost of everyday goods such as dairy and produce are directly linked to drought conditions. Yet drought has become the new normal for much of the country. In California, for example, more than 98 percent of the land is considered at least abnormally dry and almost 9 percent is in “exceptional” drought as of January 2014. California produces about 50 percent of the country’s fruits and vegetables. The lack of adequate water has forced many farmers and ranchers in California to cut production dramatically, thus impacting the supplies of the food most consumers take for granted. According to the Consumer Price Index from the U.S. Bureau of Labor and Statistics in March 2014, the prices of food have seen sharp increases since the start of 2014 and food prices are expected to continue to rise, all due largely to drought.² Additionally, drought impacts to American consumers do not stop at our own borders. For example, an ongoing drought in Brazil is impacting the prices of coffee, sugar and soybeans.³

National Integrated Drought Information System (NIDIS): Congress established NIDIS at NOAA “to better inform and provide for more timely decision making to reduce drought related impacts and costs.” NIDIS’s role is to provide forecasts, research and data dissemination for individual localities to use.

The U.S. Drought Monitor complements NIDIS by providing real-time updates on the status of drought in the United States. **Figure 2** clearly demonstrates the magnitude and reach of current

drought conditions in the U.S. Forecasts provided by the U.S. Drought Monitor indicate continued drought well into summer 2014, therefore exacerbating the impacts to the American agriculture sector and the pocketbooks of Americans across the country.

Landsat Satellite Program: An important component of monitoring and measuring drought in the U.S. is improved forecasting and understanding of land cover and terrain changes. For over 40 years, the Landsat Program has continuously provided an objective, efficient and accurate source of highly calibrated data to catalog natural and man-made changes on the Earth’s surface. The latest satellite of the series, Landsat 8, was launched in February 2013 and is estimated to provide continued coverage until at least 2018. The future of Landsat, however, is uncertain.

Utilize Existing U.S. Government Data Sources: Consideration should also be given to declassifying and re-sampling imagery and data from U.S. Government intelligence gathering satellites.

The U.S. Government does not fully take advantage of valuable imagery from commercial remote sensing satellites. Most of this data is sold to the National Geospatial-Intelligence Agency (NGA), an intelligence arm of the Department of Defense, and it largely remains there for use in DOD and Intelligence missions and mapping. For example, one such commercial provider has acquired more than 30 times the landmass of the Earth in high-resolution imagery at less than 1-meter ground resolution and that archive is not being exploited by agencies outside of the DOD and Intelligence Communities.

Recognizing the impact that drought, wildfire and floods can have on the lives of everyday Americans, decision makers must continue to protect life and property by:

- Providing funding as authorized to maintain and improve the National Integrated Drought Information System.
- Providing consistent funding for a continuous medium-resolution governmental land imaging program. Establishment of a long-term budget and acquisition strategy, to enable an uninterrupted set of critical Landsat measurements, is not optional; there must be a commitment to replace Landsat satellites as they age or fail.
- Pursuing innovative commercial space-based solutions to augment the core government Landsat program. The private sector is more than capable of filling this augmenting role.
- Seeking innovative acquisition strategies from commercial providers to ensure affordability and access to higher-resolution imagery than can be obtained from government civil Earth imaging satellites.

▾ Enabling access to older data from U.S. government National Technical Means imaging systems.

PRIORITY 3: WATER RESOURCES Advance U.S. freshwater monitoring and forecasting as a critical component of managing scarce water resources

The ubiquitous nature of water runs deep. Water truly is the lifeblood that keeps society and individuals alive and well. From day-to-day household usage to sustaining a vibrant agricultural sector to using water as a means of transporting goods, understanding and managing the nation's vital surface and ground water resources has a direct impact on the economy. Too little water results in droughts and water rationing. Too much water can wipe out a community in the blink of an eye.

National Streamflow Information Program. The National Streamflow Information Program (NSIP) within the USGS and in coordination with more than 800 other federal, state, local and tribal agencies, operates over 7,400 streamgages nationwide.

Water resource managers analyze the data to determine how to allocate scarce resources for disparate interests – anywhere from power production, crop irrigation, fisheries and habitat assessments, and even for recreational uses such as kayaking and fly fishing. Civil infrastructure projects such as designing bridges, roads, culverts and water treatment facilities all need the historical streamflow information that this network provides.

NASA Research Programs. While the streamgage system provides much-needed real-time data of the state of our freshwater, NASA research programs are paving the way for advancing monitoring and forecasting capabilities. The NASA Gravity Recovery and Climate Experiment (GRACE), launched in March 2002, was designed to map variations of Earth's gravity field and has provided scientists with information such as changes to ocean currents, groundwater storage and ice sheet variations. The mission is currently in extended operating status and the agency is developing a GRACE Follow-On (GRACE FO) mission.

More recently in February 2014, NASA and Japan launched the Global Precipitation Measurement (GPM) mission designed to improve our understanding of Earth's water and energy cycle and aid in the forecasting of extreme events.

Congress should support the advancement of state-of-the-art water resources analysis and prediction capabilities by:

▾ Gradually increasing funding to the National Streamflow Information Program from \$33.7 million in FY2014 with a goal of fully funding the program at \$122 million annually by FY2020.

▾ Ensuring that the infrastructure to transmit and analyze the streamflow data is maintained. This includes keeping the GOES-R satellite development on track.

▾ Supporting new data collection techniques, such as NASA's GRACE or GPM satellites, that measure groundwater and the water cycle from a global perspective.

PRIORITY 4: THE ARCTIC Protect U.S. environmental, economic and national security interests in the Arctic by expanding Earth monitoring and communications capabilities in the region

Over the past ten years, the Arctic has warmed at a rate twice that of the rest of the world. The melting sea and glacial ice has a large number of consequences ranging from increasing levels of freshwater going into the oceans, changing temperatures of ocean currents, altering jet stream patterns, and causing an increase of methane gases into the atmosphere.

Maritime traffic in the Arctic and Alaska, already significant as of 2013, is only expected to continue to increase as melting sea ice opens up passageways for shipping and new regions for resource extraction. See *Figure 3*.

Sea Ice Measurements and Modeling. Critical to enhancing existing observations will be the successful launch of NASA's Ice, Cloud, and land Elevation Satellite 2 (ICESat-2) and GRACE FO by the end of 2017. The mapping gravity data from GRACE FO, for example, will support U.S. Navy and U.S. Coast Guard operations and help ensure safety and security in the Arctic.

To protect U.S. environmental, economic and national security interests in the Arctic, Congress should:

▾ Maintain launch dates for NASA's IceSat-2 and GRACE FO missions to ensure expanded and new Arctic sea ice observations with requested funding and continued program oversight.

▾ Support a U.S./Canadian agreement regarding Arctic communications and weather satellite capability to provide for safe operations and improved information within the region.

PRIORITY 5: ECONOMIC COMPETITIVENESS Drive innovation, create jobs, and grow the economy by enhancing the economic competitiveness of U.S. businesses

Understanding the planet and how changes can affect the livelihood of American citizens and our global economic competitiveness is vitally important. Driving innovation and economic growth in this sector starts with adopting public-private partnership business models where feasible to augment national systems with



◀ FIGURE 3
Decreasing Arctic ice opens shipping and travel routes. Source: U.S. Navy Arctic Roadmap.

Commercial solutions to spur innovation and reduce costs. The National Mesonet Program is a great example of leveraging private innovation. Innovative uses of hosted payloads, for example, could leverage commercial satellite constellations to launch critical Earth observation sensors faster and at a lower cost than via typical government satellite programs. Likewise, purchasing commercial data from U.S. companies could be a cost-effective solution to increase the quantity and quality of data available, and to mitigate expected gaps in key weather monitoring capabilities, while also creating U.S. jobs. The U.S. government should establish a centralized mechanism to consider commercial solutions within the federal Earth observing enterprise.

Recognizing the economic impacts of promoting the global competitiveness of U.S. businesses, the U.S. government should:

- ▶ Optimize U.S. policy and Category XV of the U.S.M.L. so that commercial-class U.S. remote sensing companies are able to successfully compete against foreign suppliers.
- ▶ Enable greater access to existing data via continued support for efforts such as the National Mesonet Program.
- ▶ Establish a centralized mechanism by which commercial solutions can be considered within the federal Earth observing enterprise.

CONCLUSION

The United States has in place a network of effective and necessary observational tools that aid in the prediction of weather and changes to our climate. This network, however, is fragile and not guaranteed. It is critical that we do not take these systems for granted and instead understand how they all fit together into a global puzzle of information that is important for the protection of U.S. lives, property and economic competitiveness. ▲◊

Endnotes

- 1 NOAA Climatic Data Center, Billion Dollar Weather/Climate Disasters, retrieved from <http://www.ncdc.noaa.gov/billions/events>, February 2014.
- 2 Consumer Price Index release on April 15, 2014 retrieved from <http://www.bls.gov/news.release/cpi.nr0.htm>.
- 3 Why California's Drought Impacts Every American Who Buys Food, April 14, 2014, retrieved from <http://www.weather.com/news/science/environment/drought-boosts-food-prices-set-biggest-rise-years-report-20140319>.

commercial sources, utilize hosted payloads for dedicated sensors, field new innovative measurement capabilities, and provide the private sector with greater access to existing government data sources.

A straightforward assessment of the economic competitiveness of the U.S. Earth observation sector begins with a deliberate review of the current U.S. regulatory regime. The imperative for U.S. manufacturers to compete on a level playing field internationally has only increased in recent years. After the 2012 release of the much anticipated Section 1248 Report to Congress, many within the U.S. satellite industry were hopeful that the potential changes to U.S. trade regulations would enable access to a competitive global commercial satellite marketplace.

However, cuts to U.S. government commercial imagery purchases instead resulted in the further consolidation of the U.S. commercial remote sensing industry. In January 2013, Colorado-based DigitalGlobe acquired Virginia-based GeoEye when the NGA cancelled GeoEye's ten-year \$3.7 billion contract for Earth imagery and other services. In the acquisition, DigitalGlobe acquired the yet-to-be-launched GeoEye-2 satellite and has mothballed the satellite until there is additional demand for high-resolution imagery. Even though DigitalGlobe plans to launch WorldView-3 in August 2014, there is real interest for satellite and payload operators to look to international markets to sustain production capabilities over the long haul.

On June 11, 2014, DigitalGlobe announced that the company received permission to sell its highest quality imagery. Prior to this date, all commercial imaging providers had to resample or degrade the quality of the imagery to half-meter ground resolution. This new modification to its operating license means that DigitalGlobe can sell imagery better than that and when WorldView-3 is launched this summer, the company will be able to see imagery with a remarkable ground resolution of .31-meter or about 12 inches.

Geospatial Data Collection AND Collaboration

Made Even Easier

Consumer Tech Transfer to the Enterprise

BY GEORGE DEMMY / CHIEF TECHNOLOGY OFFICER
TERRAGO TECHNOLOGIES / WASHINGTON, D.C. / WWW.TERRAGOTECH.COM

For years, businesses have invested in Geographic Information Systems (GIS) to improve operational efficiency and enhance decision making with geospatial data. However, these assets have languished in silos due to organizational barriers, or because users needed expertise in complex GIS, photogrammetric, or remote sensing software. Even today, enterprises still grapple with liberating the data that would deliver efficiency gains and improved decision support.

Meanwhile, end users have become accustomed to free mapping services and consumer apps that make sharing location information as easy as tapping a button on a smartphone.

Fortunately, there is a new movement in the industry that makes it possible to turn every field worker into a sensor and to deliver information and situational awareness to the C-suite by making the sharing of location intelligence as simple and easy as the consumer app experience.

These new solutions help organizations create intelligent, portable location-based apps for their unique areas of interest and specialized workflows. Available with a tap from any user's smartphone or tablet, the apps deliver real-time information to and from users at the "edge of the enterprise."

LIVING IN A MOBILE WORLD

Today's world offers free, open Web-based mapping and location services that are easily leveraged and eagerly consumed. Any user can now access maps and data that were once in the hands of a select few. With Google Maps, Google Earth, or a Garmin GPS, we have all become accustomed to accessing the vast availability of data, which has fostered an expectation of being able to visualize information in a map context as a matter of course.

We are seeing some smaller enterprises adopt these

notes, photos, and videos when in the field. From there, it is possible to easily synchronize with project managers in the office, so they have a dashboard view of data, occurring in real time. The data is also easily accessed whether dealing with a lightweight or heavyweight workflow.

In addition, much of the mapping data comes from OpenStreetMap, GeoPDFs and other easy-to-use data sources—allowing anyone in the organization to access and utilize

consumer technologies for business applications. However, for organizations with a mobile workforce of employees, subcontractors or vendors, the consumer-grade programs are difficult to configure, or lack features needed for location-enabled workflows.

In many cases, these organizations don't have the financial bandwidth to make the investment in larger GIS systems. When they do have the option of investing in GIS or proprietary hardware for capturing field data, many deployment challenges remain. These solutions tend to be highly cumbersome to use, require specialized training and can be very costly.

Small businesses and enterprises need a modern alternative to these costly, outdated and inefficient methods to meet their mobile data collection and collaboration needs.

LOCATION-ENABLED COLLABORATION, SIMPLIFIED

A modern mobile data collection and collaboration solution should be as straightforward as tweeting an observation or posting a photo to Instagram. Simplicity is paramount for helping organizations drive effective and efficient decision making. Today's geospatial and collaboration applications should be as easy as clicking one button. From a straightforward product download, to rapid team deployment and swift end user adoption, the application should also provide easy payment options and encourage immediate engagement.

Fortunately, next-generation solutions offer intuitive interfaces that enable mobile workers to easily record

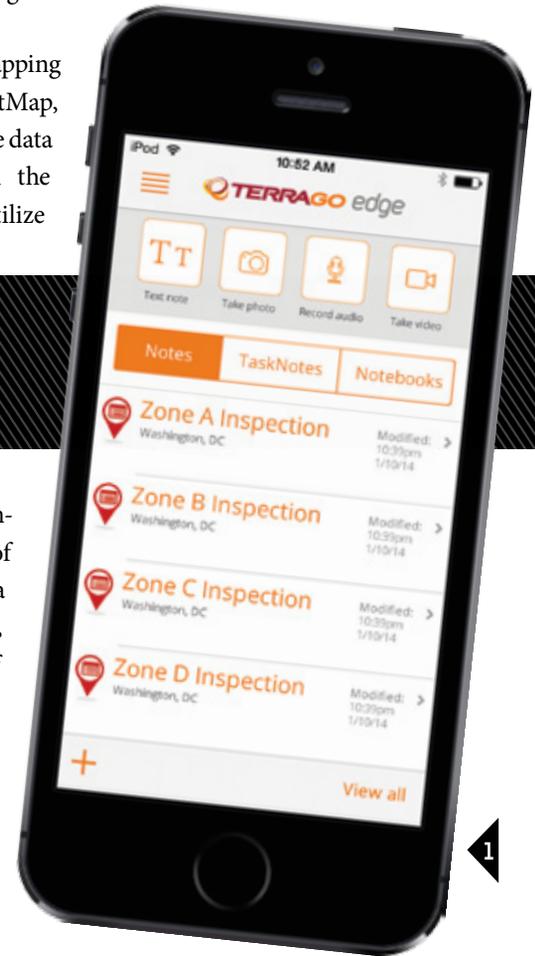
these maps. One of the advantages of these new types of solutions is that all of the data can reside on a private cloud, enhancing both the security of the data as well as simplifying access and collaboration.

The ease of this process enables small businesses and enterprises to start gaining efficiencies, better decision making, and savings immediately with a deployment as simple as a user downloading the app from an online store.

NEW CONCEPT OF TEAMWORK AND COLLABORATION

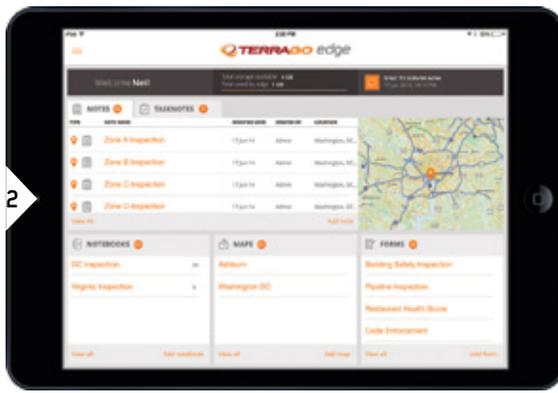
The most effective organizations foster highly collaborative cultures, where information is seamlessly shared. For far too long the most valuable information was locked in silos, and once this data was released, it was often too late. The right collaborative approach can help organizations operate at the speed of life.

Furthermore, most data collection solutions are very effective at collecting the right geospatial information. What they lack is ease of sharing. We all know that the amount of sensor data is only increasing, as are the potential uses, ranging from providing situational awareness, ensuring environmental safety or supporting mission-critical decision making.

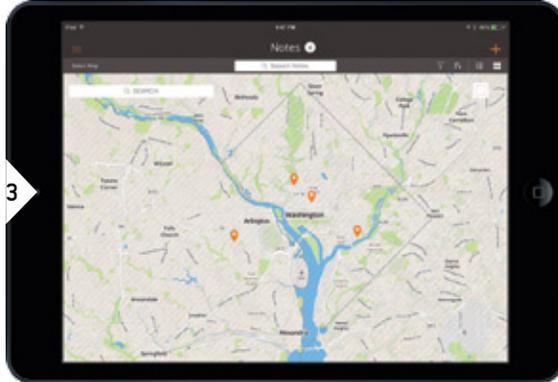


▲ FIGURE 1. TerraGo Edge on iPhone provides a lightweight dashboard to keep track of your most recent notes, tasks, and notebooks.

► **FIGURE 2.** TerraGo Edge on iPad provides an intuitive dashboard that lets you see your most recent notes, tasks, and notebooks at a glance and in real time.



► **FIGURE 3.** Notes with location data can be viewed and edited in map view. You can also add new notes by dropping a pin on the map.



The most forward-thinking organizations empower their employees for seamless collaboration in real time, enabled by business apps that enable organizational networking much like consumer apps do for social networking.

INDUSTRY FOCUS: OIL & GAS

In the oil and gas industry, companies are exploring the Earth's most remote geographies and hostile terrains, while maintaining millions of miles of pipeline and moving assets by road, sea and air. The timeliness and accuracy of data collected from remote sites is essential to the efficiency and reliability of global operations. In this sector, companies require sophisticated solutions that advance well beyond using paper forms and cumbersome, manual processes.

From pipeline inspection to oil discovery, these new types of solutions make it easy to record observations and immediately sync that information back to headquarters, or share with other field workers. Many project managers can leverage these kinds of solutions for creating notebooks with tasks, custom forms, workflows and offline maps. The notebooks can then be assigned to teams to use offsite, even in remote locations without connectivity.

Oil and gas companies can also leverage unstructured data collection, allowing on-the-spot observations to be immediately turned into tasks, and urgent operational issues can be met with an equally rapid response.

INDUSTRY FOCUS: UTILITIES

Utility companies face the challenge of maintaining a vast amount of electrical and mechanical equipment, across large geographical regions. From distribution boxes and transformers to cellular towers, this equipment requires regular monitoring from the control center and field service from the crews on the ground.

Traditionally, using paper forms and stand-alone CAD and GIS databases has made this a slow and onerous task, prolonging outages, reducing reliability and delaying response times.

New solutions now make it easier for utility crews, mobile workers and engineers to share distribution system maps and information in real time. This tremendously minimizes delays waiting on system control personnel to share equipment location data to diagnose and correct an issue.

Once again, it is easy to create notebooks with tasks, custom forms, workflows and offline maps. For example, for cellular companies, forms could be created to monitor antenna inspections, sweep tests, impedance testing and visual inspections with photos and videos. For lighting companies, forms can help keep track of the millions of light poles that dot the highways and to document deteriorating foundations or bulbs out of service.

INDUSTRY FOCUS: AGRICULTURE

In the world of agriculture, accurate environmental data and location-based intelligence is important to the sustainability and growth of an area. From crop surveys, to soil analysis, to animal health, there is a vast amount of useful data that could improve agriculture conditions. Without a solid system to keep track of this data and monitor trends in real time, it's difficult to make informed planning decisions and to have a common operating picture of conditions.

Today's solutions allow agriculture organizations to easily monitor the health of their land changes in real time from a dashboard from any location.

Landowners can also use these types of solutions to create notebooks with tasks, workflows, custom forms and offline maps. These notebooks can work in remote locations without connectivity, which is quite common in the agricultural industry.

INDUSTRY FOCUS: NATURAL RESOURCES

When it comes to natural resources, collecting data in remote regions over millions of square miles poses a difficult challenge. Traditional maps carried into the field

make collecting data a cumbersome process and getting that data back for analysis can be slow and arduous.

From forestry to watershed surveys, these new innovations make it easy to record observations to share with headquarters. This means that organizations no longer have to wait years, months, or even days for survey or inspection results.

For example, forms for a logging site could be used to collect the species of trees, status on what percent have been processed and status of equipment being used. For bodies of water, fish population surveys could be performed and tagged to geolocations—all through simplified workflows that increase visibility, reduce costs and enhance decision-making.

INDUSTRY FOCUS: DEFENSE & INTELLIGENCE

When it comes to national security, timely, accurate geospatial intelligence is a strategic advantage for policymakers and warfighters. The quality of this intelligence is critically important, and can make the difference between mission success and failure.

Military personnel act as human sensors in the field, but the challenge is quickly bringing intelligence to leaders and commanders to support strategic and tactical decisions. Unfortunately, data can be disorganized, or simply just arrive too late. For the past decade, there have been many discussions about how we need to provide actionable intelligence to the warfighter in real time.

New advancements actually make this possible, supporting multiple mission areas, including military operations, and intelligence analysis. Next-generation solutions make it easy for field personnel to record observations and immediately get the information back to a main office. This minimizes delays waiting for damage assessments, location reports, geography surveys or human intelligence.

INDUSTRY FOCUS: ENVIRONMENTAL

When it comes to the environment, accurate, detailed data and location-based intelligence are important to the sustainability and growth of an area. There is a vast amount of useful data within erosion surveys and water quality reports that could improve land conditions. Environmental organizations need to keep track of this data and monitor trends in real time, which aids in making informed planning decisions and monitoring potential risks.

Regulatory agencies or other project managers can

use these next-generation solutions to create notebooks with tasks, assign workflows, design custom forms and load maps, offline. For example, forms can be created to monitor erosion levels, retention wall conditions and terrain type. They could also be used to monitor water quality (pH, oxygen level, algae type) and compare it to the fish population in an area.

INDUSTRY FOCUS: CRISIS RESPONSE

When disaster strikes, accurate and timely data from personnel on the ground can save thousands of lives and prevent millions of dollars of property damage.

Unfortunately, conditions for reporting data are particularly challenging in that climate. Cellular connectivity may be down, transportation infrastructure can be destroyed and data can be scattered across multiple agencies. Finding a way to organize this data and quickly report it back to a central disaster planning headquarters/unit is very challenging.

The new solutions make it easy for field personnel, volunteers and others to record field observations and get the information to those who need it most. Even the smallest delay in response time can mean disaster in these types of conditions.

By using these solutions, it is possible to create forms for monitoring structural damage (building type, number of occupants, damage type), aiding facilities in the area (number of volunteers, food status, power status), and even monitoring evacuation routes (congestion, road conditions, etc.).

CONCLUSIONS

These are merely a handful of examples of how new geospatial collaboration solutions can truly help organizations with making effective decisions in real time, based on data from the field.

In the near future, we will see cumbersome GIS systems being outpaced by more simplified solutions that are more consumer-like in their operation. From the one-button push for the right information to sharing data in regions with little connectivity, it is possible to harness the power of geospatial systems in ways that will truly enhance our world. ▲

GEORGE DEMMY is Chief Technology Officer at TerraGo Technologies.

He is one of the patent holders for the process that creates georeferenced PDF files. He holds a B.A. in Physics from Florida State University and an M.E. and Ph.D. in Agricultural Engineering from the University of Florida.





PlanetIQ

COMMERCIALIZING WEATHER SATELLITES & DATA

Apogeo Spatial Q&A with PlanetIQ's CEO Anne Hale Miglarese

1



PlanetiQ plans the first commercial constellation of weather satellites, with 12 GPS Radio Occultation satellites on orbit by the end of 2017 and 18 by 2019. Backed by Moog and Millennium Engineering and Integration, PlanetIQ will offer real-time delivery of more than 18,000 occultations per day, consisting of more than 8 million observations per day of temperature, pressure and water vapor. This unique data set will greatly enhance weather forecasting, climate monitoring, space weather prediction, and weather information analytics, driving tremendous benefit to government and commercial customers worldwide.

SENSORS AND DATA

APOGEO *What sensors will your satellites carry?*
PlanetIQ's initial constellation of 12 satellites, to be fully

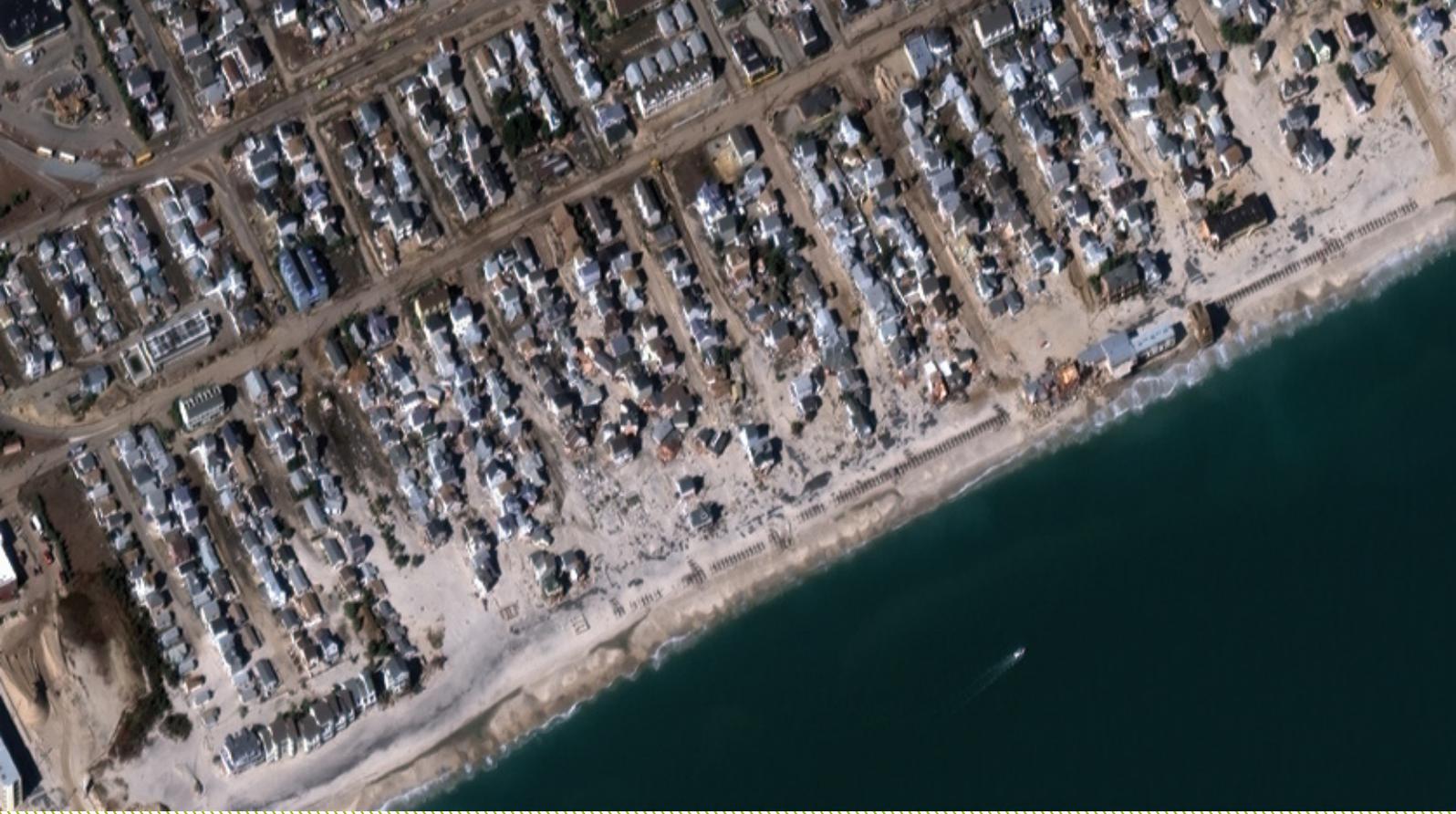
deployed by the end of 2017, will carry the fourth-generation radio occultation sensor currently in development by Moog Broad Reach. Moog Broad Reach built the existing gold standard radio occultation sensor that is proven in space on 20 missions. The fourth-generation sensor will reduce the size, weight and power of previous versions while maintaining performance. Importantly, the fourth-generation sensor will receive signals from all four major GNSS systems: GPS (US), GLONASS (Russian), Galileo (European) and Beidou (China), providing a minimum of 18,000 profiles per day of atmospheric temperature, pressure and water vapor.

Our satellites are also slated to carry sensors that measure critical characteristics of space weather. These include the radio occultation sensor, which will measure total electron content and scintillations, a wind velocity meter to measure local neutral winds and local charged particles, a photometer to measure ionosphere F and E region state, and a magnetometer to measure local magnetic fields.

Future instruments planned for satellites 13-18 and beyond include the Active Temperature, Ozone and Moisture Microwave Spectrometer (ATOMMS), and a next-generation microwave radiometer. ATOMMS is currently in development by Moog Broad Reach and will measure water vapor far more accurately than

Editor's Note:

A summary of the Earth Observation 2014 Priorities Report (by the Alliance for Earth Observations) begins on page 20. The weather data gap is also addressed there.



2

current sensors, yielding 1% or better water vapor accuracy from the lower troposphere into the mesosphere.

APOGEO *What types of data will you provide?*

PlanetiQ's constellation will provide a minimum of 18,000 profiles per day of temperature, pressure and water vapor, which equates to more than 8 million observations per day. Extensive research has shown that radio occultation has the largest forecast impact per observation among the satellite techniques (e.g., Cardinali and Healy, 2014; Joo et al., 2012).

Radio occultation data is ingested by numerical weather prediction models at NOAA and all other major forecast agencies around the world, greatly improving the forecast for a low cost relative to other technologies. However, existing governmental sources of radio occultation data are rapidly degrading, while planned replacements are considered experimental in nature and insufficient to meet the data, quantity, and continuity requirements of global forecast models and the weather enterprise.

We also will provide space weather data including Total Electron Content, scintillations, local neutral winds, local charged particles, ionosphere F and E region state, and local magnetic fields. These data are critical to providing warnings and forecasts of space

weather disturbances that can damage satellites, power grids, and civil and military communication systems used for aviation and other mission-critical purposes.

APOGEO *How will you deliver the data to your customers?*

PlanetiQ satellites will transfer the sensor data to the ground within seconds via satellite relay, eliminating the need for investment in ground stations other than as a third-party backup. The use of a satellite relay system provides a robust and low-cost alternative to the cumbersome and expensive deployment of ground stations worldwide, and at the same time dramatically improves data delivery latency. Data will be delivered to the customer in less than 3 minutes from being collected in space. This low latency is a dramatic improvement over existing delivery times and is critical to weather and space weather forecasts.

APOGEO *What is your deployment timeline, and when will you begin to deliver data?*

Deployment plan is 12 satellites by the end of 2017, and 18 satellites by 2019. We will deliver data beginning in 2017.

APOGEO *Will the data gap start at the end of 2014? To what extent will you be able to fill it?*

The Government Accountability Office, NOAA, and

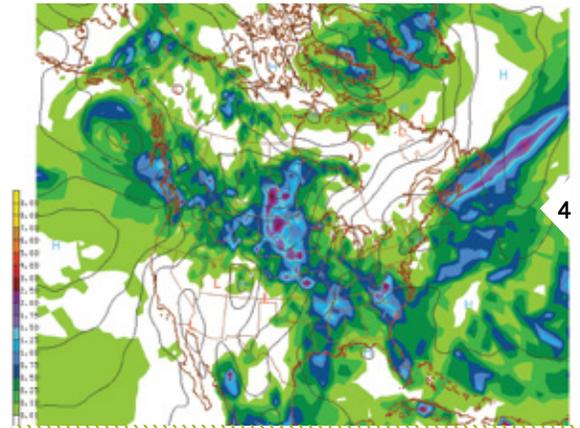
◀ **FIGURE 1.** Seaside Heights, a borough in Ocean County, N.J., before Superstorm Sandy, on Sept. 11, 2011. Image courtesy of DigitalGlobe.

▲ **FIGURE 2.** The same area as Figure 1, after the storm, on Nov. 4, 2012. PlanetiQ satellites will enable better severe weather predictions. Image courtesy of DigitalGlobe.

► **FIGURE 3.** Example of simulated radar reflectivity forecast from the North American Model (NAM), courtesy of NOAA.



► **FIGURE 4.** Precipitation forecast from the Global Forecast System Model, where greens indicate .25 inches, blues are about an inch, purple is 2 inches, and dark red goes to 3-4 inches, courtesy of NOAA.



an independent review team tasked by NOAA are concerned about multiple risks of data gaps now through 2038. Radio occultation data is considered by NOAA and others as an effective gap-mitigator—for expected gaps in polar-orbiting data such as provided by JPSS—because it not only improves the model forecasts on its own, but also calibrates data from other satellites, thereby improving the forecast impact of other satellite data and improving the overall forecast. We plan to have data available for this purpose starting no later than 2017.

APOGEO *When talking about Earth observation, a key metric is the refresh rate for every pixel on the ground. What are the key metrics for your kind of data and how do you expect your system to perform?*

The key metrics for radio occultation data are the number of profiles, the geographic distribution, and the latency of the data (how long from when the data is collected until it reaches the customer). In these respects, we plan to provide radio occultation data with unprecedented quantity (18,000+ profiles/day), coverage (globally distributed), and latency (delivered to the customer in less than 3 minutes from being collected).

TECHNOLOGY

APOGEO *Are you building all of your own hardware?* Our founders and partners—Moog, Moog Broad Reach, and Millennium Engineering and Integration Company—are industry leaders in designing, building and operating space sensors, systems and missions, with combined experience of more than 70 years. Moog is a highly experienced provider of spacecraft systems for both government and commercial customers, with annual revenues of \$2.6 billion. For more than 40 years, the international space industry has relied on Moog products for commercial, military and civil/scientific satellite and launch vehicle applications.

Moog Broad Reach, founded in 1997 as Broad Reach Engineering and acquired in 2013 by Moog, has a long heritage in mission design and development of instruments and flight systems. Moog Broad Reach specializes in space avionics, systems and software, and built the gold standard for radio occultation sensors currently on orbit.

Millennium Engineering and Integration Company (MEI) is an employee-owned small business and a premier space systems engineering company, with annual revenues of \$90 million. MEI has more than 15 years of

experience as a leading provider of space systems engineering, satellite integration and testing, and launch and on-orbit operations for NASA, the U.S. Air Force and the Missile Defense Agency.

APOGEO *How will you get your satellites into orbit?*

Our current plan is to launch the first four satellites as a secondary payload by the end of 2016, with the next eight satellites going up on a dedicated launch vehicle by the end of 2017. However, we will continue to look at any opportunities that could get us to orbit and start delivering data sooner.

BUSINESS

APOGEO *What is your business model?*

Our primary customer base to start will be those forecast agencies around the world that already ingest radio occultation data into their numerical weather prediction models and know the great impact the data has on the forecast. In parallel, though, we expect increasing demand for our data by commercial weather companies whose modeling capabilities continue to advance forward every day. In the medium and longer term we see tremendous demand among numerous industries for weather and climate analytics to inform risk management, as well as an increasing need for space weather alerts and forecasts.

APOGEO *Will you develop specific information products for customers or will it be up to them to develop the specific information they need from your raw data?*

To start we will provide quality-checked raw data from the sensor and derived profiles in the same formats that are currently ingested by forecast agencies around the world. In the long run, however, we plan to offer weather and climate analytics products especially in the commercial sector. We plan to work closely with our customers to determine the types of products that will best address their needs. We will not get into the business of weather forecasting.

APOGEO *What will happen to your business at the end of the data gap?*

The most immediate data gap—between the end of life for Suomi-NPP and the launch of JPSS-1—is only one of several factors driving the commercialization of satellite weather data. We believe, and our investors agree, that there is a strong business for commercial weather satellite data independent of the gap. The impending gap is merely a symptom of the limitations associated with the traditional government-centric approach to weather satellites. Augmenting government systems with commercial data not only will lessen the risk and impacts of gaps in governmental data this decade and well beyond, but also will lower the costs and technical risks inherent in government programs, while making the global observing system more resilient and accelerating innovation in satellites, sensor technology and data collection.

APOGEO *We are watching the trend of government moving more towards commercial companies for products and services from satellite imagery data (DigitalGlobe), to transportation to the International Space Station (SpaceX). What are the benefits of this trend occurring for weather data?*

Currently, the U.S. faces a gap in critical weather forecast data. As we've seen in the areas of satellite imagery, satellite communications and space transportation, allowing industry to augment government systems and programs with commercial sources increases the supply of mission-critical data and services, increases innovation in those data and services, and reduces costs to the government and taxpayers.

APOGEO *What is the background on the*

government's acquisition of weather data versus that of satellite imagery?

The situation with satellite weather data today is remarkably similar to that of satellite imagery in the early 2000s. At that time, delays and cost overruns in the next generation of U.S. intelligence satellites, called the Future Imagery Architecture, threatened a gap in satellite imagery. The National Geospatial-Intelligence Agency then partnered with the private sector by awarding imagery purchase contracts (via the ClearView program, then the NextView and EnhancedView programs) to commercial providers. The result was a reliable and affordable supply of high-quality imagery for both military and civilian use, and a robust U.S. commercial industry.

The same dynamics are occurring with satellite weather data. Existing satellites are reaching the end of their design life, replacements have been delayed and gone over-budget, and the nation now faces a potential gap in data that is critical to providing accurate forecasts and early warnings. A new commercial weather satellite industry is ready to step in and augment government systems with data that is less expensive and can be available sooner than from government systems.

It is important to note a few key possible misconceptions. First, one difference from the commercialization of satellite imagery is that we are not asking for any money up front. Investors are willing to fund the development and deployment of the systems as long as key public and private customers around the world sign Letters of Interest demonstrating a willingness to purchase data once available. They are very enthusiastic about the market.

It is also important to realize that the use of commercial satellite data would not cause governments to charge for the weather forecast. It would simply augment and improve the observing system that generates the weather forecast.

APOGEO *What is the PlanetiQ Foundation?*

The PlanetiQ Foundation will provide archived data free of charge to researchers, with the goal of encouraging research to further improve the impact of radio occultation data on weather forecasting, climate monitoring and space weather prediction. In addition, a scientific advisory under the auspices of the PlanetiQ Foundation will keep PlanetiQ connected to the user community, to developments in science and technology, and to the changing requirements of the weather enterprise. Input from this board will inform the evolution of our sensors, satellites and data offerings. ▲

PEOPLE

MAPPING

People

Human Landscape

BY MATTEO LUCCIO / CONTRIBUTING WRITER

PALE BLUE DOT LLC / PORTLAND, ORE. / WWW.PALEBLUEDOTLLC.COM

The executive director of an international nonprofit organization needs to map all the hospitals, clinics, and first aid facilities in Ecuador, Colombia, and Venezuela that are within five miles of elementary schools.

An entrepreneur is researching the market for laundromats in low income areas in mid-sized U.S. cities. A State Department diplomatic security agent wants to map the police stations and military bases that are within a 20 minute drive from U.S. embassies and consulates in 17 Middle East countries. All three face the same challenge: finding a comprehensive, reliable, up-to-date database of geo-located points of interest (POI) that they can import into their geographic information system (GIS) and analyze. For each project they can find hundreds of relevant databases on the Internet—but few of these sources, if any, will meet all of their requirements.

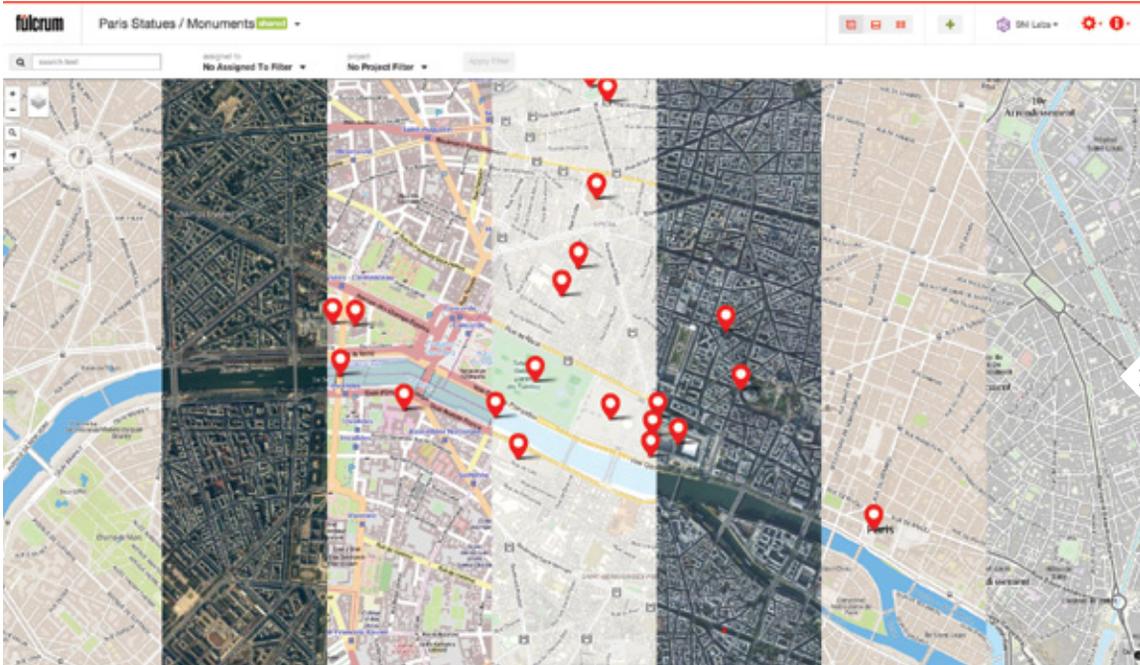
The creation and analysis of geospatial data by individuals and non-government organizations (NGOs)—commonly known as crowdsourced data—has exploded in the last couple of years, dwarfing the amount of information in government databases and proprietary commercial systems. While massive, however, these troves of data are often not sufficiently reliable and accurate for uses such as the ones in the examples above. Moreover, it is challenging to make sense out of disparate socio-cultural data, collected by a multitude of systems, for different purposes, and at different levels of specificity. Enabling users to rapidly gain understanding of their regions of interest requires fusing these non-standard data sources into consistent datasets.

Data about the location of human activities falls under the rubric of human geography, but is also referred to as “human terrain” or “human landscape.” In recent years, as the collection of this type of geospatial data and the ability to store it and analyze it have grown exponentially, so has demand for it, and several companies have entered the market to provide it. Among them are

DigitalGlobe, a satellite imagery company now focused on providing customers with information, and Spatial Networks, a geospatial technology company.

ORIGINS

DigitalGlobe began its Human Landscape project about three years ago. The company was already compiling geospatial analytical products that included a lot of human landscape information. “We were finding that our analysts were spending a lot of time gathering the data and getting it into the right format so that they could do the analysis,” recalls Alex Dunmire, DigitalGlobe’s SOCOM/CENTCOM Program Manager. (SOCOM and CENTCOM are the U.S. military’s Southern Command and Central Command.) “So, we came up with the idea that we could independently build the human landscape geospatial products to help us speed up the analytical products when we got to them. Instead of geospatial analysts spending 60-70 percent of their time gathering geospatial data, verifying it against different



◀ **FIGURE 1.** Example of map of Paris, France, with several layers and data sources, on Fulcrum. Courtesy of Spatial Networks.

sources, and getting it into the right formats, if the data was already there, they could go right into doing the analysis. We’ve built these datasets for more than 50 countries.”

Anthony Quartararo founded Spatial Networks in 2000 to conduct strategic research and provide competitive business intelligence, using geospatial technology. Demand for human geography data has rapidly increased over the last several years, he points out, “particularly when it comes to the high fidelity data about what people do, where they do it, and why they do it. That is the essence of human geography and we are in that market.”

CAPABILITIES AND PRODUCTS

Compiling country-wide geography datasets is difficult, Dunmire argues. “You have to go to numerous Web sites, publications, analytical books; some of them are in a different language. Pulling all of this geospatial data together takes a lot of focus and expertise in understanding geospatial data to get it to feed into the predictive geospatial models that we use for analysis.” DigitalGlobe uses the imagery acquired by its satellites to verify the data and to include images with the POIs. This is the company’s greatest strength in the human geography market. For example, to develop the layers for North Korea, it used 131 different sources and produced 16,000 POIs, each with an image chip showing the point on the ground (see sidebar).

Spatial Networks is focused on data, analytics, and technology. “We provide raw data and/or derivative

products to the U.S. federal government, including the State Department, the Defense Department, and the Intelligence Community, as well as to portions of the commercial industry, including the energy market, financial services firms, and futures trading organizations,” says Quartararo. The company’s main technology offering is Fulcrum, a do-it-yourself mobile app platform that allows users to develop mobile data collection apps or forms for use in the field with smartphones.

The company also often uses it for its own data collection. “Our products and capabilities are unique in several ways—because of our access to places around the world at the street or neighborhood level, where we have relationships with people who live in places that happen to be of interest to our customers. We travel extensively. We also have a large database of geographers around the world who we work with to help us provide credible, authoritative, and original answers to questions in a timely fashion.”

DATA

The kinds of data that Spatial Networks collects vary considerably, based on who is asking for what data, in what part of the world, and for what type of application, Quartararo explains. “A very generic, average use case would be the kind of data you find via Google when you do a search on a hotel in a city. We provide that kind of data in places where Google doesn’t and go above and beyond what Google does, almost to the extent of what Dunn & Bradstreet provide to businesses.” The company, he points out, does not mine and compile data

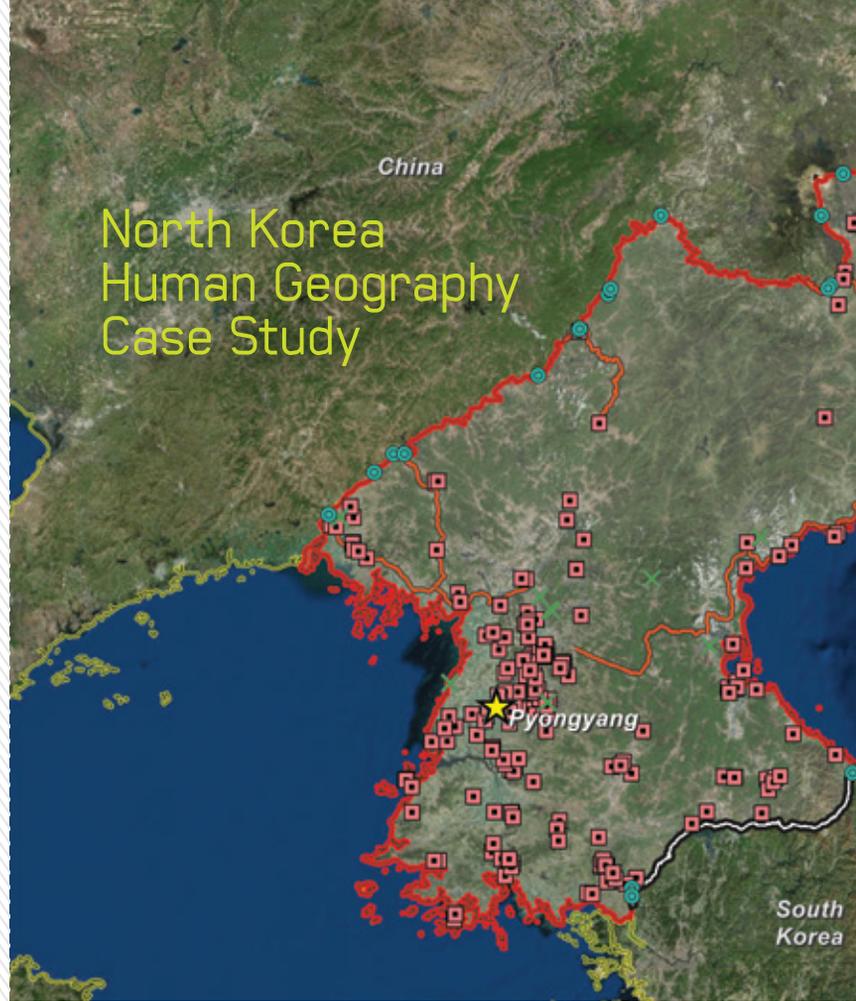
from social media, such as Twitter, or other databases. “We are doing that from the ground, with local context, working with local knowledgeable people.”

TOOLS

Spatial Networks has been using a predecessor of Fulcrum for the better part of ten years to acquire data. “We didn’t like anything else on the market, so we invented our own product and have been building on that,” says Quartararo. “About three years ago, we realized that there was a bigger market for Fulcrum if we made it into a commercial product that we could support and continue to develop and maintain and offer at a reasonable price across the world and do it in the cloud, so we embarked on that. We have people who use the application for their own personal travel, and for real estate, to rate office spaces. It is designed to work in data-starved or communications-denied areas, such as rural Afghanistan or East Africa, where WiFi and cellular are not very robust. You can collect data offline for weeks, if not months, and the next time you come in contact with a live WiFi hotspot or a cell service all of that data gets uploaded to your account in Fulcrum.” While Spatial Networks uses Fulcrum to collect data for its own projects, Quartararo assures that it does not access the data collected by any other users of the platform.

ANALYSIS

DigitalGlobe’s Human Landscape products, sold as stand-alone products as of this spring, consist of many files of geospatial data, typically in shapefile or KMZ format, which can be opened and analyzed in

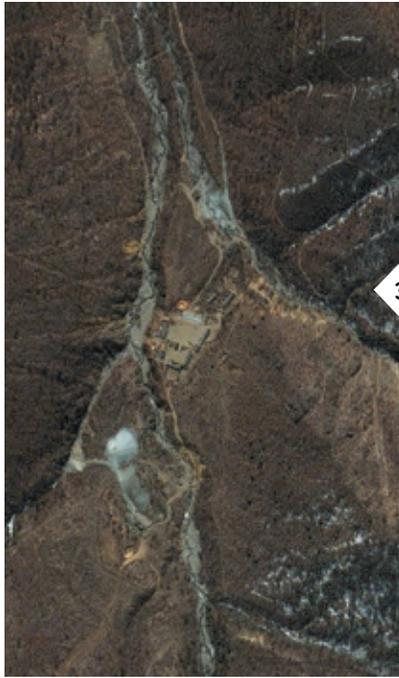
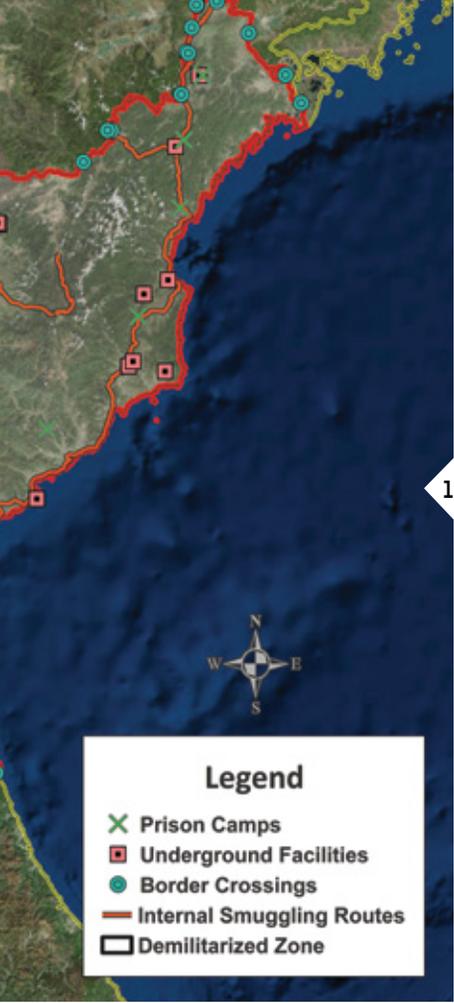


Since Kim Jong-un assumed power in North Korea after his father’s death in 2011, he has overseen an increasingly unpredictable military state that is shoring up power domestically and causing worry among the military state’s regional neighbors. In 2013, Kim threatened a pre-emptive nuclear attack on the United States and released a video showing nuclear war breaking out across the United States.

That same year, North Korea tested short-range missiles that could cross the Sea of Japan, causing the U.S. to deploy additional Aegis missile cruisers to the region to fulfill its defense commitment to Japan. Indeed, preserving relative peace and stability on the Korean peninsula is one of the drivers of America’s recent pivot to Asia. As North Korea assumes a more threatening posture on the international stage, there are still important questions left unanswered.

Yet with so much of the world’s attention focused on this hermetic and polarizing state, our knowledge about the country is limited. Our satellites provide insights in the general geography, but government and non-governmental bodies alike are constantly searching for more and better geospatial data to understand not just the physical realities of the nation, but also its human geography.

We have known for some time that North Korea illegally detains tens of thousands of its own citizens in political



◀ **FIGURE 1.** North Korea showing prison camps, locations of underground facilities, internal smuggling routes, and the demilitarized zone (DMZ) on the southern border with South Korea

◀ **FIGURE 2.** Pyongyang, North Korea, showing embassies, medical facilities, military installations, and other areas where people move from place to place

◀ **FIGURE 3.** Punggye-ri Nuclear Test Site, North Korea, April 11, 2014

◀ **FIGURE 4.** Showing the same site, May 9, 2014

Legend

- ✕ Prison Camps
- Underground Facilities
- Border Crossings
- Internal Smuggling Routes
- Demilitarized Zone

prisons hidden from outsiders. Although North Korea's government denies such facilities exist, a recent report by Amnesty International found that these camps are expanding to hold even more political prisoners. Murder, rape and forced labor for military production purposes are common in these camps. DigitalGlobe's satellite imagery and geospatial data has played a crucial role in revealing the location, nature and potential future sites of North Korea's prison camps (gulags).

Similarly, North Korea's secret underground facilities have long been the nerve center of the nation's military-industrial complex. The hundreds of Underground Facilities (UGFs) have been used to develop and test nuclear weapons, create munitions, store military hardware and pursue other activities the Kim regime would like to hide from Western eyes. Although we know what many are used for, the activities and locations of some are still unknown.

Given the military nature of all of North Korea's known Underground Facilities, it's vital that we know the answers to questions such as: Where are current UGF sites located? Where might North Korea build future UGFs? What are the location-based factors most closely tied to the presence of UGFs? Identifying areas where future UGFs will be located allows leaders and planners to focus their limited data collection assets and resources.

To identify areas where future sites are most likely to be located, DigitalGlobe identified more than 16,000 geospatial points of interest in North Korea based entirely on open source data, using more than 130 data sources, creating more than 60 data layers that included religious institutions, roads, schools, hospitals, transportation hubs, manufacturing facilities, and more.

The location of each point of interest was then correlated with known UGFs. Knowing where each one was located relative to the points of interest allowed DigitalGlobe to significantly narrow the area of locations where North Korea is most likely to either build or already have secret UGFs.

This information gives NGOs and governments a significant tool in their ability to fully understand North Korea's military capabilities, potentially allowing them to monitor activity around them. Increased activity at one of these facilities could reveal clues about North Korea's state of military readiness—for instance, potentially allowing allied governments to prepare for a coming attack.

Given North Korea's recent aggression and unpredictability, this information is vital to fully understanding the military threat and formulating an appropriate response. It is also just one example of how human geography data helps provide insight into the world.

ArcGIS, Google Earth, or other similar programs. If an analyst at the company were tasked, for example, with predicting the locations of famine areas in North Korea or of future attacks in South Sudan, he would run the relevant data through DigitalGlobe's special analytical tools and generate a predictive model, Dunmire explains. "The foundation that enables us to do that hard core predictive analytics is this human terrain data that we are producing. You can hunt around on the Internet and find pieces of this, but our analysts spend a lot of time compiling this data from multiple sources—well over 100 sources for most of these countries—and then, to the maximum extent possible, we use our imagery to confirm that data." Some of the analysis is automated, "but we still use the human eye-ball at some level to help verify the data."

DigitalGlobe recently analyzed election violence in Afghanistan for the U.S. government, by taking the human terrain base layer and then using analytical tools to do predictive analysis. Based on historical trends and the current environments, it identified the locations most susceptible to election violence. "We can model anything as long as we have the geospatial data for it," says Dunmire.

DigitalGlobe, whose staff includes several Ph.D.s, does most of its analysis in house, bringing in experts to help as needed. At times, after completing one of these human landscape projects, they send it out for review by academic subject matter experts.

For Spatial Networks, analytical work is a relatively new program and is done all in-house. "When I talk about doing work in Brazil with people we know there, they are not doing the analysis," Quartararo explains. "They are providing the raw data and then that data comes to us and we provide the analytical narrative or the ability to pull all that data together as a product for our customers."

CUSTOMERS

DigitalGlobe sells its data products and analyses to companies, governments, and non-profits. "We rarely get the same request from different customers, so our products are all a bit custom-tailored," says Dunmire. Some customers, such as George Clooney's Sentinel Project, post the data they acquire from DigitalGlobe on their Web sites, while most commercial companies are targeting some commercial interest and don't want to advertise broadly what they are doing. Either way, DigitalGlobe uses only open source

information, so that their customers are free to share it with other interested parties if they want to. "Our products' metadata is extremely rich. We are very clear on where we got the information, what sources we used to verify it, and whether we verified it using our imagery." They don't, however, use social media feeds.

PRIORITIES AND BUSINESS MODEL

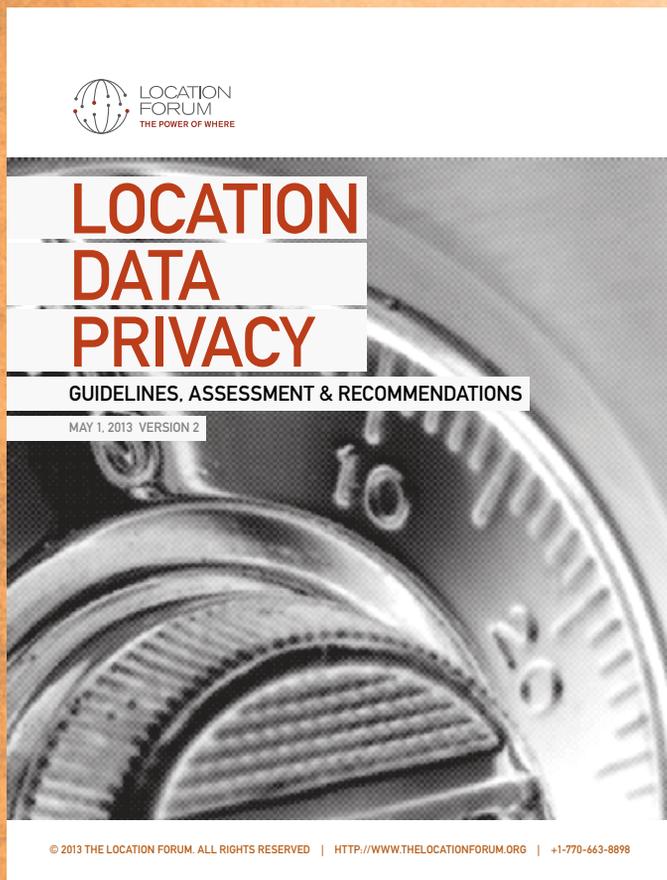
Current or anticipated customer requirements are generally what drive DigitalGlobe's priorities in deciding which country data set to produce next and which to update. "Africa is probably the continent that we are going to try to complete first," say Dunmire. "There are 53 countries in Africa and we have done well over half of them—mainly in Northern Africa, because that is where there has been a lot of interest. There is huge benefit in having the whole continent done because some of the trouble bleeds over from one country to another and some of the human terrain issues move from country to country and the boundaries often follow ethnic lines rather than national borders."

"Our business model is to gather raw data wherever we can, based on what we understand is a requirement by a customer or a segment of the market for derivative products," Quartararo explains. "Then there are analytical products that are a combination of both the derivative data products themselves as well as providing subject matter expertise from an analyst standpoint that helps the customer understand the data and how it can be used. Then, of course, there is our technology component, which offers products like Fulcrum and a number of other ones." One, called Pushpin, is a mobile application derived from Fulcrum that is designed to allow people around the world to contribute to the OpenStreetMap community. Spatial Networks made it available for free. Another derivative of Fulcrum, GraffitiMapper, enables users to measure graffiti as an indication of social well being—good, bad, or indifferent.

CONCLUSIONS

DigitalGlobe and Spatial Networks are only two of the many companies that are now offering data and analysis on human geography. Market demand and capabilities for data collection and analysis are sure to grow in the near future—paralleling the growth in the demand for and the supply of ever more accurate and comprehensive data on our planet's physical geography. ▲◊

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