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CELEBRATING EARTH IMAGERY
1985-2015

ELEVATING GLOBAL AW

Focus Shifts to Disaster Preparedness

by Victoria Samson, Washington Office Director, Secure World Foundation *pg. 20*

Building Bridges Between EO and SatCom

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Geospatial Tools Address Sea-Level Rise

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DISASTER

Risk & Response

"The growing and increasingly interconnected and exposed global population faces a mounting risk of global catastrophes caused by extreme natural hazards."

– Hans-Peter Plag, PhD, Mitigation & Adaptation Research Institute, Old Dominion University *pg. 10*

"What (the Satcom community) would like to do is to engage with the EO community to explore and see how we can collaborate between our sectors to leverage these exciting new synergies (in disaster relief efforts)."

– David Hartshorn, Secretary General, Global VSAT Forum *pg. 16*

FORMERLY Imaging NOTES

Kathmandu, Nepal, April 27, 2015, two days following the 7.8-magnitude earthquake, courtesy of DigitalGlobe.

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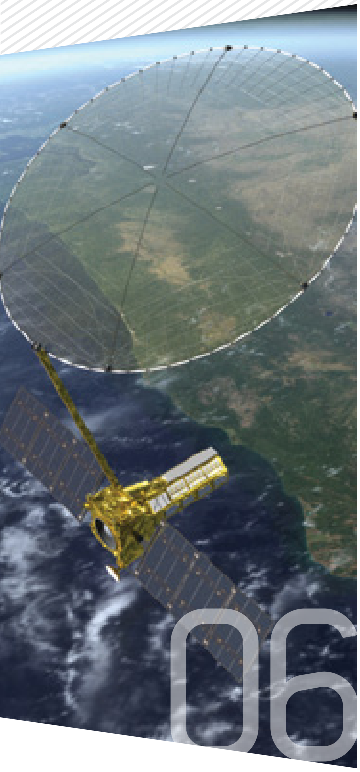

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Columns

Features

COVER IMAGE

Kathmandu, Nepal Post-Earthquake

ON APRIL 25, A 7.8-MAGNITUDE earthquake devastated Nepal. Its epicenter was the village of Barpak, Gorkha district. The quake has thus far killed more than 8,000 people, injured 19,000, and rendered hundreds of thousands homeless as entire villages were destroyed.

The earthquake triggered an avalanche on Mount Everest, killing at least 19, and it triggered another huge avalanche in the Langtang Valley, where 250 were reported missing. Before-and-after images of Langtang are included in the article, Disaster Risk Management on page 20.

A second major 7.3-magnitude earthquake occurred on May 12. The epicenter was near the Chinese border between the capital of Kathmandu and Mt. Everest. It occurred along the same fault as the original quake, but further to the east; it is considered to be an aftershock of the April 25 quake.

This cover image was taken by WorldView-3 on April 27, 2015, courtesy of DigitalGlobe.

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Formerly Imaging NOTES

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MISSION

Apogeo Spatial communicates the power of geospatial tools and technologies in managing the world's environment and scarce resources, so that the global population has the security of water, food, and energy.

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Myrna James Yoo
Publisher and Managing Editor
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Priorities Changing for Disaster Response

ONE OF THE MOST IMPORTANT and powerful uses of geospatial tools is for disaster response and mitigation. This issue of *Apogeo* takes direct aim at this subject, from several different angles. As I write this, the incredible country of Nepal has endured not one, but two massive deadly earthquakes, on April 25 (7.8 magnitude) and again on May 12 (7.3 magnitude). In addition to the devastating loss of life, with over 8,000 killed, 19,000 injured, and countless homeless, centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Square, the Bhaktapur Durbar Square, the Changu Narayan Temple and the Swayambhunath Stupa.

Photos from trekking in the gorgeous Annapurna Sanctuary of Nepal, 1998, courtesy of the author.

Like many people, I have traveled there. In 1998, I spent a few months in Nepal, trekking the Annapurna Sanctuary (see photos), which was enlightening for me in many ways. This area is known as one of the most spiritual in the world, and I did see that the people seemed more at peace than most, while most of them lived in extreme poverty. It was a fascinating juxtaposition that I have since studied, and find to be very important. My heart goes out to all who are affected.

One important note from *On the Edge* columnist Hans-Peter Plag is that these extreme events are more disastrous in areas like Nepal. He notes on page 10, "The impact of earthquakes is amplified in regions with poor building standards, which often coincide with poverty and corruption. As a result, the deadliest earthquakes on record are mostly not the largest in magnitude."

Appropriately, the focus has shifted from disaster response to disaster risk management and mitigation for geospatial companies and NGOs, according to speakers at the Secure World Foundation salon on Disaster Risk Management during the National Space Symposium in April 2015. UN-SPIDER's Dr. Shirish Ravan shared that helping at-risk communities before disasters is the focus now, which was reflected also in Taner Kodanaz' comments regarding the efforts of DigitalGlobe's "Seeing a Better World" Program. Read about these and additional perspectives by NASA's Dr. David Green and Airbus' Joerg Herrmann, on page 20.

The amount of time and resources that the for-profit companies can invest in disaster response emergencies is limited, of course, even though lives are on the line. This ethical dilemma is discussed in our Executive Interview with David Hartshorn, who is Director General of the Global VSAT Forum. While he has been entrenched in the satellite communications industry, he sees a tie with the Earth observations community and has a vested interest in working together, because of the way that the companies respond to disasters. You will find this interview on page 16.

Thanks for reading!

Myrna James Yoo, Publisher

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International Cooperation in Earth Observations

BILATERAL PARTNERSHIPS: CHINA AND BRAZIL; U.S. AND INDIA

EARLY LAST YEAR, THE GROUP ON EARTH Observations (GEO) renewed its 10-year mandate as ministers from all over the world signed a declaration under the theme of "Integrating Observations to Sustain our Planet." The renewed mandate was one of the landmarks in multilateral efforts to advance global access to and use of Earth observation data in 2014.

While multilateral efforts such as GEO, the Committee on Earth Observation Satellites (CEOS), and the World Meteorological Organization (WMO) continue expanding to meet global needs, progress is also being made at a smaller scale. Efforts such as AfriGEOSS, involving 23 countries in the African region, and the U.S. decision to release global high-resolution elevation data from the Shuttle Radar Topography Mission-2 (SRTM-2), are good examples of how regional and unilateral actions can help improve access to EO data.

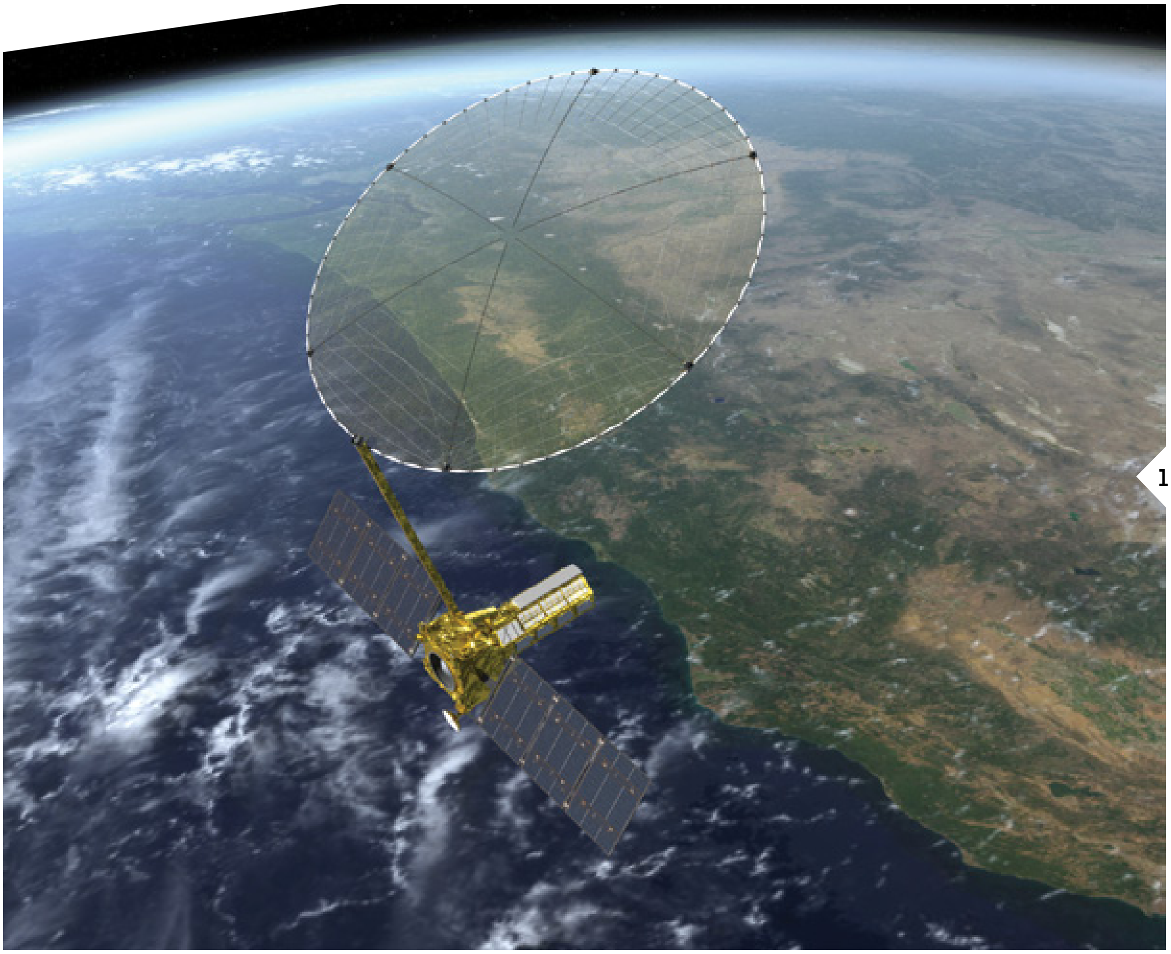
This article focuses on the value of bilateral partnerships in Earth observation, a unique mode of international cooperation. Collaboration between two countries may involve data exchange, expert collaboration in the processing, analysis, and use of such data, and the joint development of spacecraft and programs. This article will discuss recent developments in two long-standing bilateral partnerships: the United States and India, and China and Brazil. It will conclude by describing key policy and legal issues that arise during bilateral relationships, as examined in a recent Earth observation data sharing workshop held in Washington, D.C.

NISAR: ANOTHER MILESTONE IN U.S.–INDIA COLLABORATION

An agreement to proceed with an innovative dual frequency radar satellite – the NASA-ISRO Synthetic Aperture Radar (NISAR) – is one of the highlights of the 2014 U.S.-India bilateral exchanges. The mission, slated for launch in 2020, will enable a detailed study of land surface changes, thereby improving our understanding of the effects of complex Earth processes, climate change impacts, and natural hazards. According to the September 2014 agreement, NASA will provide the mission's L-band synthetic aperture radar (SAR) instrument and other hardware, while ISRO will provide an S-band SAR, the spacecraft bus, the launch vehicle, and associated launch services.

NASA's relationship with India began in the 1960s. The establishment of a Landsat receiving station in India in the late 1970s is one of the early space-based EO cooperative efforts between the partners, paving the way for activities that would include data sharing agreements, and scientific and technical collaboration in applications such as agriculture, disaster management, weather, and climate.

According to Ashok Maharaj in *NASA in the World* (2013; Palgrave Macmillan), the use of revolutionary Landsat images in the 1970s for natural resource management motivated the institutionalization of remote sensing in India. Moreover, NASA's efforts to promote this new field, which included scientific and technical collaboration, contributed to the development of the first satellite in the Indian Remote Sensing (IRS) system. The Embassy of India in Washington, D.C. cites the long-standing relationship as key



◀ FIGURE 1. Artist rendition of the NASA-ISRO NISAR satellite, to be launched in 2020. Credit: NASA.

▼ FIGURE 2. CBERS-2 image of Fortaleza, the fifth most populous city in Brazil and capital of the state of Ceará, captured in March 2004. Credit: CBERS/INPE.

in enabling India to gain experience in the reception, processing and application of remote sensing data, contributing in the development by India of what is today the world's largest constellation of civil Earth observation satellites.

The U.S. State Department describes this relationship with India as "productive cooperation" that is "vital in achieving a broad range of shared goals." For example, under the terms of a data sharing agreement signed in 2008, ocean surface wind measurements from India's Oceansat-2 satellite were used extensively as data inputs to hurricane models during Hurricane Sandy, which struck the east coast of the United States in 2012, leading to over $60 billion in damages.

"The signing of these two documents reflects the strong commitment NASA and ISRO have to advancing science and improving life on Earth," said NASA Administrator Charles Bolden of the 2014 agreements. According to NASA, the partnership has been important to many of the mission's science objectives developed in response to the priorities identified in the U.S. National Research Council's 2007 Earth science decadal survey.

CBERS: THE SYMBOL OF CHINA–BRAZIL SPACE COOPERATION

In December 2014, China and Brazil celebrated the launch of CBERS-4, the fifth in a series of multispectral imaging satellites from the China-Brazil Earth Resources Satellite (CBERS) system. The success was especially welcome as it followed a failed launch attempt of the Chinese Long March 4B in 2013 that destroyed the CBERS-3 satellite. That loss prompted the partners to speed up development of CBERS-4, meeting yet another challenge that the partners of this decades-long collaboration have taken in stride.

The CBERS program began with a 1988 technical cooperation agreement between Brazil's Institute of Space Research (INPE) and the

▶ FIGURE 3. Satellite product provided by USGS to China through the International Charter: Space & Major Disasters, in the aftermath of the 2008 earthquake in Wenchuan. Credit: K. Hudnut, USGS.

Chinese Academy of Space Technology (CAST). The goal was to enable an indigenous source of multi-spectral optical data to help manage the countries' vast natural resources. The development of the system allowed the partners to achieve data independence and transformed them into data providers, so that they were no longer reliant on foreign sources of satellite imagery. According to INPE, this has allowed Brazil to "consolidate an important autonomy" in remote sensing.

The China-Brazil partnership is rooted in joint development and technology transfer, as a way to meet national observational goals while advancing the development of the space programs on both sides. The relationship has helped advance Brazil's know-how in satellite development to the point that half of the components of the CBERS-4 satellite are of Brazilian origin. The new satellite represents an evolution from the first-generation systems with improved spatial and temporal resolution, and added capability, such as a new panchromatic and multispectral camera with the capability for stereoscopy.

The program has been credited with contributing to the technological, social, and economic development of both partners. "The continuity of the CBERS program is viewed as strategic for the environmental monitoring of both countries," wrote José Carlos Epiphano, then coordinator of the CBERS application program at INPE in a 2008 *Imaging Notes* article. Thousands of users in Brazil and China use CBERS images for numerous monitoring, planning, and natural resource management applications. Of note is the role of the system in Brazil's Amazon deforestation monitoring program, DETER, part of improved monitoring and law enforcement programs that contributed to a dramatic reduction in the rate of deforestation in the 2000s.

CBERS has also achieved several political goals. The first satellite cooperative program involving two developing countries, its success has been showcased as an example of South-South cooperation and as a way to defeat perceived obstacles to developing countries' access to high technology. Writing in a 1997 article in *Space Policy*, José Monserrat Filho, now head of international relations at the Brazilian space agency, noted Brazil had "the strategic conviction that cooperation with China in remote sensing based on strong mutual interests could open new opportunities to acquire space technologies otherwise impossible to establish or buy for a developing country." The continuation of the program was similarly consistent with goals described in a 2008 *Chinese Policy Paper on Latin America and the Caribbean* to build strategic partnerships in the region for mutual benefit and common development.

CBERS is also one of the first programs to adopt a free-of-charge distribution policy that has been extended to users all over the world. Through programs such as CBERS Africa, which involved installing receiving stations throughout the region, the partners have advanced data democracy goals, facilitating open access to CBERS data to other developing countries.

In 2014, the partners announced plans to develop CBERS-4A to be launched in 2017. In the context of the development of the next 10-year cooperation plan, China and Brazil are also considering two more CBERS satellites, as well as joint development of meteorological satellites.

EXPLORING ADVANCES IN U.S.–CHINA EARTH OBSERVATION DATA SHARING

In August 2014, the U.S. National Research Council's Board on Research Data and Information, which also serves as the U.S. Committee on Data for Science and Technology (CODATA), held a workshop with the Chinese Academy of Sciences (CAS) to examine EO data sharing and cooperation. The event was co-sponsored by the author's employer, the Secure World Foundation (SWF), a private, operating foundation that works with stakeholders worldwide to promote space sustainability.

The workshop engaged members of the Chinese and U.S. EO communities. The goals of the event were to: identify opportunities related to data sharing; showcase recent successes and existing efforts; improve understanding of Chinese and U.S. EO data policy, programs, and issues; and identify possible follow-on activities, with a focus on data sharing for disaster management.

The highlights of the discussion point to important themes that play a role in the development of bilateral partnerships in EO.[1] In particular, it was clear how interactions among government, industry, and academic partners in the collection and provision of EO data lead to legal, economic, and institutional issues that impact data sharing. In the case of China, some of the challenges that were discussed include complex relationships among central and local governments, and research communities, overlapping lines of authority, and lack of a unified set of distribution policies. In the United States, an open access policy for government sources of data is paired with copyright and other ownership restrictions that limit redistribution of certain datasets. Participants discussed different legal and regulatory mechanisms that may be adopted to balance these kinds of limitations and bring value to the partnership.

The discussion also emphasized that improved understanding of the political and institutional assets and challenges of the partners can be critical. In the United States, a current ban on bilateral cooperation with Chinese partners has been imposed on NASA and the White House Office of Science and Technology Policy. However, both sides engage regularly through bilateral and multilateral mechanisms. For example, the U.S. National Oceanic and Atmospheric Administration (NOAA) and the Chinese Meteorological Administration (CMA) share information on atmospheric science and technology through a bilateral protocol, and both participate regularly in platforms such as CODATA and GEO. China's participation in GEO is one of the key drivers in the shift towards developing improved EO data sharing policies within and outside of China.

Workshop participants discussed EO data sharing for the full cycle of disaster management – from disaster mitigation through long-term recovery – as an opportunity for enhanced cooperation. Given China's unique vulnerability to natural disasters, as well as an interest on both sides to improve understanding of hazards, exposure, and vulnerabilities to natural disasters, disaster management is a shared priority. An opportunity that participants agreed to explore is for CODATA to facilitate data sharing between China and the United States on third-party scenarios, such as natural disasters occurring in Africa.

CONCLUSION: THE BENEFITS OF A TWO-WAY CONVERSATION

Multilateral efforts often dominate discussions of international cooperation in Earth observations. While such programs advance important goals at a global level, other modes of cooperation such as bilateral partnerships co-exist to meet various scientific, technical, and political goals. Long-standing collaboration between partners such as the United States and India, or China and Brazil, indicate how experienced and emerging space nations can find value in such relationships.

Bilateral partnerships can also evolve to include other countries. The CBERS Africa program allowed direct broadcasting of CBERS data to users in Africa. Elsewhere, India's Megha-Tropiques satellite was incorporated into the U.S. and Japan-led Global Precipitation Measurement mission.

It is important to have an accurate understanding of partners' interests, incentives, and capabilities to determine how each would be served by the relationship. For some actors, multilateral forums remain the primary venue for developing this awareness and maintaining relationships where closer bilateral engagement may not be politically feasible.

A key element of strategic relationships between countries, bilateral partnerships can bring added value to national investments in space-based EO while also supporting political stability, thus helping improve the ability of decision makers worldwide to continue relying on these critical information tools in the long run.

Endnote:

1. Visit the SWF website at http://swfound.org to find the workshop agenda, summary report, and links to the presentations available on the NAS website.

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Extreme Volcanic Eruptions

THE GLOBAL POPULATION MAY NOT BE PREPARED

TWO HUNDRED YEARS AGO, ON APRIL 10, 1815, the volcano Mount Tambora in Indonesia had a climactic explosion in a sequence of explosive eruptions that lasted several months and ejected about 150 km^3 of tephra into the atmosphere. The explosion was heard in a large area spanning more than a thousand kilometers. The ash cloud eventually covered an area on the northern hemisphere reaching from Indonesia over Europe to the East coast of the United States (***Figures 1-2***).

At the time of the eruption, people in Europe had no idea that they were heading for – what became known as "the year without summer" and a hard time with cold and severe weather, food shortages, and epidemics. Many communities on the Northern hemisphere turned out unprepared for the severe impacts of the eruption and the climate signal it produced. Today, the news of such an eruption, no matter how remote, would spread around the globe more or less immediately. But is the modern, globally connected society better prepared for such an event than communities were 200 years ago? How likely is it that we will experience an eruption as severe in this century? Do we know the risk that these eruptions pose and can we afford not to consider this risk in our efforts for disaster risk reduction (DRR)? Could large volcanic eruptions cause global disasters or even a global catastrophe? The European Science Foundation (ESF) just published a science position paper that studied these questions in detail.[1] The following is a summary of the main findings of this position paper.

On the scale defined by the Volcanic Explosivity Index (VEI),[2] which uses a combination of the volume of the erupted tephra and the eruption plume height to assess the severity of an eruption, the Mount Tambora eruption measured VEI 7. During the Holocene, the most recent geological epoch that began 11,700 years ago, there were seven known VEI 7 eruptions (***Figure 3***); and possibly one or two more that are not known yet. All but one of these eruptions took place at a time when global population was far below 1 billion. At the time of the Mount Tambora eruption, population had just reached 1 billion. With a population above 7 billion and heading for 12 billion,[3] a recurrence of a VEI 7 eruption could have extreme consequences, potentially causing a global disaster. The probability of such an event occurring in the 21th century is 5-10%. Consequently, VEI 7 and larger eruptions are a severe threat to our modern society.

Humanity is exposed to a broad ensemble of natural and anthropogenic hazards that could cause global disasters and catastrophes.[4,5,6,7] Geohazards such as earthquakes, landslides, volcanic eruptions, tsunamis, and floods cause significant loss of lives and properties. Most of these losses occur during high-impact events and they are increasing, as more and more people live in areas exposed to such hazards.

Recent events such as Hurricanes Katrina in 2005 and Sandy in 2012, the 2004 Indian Ocean tsunami, the 2011 Tohoku earthquake and tsunami, and the 2013 Typhoon Haiyan illustrate the destruction extreme hazards can inflict on a modern society, particularly through cascading effects and chains of failure. They also show that the risks associated with extreme natural hazards are still difficult to estimate and that procedures for reducing the disaster risk and mitigating the resulting losses are inadequate. This is even more so for more extreme events that could occur any time.

The recent major geohazards are dwarfed by the largest geohazards that occurred several

times during the Holocene (e.g., ***Figure 4***). If such a mega-hazard were to occur today, the resulting disaster impacts would be unparalleled. Efforts in DRR are challenged by the nature of such extreme events: they are rare, occur as surprises, and tend to have high impacts. Because they are rare and we lack direct experience, the serious threat posed by extreme events tends to be underrated. The increasingly complex built environment and global economic dependencies can lead to domino effects amplifying the direct impacts of the hazards.

The sensitivity of our modern communities was exemplified by the widespread impacts of the minor Eyjafjallajökull eruption VEI 4; 0.25 km^3) in Iceland in 2010. Global disasters caused by extreme hazards have the potential to severely impact the global economy, food security and stability. Floods and droughts are major threats that potentially could reach planetary extent through secondary economic and social impacts. With mega-cities and crucial industries in areas exposed to natural hazards, earthquakes, tsunamis, and volcanic eruptions might cause disasters that could exceed the coping capacity of the global economy. Unfortunately, the more we learn to cope with the relatively frequent hazards that we experienced during the last 50-100 years, the less we are worried about the low-probability, high-impact events, which do not occur every century, but which might occur in the near future. As a consequence, threats from the less frequent extreme floods, droughts, volcanic eruptions, asteroid impacts, solar storms, etc. often are not appropriately accounted for in DRR discussions.

Addressing the challenges that the rare, high-impact events pose to human life and property is essential for long-term sustainability of civilization. Given the nature of the extreme hazards, most ideas about them are based on indirect evidence, and particularly the impacts of the hazards on environment and society are difficult to assess with certainty. Risk as conventionally defined – the product of hazard probability, value of assets exposed to the hazard, and the vulnerability of the assets – is hard to assess. The hazard probability goes to zero, and we lack the knowledge to reliably estimate the vulnerabilities, especially from

▲ FIGURE 1.
The ash cloud of the Mount Tambora Eruption in 1815 covered a large part of the northern hemisphere. The eruption caused global climate anomalies including the phenomena known as "volcanic winter" and 1816 became known as the "year without a summer." Average global temperatures decreased by about 0.4 K, enough to cause significant agricultural problems around the globe. Associated health impacts included a severe typhus epidemic from 1816-1819 in southeast Europe and the eastern Mediterranean, and a worldwide spread of a new strain of cholera originating in Bengal in 1816.

indirect and cascading effects, both in the near- and far-field of the hazardous event.

Increasing global resilience and reducing the disasters induced by the occurrence of extreme hazards at an acceptable economic cost requires a solid scientific understanding of the impacts these hazards could have on modern society. While the probabilities of most natural hazards do not change much over time, the sensitivity of the built environment and the embedded socio-economic fabric has changed. Exposure to geohazards has increased dramatically in recent decades and continues to do so. Most of the increasing losses occur during less frequent high-impact events at the upper end of the hazard spectrum. The increasing complexity of societies allows even moderate hazardous events to cause regional and global disasters. Understanding the disaster risk therefore requires distinguishing between the event (the occurrence of a hazard) and the processes that are triggered by this event and that determine its consequences.

▶ FIGURE 2. The 1815 eruption of Mount Tambora formed a huge caldera in Indonesia. Source: Jialiang Gao, see http://en.wikipedia.org/wiki/Mount_Tambora#/media/File:Caldera_Mt_Tambora_Sumbawa_Indonesia.jpg.

For risk assessments, it is crucial to understand the processes triggered by the event in the complex coupled human-natural system that lead, or do not lead, to so-called X-events.[7] X-events are rare, surprising, and have potentially huge impact on human life. These X-events are outliers outside of the "normal" region that could lead to "the collapse of everything." Increasingly, the complexity of modern life amplifies the impacts of natural hazards. Although we understand the "how" and "why" for most of the natural hazards events (although not necessarily the "when"), how such hazards lead to X-events is less studied and understood. For many natural hazards, the unfolding time is short, but the impact time can be much longer. Events that have a short unfolding time but large total impacts over very long impact times are those that are surprising and difficult to prepare for. Extreme geohazards fall into this class of events.

The extreme earthquakes that occurred during the last 2000 years have illustrated the destruction they can inflict, both directly and indirectly through tsunamis. The resulting disasters are amplified in areas with poor building infrastructure. As a consequence, the earthquakes with the largest magnitude are not necessarily those that turn out to cause the most fatalities or greatest damage. In general, poor countries that are exposed to the same level of hazards as more developed countries experience a disproportionate number of disasters. Poverty, often paired with corruption, is the basis for processes that can turn hazards into disasters, and the means to increase preparedness and resilience are not sufficiently available in areas with high degrees

Categories of Disasters

X-events differ in terms of the disasters they cause. We distinguish four categories:

a. *Extinction-Level Events are so devastating that more than a quarter of all life on Earth is killed and major species extinction takes place.*

b. *Global Catastrophes are events in which more than a quarter of the world human population dies and that place civilization in serious risk.*

c. *Global Disasters are global scale events in which a few percent of the population die.*

d. *Major Disasters are events exceeding $100 Billion in damage and/or causing more than 10,000 fatalities.*

of poverty. The very recent earthquake in Nepal underlines the causal link between poverty, corruption, a poorly built environment, and the extent of the damage caused by a natural hazard.

Volcanic eruptions experienced in the last few decades often have a high ratio of fatalities to the immediately impacted population. All but one of these eruptions were relatively minor and direct impacts were local. For larger volcanic eruptions, volcanic ash and gases can induce large indirect effects often exceeding the direct impacts in the near-field of the volcano. This is illustrated by a number of eruptions that took place in the last few hundred years.

Extreme geohazards that occurred throughout the last few thousand years rarely caused major disasters because population density was low, the built environment was not sprawling into hazardous areas to the same extent as today, and the complexity of human societies was much lower than today. Similar extreme events today could cause unparalleled damage on a global scale and worsen the sustainability crisis. Simulation of these extreme hazards under present conditions can help to assess the disaster risk and underline the fact that we have been lucky during the last century.

The intercomparison of natural hazards indicates that large volcanic eruptions are the low-probability geohazards with potentially the highest impact on our civilization. Large volcanic eruptions can have more severe impacts through atmospheric and climate effects and can lead to severe problems in food and water security, as emphasized by the widespread famine and diseases that were rampant after the Laki 1783 and Tambora 1815 eruptions. Hence extreme volcanic eruptions pose a higher associated risk than all other natural hazards with similar recurrence periods, including asteroid impacts.

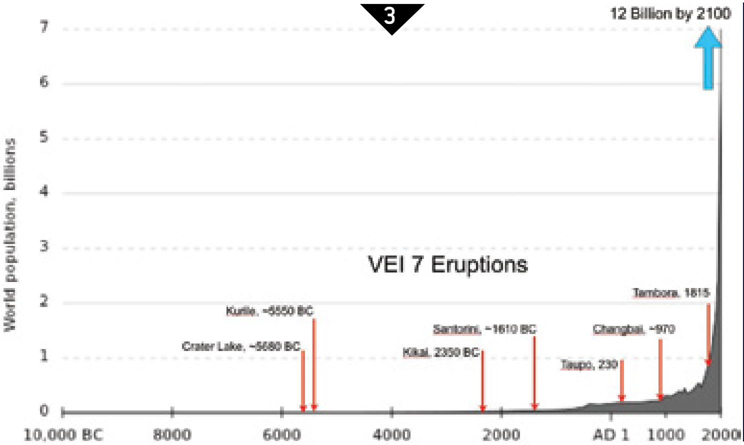
So far, modern civilization has not been exposed to an eruption comparable to the most extreme events during the Holocene. However, under the present conditions of a globally connected civilization facing food, water and energy scarcity, the largest eruptions during the Holocene would have had major global consequences. Events like the Toba eruption 74,000 years ago could return humanity to a pre-civilization state.

In terms of energy release per event, extreme volcanic eruptions are the largest high-intensity terrestrial phenomena known.[8] Considering the long-term, time-averaged mass eruption, volcanic M7 eruptions are associated with a 10-100 times larger contribution than M8 and M9 eruptions. At recurrence periods of up to 100,000 years, explosive volcanic eruptions are more frequent than asteroid impacts with similar energy releases. Although energy release of the one in one million years eruption is comparable to that of equally frequent impactors, volcanic eruptions may be far more impactful since they are more likely to occur on land, are associated with large amount of ash and gas emissions, and are likely to impact climate and food security more severely. This has important implications for risk assessments of extreme events and DRR. The impacts on our modern society could result in a global disaster, and it is timely to take measures to reduce this risk.

It needs to be mentioned here that the anthropogenic climate change expected for the 21st century may be associated with a higher risk than any other geohazard at the 500-year to several thousand-year event scale, with the upper limit of this risk being very uncertain. The probability of severe impacts is very high, and it keeps increasing with every year passing without a significant effort to mitigate climate change. March 2015 was the first month in which the globally average atmospheric carbon dioxide content was above 400 ppm for the whole month, marking a significant milestone on our journey to a much warmer planet, and there are few signs that humanity will manage to get together in a significant effort to curb the current trends. Increasingly, communities are impacted and forced to migrate. Adding a major volcanic eruption to the pre-stressed global community could easily cascade into major food scarcity, famine, epidemics, large-scale migration, economic instability, and social unrest.

With the prospect of the global population reaching 12 billion by 2100,[3] humanity faces the crucial challenge of developing in a very limited time an effective program to reduce the risk of global disasters and catastrophes caused by natural hazards. Considering risk as the product

▶ FIGURE 3.
VEI 7 Eruptions during the Holocene and global population. Recent studies indicate that we are heading for a global population of 12 billion by 2100.



▶ FIGURE 4.
The Greek island Santorini is the site of one of the largest volcanic eruptions during the Holocene. It occurred about 3,600 years ago during the height of the Minoan civilization, left a large caldera surrounded by volcanic ash deposits hundreds of meters thick. The eruption had severe impacts on the civilization in the Mediterranean. Source: NASA, see http://photojournal.jpl.nasa.gov/catalog/PIA02673.

of hazard probability, sensitivity to the hazard, and the value of the exposed assets, it is obvious that risk mainly can be reduced by reducing sensitivity and exposure. Adaptation and mitigation efforts to reduce sensitivity and exposure are insurance against the risk. Willingness to engage in adaptation and mitigation depends on risk perception. The challenge of extreme geohazards is that they are infrequent and risk awareness is generally low. Therefore, the costs for adaptation and mitigation are often postponed.

Risk awareness and monitoring, as well as the capabilities and means to mitigate risk, are highly uneven across the world. As a result, potential hazards are much more closely monitored in wealthy countries than in the developing world. Low risk awareness combined with poverty and corruption turns hazardous events more easily into disasters throughout the developing world. However, the largest hazards are global in nature, and efforts need to be made to have a well-developed global monitoring system for geohazards in support of early warnings. An international governance structure is needed to coordinate global risk assessments and responses.

Research focusing on community disaster resilience is at its beginning. Simulation of selected extreme hazards under present conditions can help to identify weaknesses in the global socio-economic system that could lead to cascading effects. Essential variables to be observed by a human observatory need to be identified. Research on the response of our global community to a warning that an extreme hazard is developing is limited and efforts need to be made to understand the impacts of such warning on global stability and preparedness.

Although significant efforts have been made to coordinate global Earth observations (e.g., through the efforts of the Group on Earth Observations, GEO), a comprehensive monitoring system of systems that could give timely warning for an impending extreme volcanic eruption is not in place. A monitoring system should combine surface displacements, gravity changes, seismicity, chemical variables, and infrasound to detect emerging volcanic eruptions and assess their potential magnitude ahead of the main eruption.

In conclusion, it has to be acknowledged that humanity is poorly prepared to meet the challenge of extreme geohazards. In particular, a large volcanic eruption (VEI 7 or larger) would challenge modern society to the core. Reasons for not being prepared include low perceived likelihood, a low political sensitivity, a disconnect between the scientific communities and decision-makers, the lack of socially acceptable strategies including the cost of preparing, and the common belief that consequences are so extreme that preparedness is futile. To overcome these issues, a better process for understanding the available scientific knowledge and using it in proactive decision making needs to be developed.

If we want to reduce the risk associated with extreme geohazards, particularly severe volcanic eruptions, the global community needs to facilitate the development of several elements in science, monitoring, and governance:

- A global scientific framework for strategic extreme geohazards science in support of warnings, preparedness, mitigation and response to be implemented by governments, communities, and the private sector on global scales in order to minimize the impacts of extreme geohazards;

- Scenario contingency planning to better understand the threats and reduce the risk particularly by reducing systemic weaknesses that could lead to cascading effects;
- Improved risk awareness through dissemination of information on the risk associated with extreme geohazards;
- A global monitoring system to provide early warning for emerging extreme volcanic eruptions;
- An informed global governance capable of responding to emerging global threats and coordinating measures to increase preparedness and general resilience with the goal to reduce the global disaster risk.

As an immediate step, the existing International Charter on Space and Major Disasters should be extended to also cover actions increasing preparedness and cases of emerging threats for early warning purposes.

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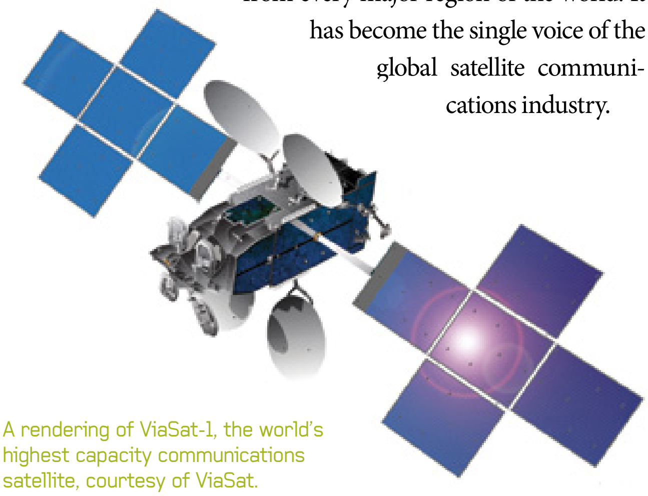
THE URGENCY OF BUILDING BRIDGES BETWEEN EO & SATCOM

Discussing the ethical dilemma of for-profit companies that offer free disaster response products and services: How far can they go?

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

Currently, billions of individuals in every major world region—and billions of dollars worth of commerce—are supported by satellite-based broadcasting and telecommunications. VSAT, short for very small aperture terminal, are earthbound stations used in satellite communications of data, voice, and video signals, excluding broadcast television. The Global VSAT Forum (GVF), a non-profit, international association, was founded in 1998 to represent globally the interests of VSAT system and service providers, as well as end users, and to promote the technology and the services it supports. Headquartered in London, with a regional office in Washington, D.C. and global affiliates, the GVF is an independent, non-partisan organization with more than 200 members from every major region of the world. It has become the single voice of the global satellite communications industry.



A rendering of ViaSat-1, the world's highest capacity communications satellite, courtesy of ViaSat.

David Hartshorn has been GVF's Secretary General since its inception. He leads its efforts to facilitate the provision of satellite-based communications solutions throughout all nations of the world; works closely to support policymakers at the national, regional, and global levels as they formulate satellite regulatory frameworks; and is responsible for creating greater awareness of the commercial, economic, political, and technological advantages that satellite-based communications provide.

Apogeo Spatial's contributing writer Matteo Luccio asked Hartshorn to explain his vision for a much tighter collaboration between the satellite communications and Earth observation (EO) communities to assist first responders in disasters.

APOGEO *Apogeo Spatial's readers are familiar with how EO can provide information of relevance to first responders. How do EO and VSAT intersect with respect to disaster preparedness?*

HARTSHORN Technology advances are underway both in the EO space and, in parallel, in the satellite communications space. These advances create a sense of moment that has not been there before and which calls upon both industry sectors to coordinate more closely than ever to leverage the synergies between these respective industries in facilitating more effective disaster response. One example is the current response in Nepal. Longer term, disaster preparedness strategies involve both industries, as well as the first responders themselves and other stakeholders in the disaster preparedness space.

APOGEO *What got you involved with disaster preparedness?*

HARTSHORN GVF is almost two decades old. When we had just launched the organization, we received an urgent phone call from the UN. This was around the time of the Sudan famine. They wondered whether we could facilitate their connection with satellite communication system and service providers who might be able to provide services and systems in support of the famine [relief effort]. Of course, we said, "Yes, what would you like?" and it was agreed that we would push an emergency notification button, reaching out to all of our members worldwide and putting them into direct contact with the UN, who would then engage them and see what, if anything, could be provided. That evolved into a formalized relationship over the years.

Fast forward to the Haiti earthquake, a few years ago… By that time, we had the formal arrangement in place, and we had expanded our collaboration to include NGOs, as well as national and state or provincial-level response agencies. We had pushed the emergency notification button many times and what we had begun to see and what really became underscored for everybody involved, during the Haiti earthquake, was a pattern of dysfunction among the communications industry—not just satellites, but the whole communications industry—and the first response community.

What happens traditionally is as follows: the first response agencies reach out to the communications industry, having implemented in advance an insufficient level of preparedness. They reach out in an emergency setting to the industry and ask for help. The industry—those who are able—responds and, typically, because it is on such short notice, because there is a real disaster being attended to and lives are on the line, the industry provides free systems and services where possible. The justification for this engagement is, in varying degrees based on altruism, a sense of corporate social responsibility, and, for some, there is a hope that after the disaster, having stepped up to provide the support, there may be a more commercially sustainable level of engagement with that company, that donor.

APOGEO *How did the Haiti earthquake change the relationship between the VSAT and disaster relief communities?*

HARTSHORN Haiti was huge. It was a massive disaster and we pushed the button and, as usual, a number of our member companies from around the world stepped up and provided very substantial systems and services for support of the relief efforts. After the disaster, as usual, we went out to those members, as well as to the first-response community, and we asked, "How did it go? Did you learn any lessons?" We heard two stories, with the same conclusion. Our industry members said, "Well, we were proud to have been given the opportunity to support the relief effort, but it was hard, it was expensive, and if we were called again anytime soon, we are not sure that we could afford to do it."

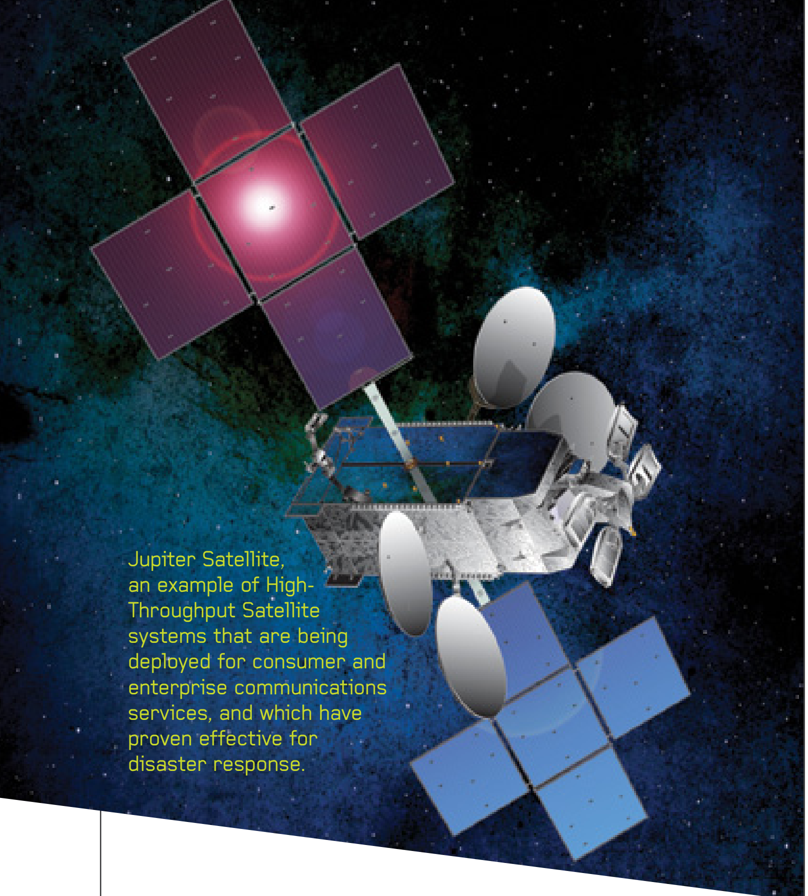
The first responders, around the same time, spoke with us and said, "Thank you for the donors, but when are we going to have real preparedness and sustainable engagement?" By this time, the Pakistan floods had begun to happen and the UN had gone out in the same way, with our assistance, to reach out for donors.

The final part of this pattern is donor fatigue. There was a faint shadow of industry support for Pakistan flood relief, because the floods happened right after Haiti. Because this level of engagement is not commercially sustainable and this is such a recognizable pattern that the term "donor fatigue" has been coined and is part of strategic operational plans for disaster preparedness and response.

So, we told our first-response partners: "We are frustrated, too. Our member companies cannot provide unlimited assurances of ongoing support for disaster response. Let's clear the deck here and start from scratch. What is your dream scenario for disaster response as it relates to communications?" They said: "Dream scenario? OK, one, we want pre-positioned people, in-country, all over the world, who are trained on deployment of communications and we can't pay anything for that." [I said,] "OK. What else?" They said, "Well, second, we want to know who the local communications service providers are in-country."

APOGEO *How do relief organizations relate to existing communications service providers in disaster areas?*

HARTSHORN Typically, for example, when an organization like the UN comes into a disaster, they find that there is still a licensed communications service provider who has some level of capability that has survived the disaster. The international disaster-response organization, not knowing in advance who these companies are, comes right in on top of them and winds up, inadvertently, in effect in competition with that company, at a time when



Jupiter Satellite, an example of High-Throughput Satellite systems that are being deployed for consumer and enterprise communications services, and which have proven effective for disaster response.

they can least afford that form of competition. It is also an opportunity cost, because they would like to use those services from the local provider and they would like not to bring in systems and services that are redundant, using, typically, aircraft capacity that could be put to better use for other things that are not available on the ground when they arrive.

APOGEO *How is GVF able to assist?*

HARTSHORN The GVF already runs a global certification program. We have more than 10,000 people enrolled who we train in how to deploy satellite communication systems. We maintain contact details for those personnel in a public database. We formalized with first-responders an arrangement where they can go out to these pre-trained personnel all over the world, wherever they may be, and enlist their services in support of deployments for disaster relief efforts.

Now, this is conducted on the basis of whatever terms are mutually agreeable between the installers and the first response entity. This becomes really important because those installers can be leveraged after the disaster, during the redevelopment phase of the effort, where longer-term commercial contracts may materialize. That phase, by the way, is usually when the funding support shows up. It is often not there before and during the disaster; it is often there afterward. So, it would create a bridge between those who are already there, as a pre-trained entity, so that they can help out during the disaster, maybe as a donor, maybe not, but certainly to be a prime candidate for longer-term contracts. So, we are addressing the financial sustainability.

Second, how can first response entities know who the local communications service providers are? These companies are typically the employers of those installers. So, by having that contact established before the disasters, and that's now been done, first response agencies have access to locally licensed communications capabilities. That is useful during the disaster and here again, during the re-building phase when contracts show up and these types of companies locally may become beneficiaries and provide long-term support.

APOGEO *Where does EO fit into all of this?*

HARTSHORN Satellite communication is typically, at its most fundamental, a bent pipe through which information flows that would be useful in guiding and directing the efforts of the first responders on the ground during a disaster. EO obviously is a primary source of the type of data that can guide those first responders. Now, there are other sources, of course. Crowd-mapping is a new source of data that has begun to flow through that satellite bent pipe to the first responders. However, EO information of every kind is great in providing higher levels of situational awareness, so that precious resources can be directed toward those areas most in need. Again, eliminating redundancy of effort is key here and Earth observation has a major role to play in that.

EO is already being used for emergency response but we want to see that data getting more deeply down range to those on the bleeding edge of the response effort. Another recent development that enables that to occur at a level that has not previously been possible is the implementation, right now, in every major region of the world, of high-throughput satellite (HTS) systems and services. To give an indication of what these are and what they represent and how they can become that conduit or bent pipe to move EO data further down range to the first responders, the first of the high-throughput satellites were launched several years ago in the United States by a company called ViaSat. When the first ViaSat high-throughput satellite was launched, it had a throughput on one satellite equivalent to that of every other conventional satellite over North America combined. So, we are talking about a capability orders of magnitude higher in moving data through to the recipient.

APOGEO *How is the development of HTS changing the economics of satellite communications?*

HARTSHORN Satellites are now a consumer play and the economies of scale enable much lower cost equipment with that much higher throughput capability. Today, several years on, there are more than one high throughput satellite providers in the United States and they have signed up close to two million paying consumer- and enterprise-class subscribers using that service. It is a mature service that has now proven itself. In the meantime, also, the same type of service has been rolled out in Africa, the Middle East, Asia-Pacific, Europe, South America, and elsewhere.

So, again, those economies of scale continue to mount. The GVF has begun to embed our personnel in disaster relief efforts and to work directly with the first responders to place these types of systems for support of on-the-ground operations. They love it! It works. It is much more cost-effective, it has high throughput, so we can move types of data that are very bandwidth-hungry, more deeply down range. This has all been happening in real time, with recent disaster relief efforts, and what we would now like to do is to engage with the EO community to explore and see how we can collaborate between our sectors to leverage these exciting new synergies.

APOGEO *What are some of the obstacles to implementing your vision?*

HARTSHORN There are many moving parts. Everything that I just said is a lot easier to say than it is to do. One of the big challenges that we have seen is simply getting doors opened that have been closed or further opened that are only cracked. That is between the centers, the stakeholders, variously, who have a role to play in disaster preparedness and response. For example, the military and humanitarian organizations are often among the first on the scene when a disaster occurs. However, traditionally, those two sectors haven't talked to each other. That prevented coordination that would enable elimination or, at least, reduction of redundancies, and it would optimize the response effort.

That has begun to change. These humanitarian organizations have, at some significant level, begun to set aside their reservations and to provide higher levels of awareness of what their priorities are, their strategic plans, how they operate, so that that can more fully inform the way that the military entities are engaging in the response efforts. Local responders (fire, police) and national emergency response agencies have begun to engage more fully than ever before with external first response entities, in an international context.

Also bear in mind that the emergency management sector itself is, in the long term, relatively new. It didn't even really exist as a discipline until a couple of decades ago. So, everybody is making this up as they go along

> "What we would now like to do is to engage with the EO community to explore and see how we can collaborate between our sectors to leverage these exciting new synergies."

and what's exciting is that we are seeing closer coordination, globally, at the regional level, and nationally, where all stakeholders are being brought into the room, in varying degrees, to leverage, to coordinate, to optimize, to reduce redundancy, and so forth.

APOGEO *What are some upcoming opportunities to significantly increase the collaboration between the VSAT and EO communities for disaster preparedness and response?*

HARTSHORN I've been in the satellite communications industry for more than 20 years and I will confess, fully, that over those 20 years I have thought of myself as a professional of the satellite communications industry. Full stop. I have seen the EO sector as being over a fence and this delineation becomes even more crystallized because you have industry associations that are focused on satcom and industry associations that are focused on EO. You have conferences focused on EO and conferences focused on satellite communications. [The difficulty of] getting dialog going and coordination across those fences has limited the types of discussions that occur in the disaster preparedness effort. We want to take those fences down and begin more full engagement and dialog. At GEOINT, the week of the 22nd of June in Washington, D.C., we are looking to have the first in a series of meetings to take that dialogue to the next level.

Disaster Risk Management

Focused Efforts of Four Organizations

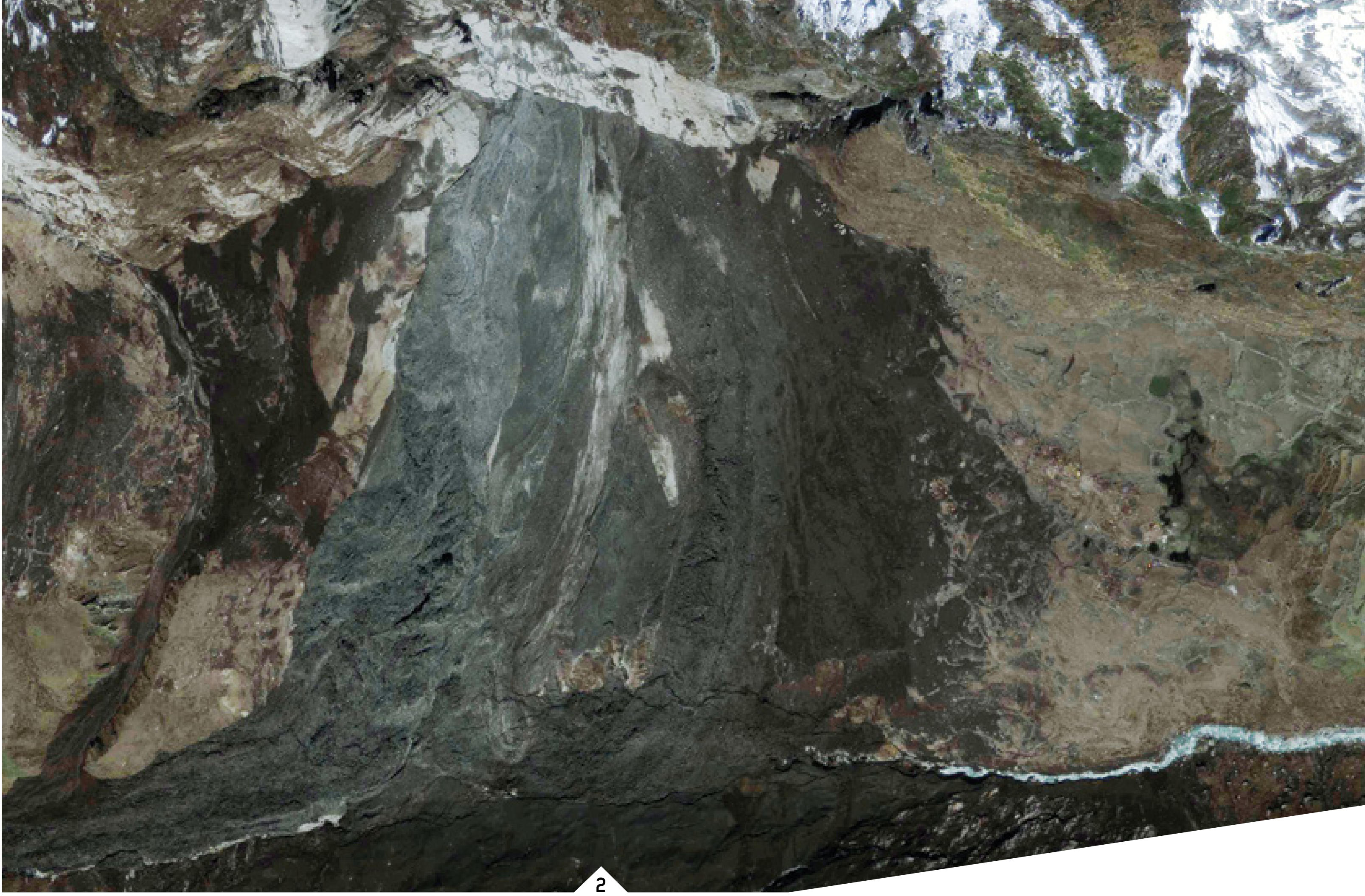
VICTORIA SAMSON / WASHINGTON OFFICE DIRECTOR / SECURE WORLD FOUNDATION / WASHINGTON, D.C. / WWW.SWFOUND.ORG

EARTH OBSERVATIONS AND GEOSPATIAL information are critical in providing data to first responders and policymakers after natural disasters have occurred. Satellite imagery, communications, and position, navigation, and timing capabilities are playing an increasingly important role in government and industry efforts to understand and potentially mitigate risks from weather and other extreme events. However, questions remain about how to use space assets as efficiently as possible in order to better inform the full cycle of disaster risk management (DRM).

Better communication is required about the needs and capabilities of users and providers. Can effort be taken prior to disasters in order to assess potential risks and hazards? What kind of response time exists currently when disasters occur and imagery is needed, and is there a way to expedite that? Are there new ways to utilize existing data in order to make more use of it? How can we improve the capacity of first responders? These and other questions were discussed at a lunchtime salon that the Secure World Foundation co-hosted with the Space Foundation at the latter's 31st National Space Symposium in April 2015.[1]

NASA EFFORTS FOR DISASTERS DESCRIBED BY DR. DAVID GREEN

The first speaker was Dr. David Green, program manager for disaster applications, in NASA's Washington, D.C., headquarters' Earth Science division. He started off by discussing the importance of enabling the DRM cycle from research to its application. He went over the need for good communication of needs, as well as strengthening capabilities of users for DRM data. Part of this requires a significant ability to assess hazards, risk, and vulnerability. In terms of international collaboration, Dr. Green spoke about various ways in which to do so, including capacity building, sharing data, and the United Nations' Disaster Charter. He ended by



examining possible roadblocks for this cooperation and how this cooperation could be implemented.

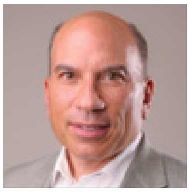
When looking at enabling DRM, NASA considers several methods for doing so: observation and monitoring, data analysis and management, mapping and modeling, assessment, recovery, and general capacity building. Some missions planned for observation and monitoring include Exploration Systems Development (ESD)-developed missions, with three launched in the 2014-2015 timeframe. NASA plans on 11 additional ESD Earth observation launches by 2022. See ***Figures 5-6***.

THE DISASTER CHARTER

The International Charter on Space and Major Disasters describes itself on its website as trying to provide "a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each agency member has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property."

While users can activate the charter in order to get access to satellite images, as of 2012, the Charter now allows "Universal Access" for emergency responders for countries that are not members of the Charter. According to the March 2015 newsletter of the Charter, in 2014, the Charter was activated for 41 disasters,[2] out of 443 activations total, from November 2000 to January 2015. There has been some concern about the Charter's ability to respond in a timely manner to requests for data; it can often take several days to get the data in a format that is usable for the first responders. See ***Figure 7***.

DIGITALGLOBE'S "SEEING A BETTER WORLD" PROGRAM DIRECTOR TANER KODANAZ



The second speaker was Mr. Taner Kodanaz, who is the director of DigitalGlobe's "Seeing a Better World" Program. He noted that DigitalGlobe identified the following four issues

◀ ▲ **FIGURES 1-2.** These images show a massive landslide in the Langtang area of Nepal, before (Figure 1, March 17, 2011) and after (Figure 2, May 3, 2015) the earthquake that occurred on April 25, 2015. A second quake hit on May 12. Langtang is a region with a national park in the Himalayas to the north of the Kathmandu Valley and bordering Tibet. Images courtesy of DigitalGlobe.

as ones which the world needs to deal with: food and nutrition security, infrastructure development, environmental sustainability, and human rights. Kodanaz stated that disasters require preparedness, response, and resiliency.

DigitalGlobe has a rich archive of images, as it has been collecting them since 1999 (and provides up to 30-cm resolution), which it can deliver in near real-time to end users. What they have found to be key in figuring out what steps are needed as

As of writing this piece, Nepal has just suffered a 7.8 magnitude earthquake on April 25, 2015; DigitalGlobe started a crowdsourcing campaign in order to catalogue the extent of the damage.[3] It made imagery of the area affected by the earthquake open to those involved in the recovery effort through its FirstLook program, and activated its Tomnod program, a crowdsourcing program which allows volunteers to tag damage visible in the satellite imagery in an effort to help first responders on the ground. See ***Figures 1-4, 8-9***.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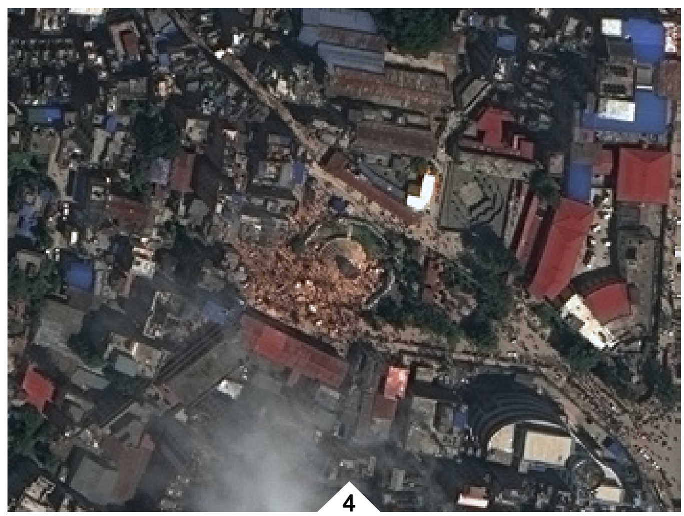
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▲ ▶ **FIGURES 3-4.** Dharahara Tower in Kathmandu, Nepal, on Oct. 25, 2014, before the earthquake, and after, on April 27, 2015. Images captured by WorldView-3, courtesy of DigitalGlobe.

part of disaster management is determining what the affected areas looked like prior to the disaster at hand; also helpful is expediency in getting imagery out to the affected areas.

Kodanaz noted that DigitalGlobe's FirstLook program can, in less than four hours, task and disseminate imagery for first responders. Partnering with organizations can help spread out information and data to those in need in a more rapid fashion. He did point out that a longer planning horizon is needed which could identify vulnerabilities and be proactive in dealing with them, rather than simply being reactive.

Food and nutritional security is crucial in these times; they work to better understand the agricultural impact of disasters so to minimize their effects and speed up recovery. Overall, he emphasized that when discussing disasters, it must be recognized that there are broad implications for fragile areas.

UN-SPIDER'S DR. SHIRISH RAVAN: FOCUS MOVES TO RISK REDUCTION

Next to speak was Dr. Shirish Ravan, head of the Beijing office of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), who discussed the challenges in using space-based information. He spoke about recent capacity-building programs which strove to connect the space community with local disaster managers. One lesson that they have learned is that disasters are not times to be learning how to use a specific capability: the end users should be comfortable with space technology tools during non-emergency times so that they can expand their use as needed (but not have to undergo a learning curve) during an emergency.

The international community is shifting its focus from emergency response to disaster risk reduction. Along those lines, the Third United Nations World Conference on Disaster Risk Reduction was recently held in Sendai, Japan, March 14-18, 2015. This conference created the Sendai Framework on Disaster Risk Reduction 2015-2030, which set out the following goal: "The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries."

To achieve that goal, it created seven global targets, including to reduce:

1. global disaster mortality,
2. the number of affected people,
3. direct disaster economic loss, and
4. damage to critical infrastructure and disruption of basic services;

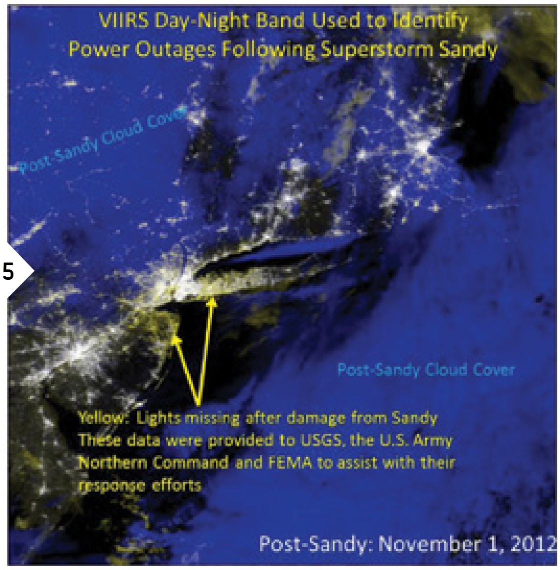
and to increase:

5. the number of countries with risk reduction strategies,
6. international cooperation, and
7. availability of and access to disaster risk information and assessments.

The four priorities given for the Sendai Framework were:

1. understanding disaster risk,
2. strengthening disaster risk governance,
3. investing in disaster risk reduction for resilience, and
4. improving recovery and rehabilitation.

Dr. Ravan also spoke about a few of the challenges for effectively using space-based data for disaster management. The first is that there is often a gap between the end users on the ground and the providers of the satellite imagery and space-based data. He also brought up the need to prepare for disasters in advance, to the best of



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◀ FIGURES 5. Power outages after Superstorm Sandy in New Jersey. Image courtesy of NASA.

▼ FIGURES 6. NASA missions, current and planned, courtesy of NASA.

▼ FIGURES 7. The International Charter on Space and Major Disasters includes these global partners.

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▼ **FIGURES 8-9.**
This area of Nepal shows a newly formed tent city following the earthquake. Before image is Oct. 25, 2014, and after is April 27, 2015. Images by WorldView-3, courtesy of DigitalGlobe.

▶ **FIGURE 10.**
WorldDEM graphic showing sea-level rise modeling for Marseille, a port city in southern France, with red showing 3m, orange showing 5m, and yellow showing 10m. Copyright and courtesy of DLR 2015 and Airbus DS Geo GmbH 2015.

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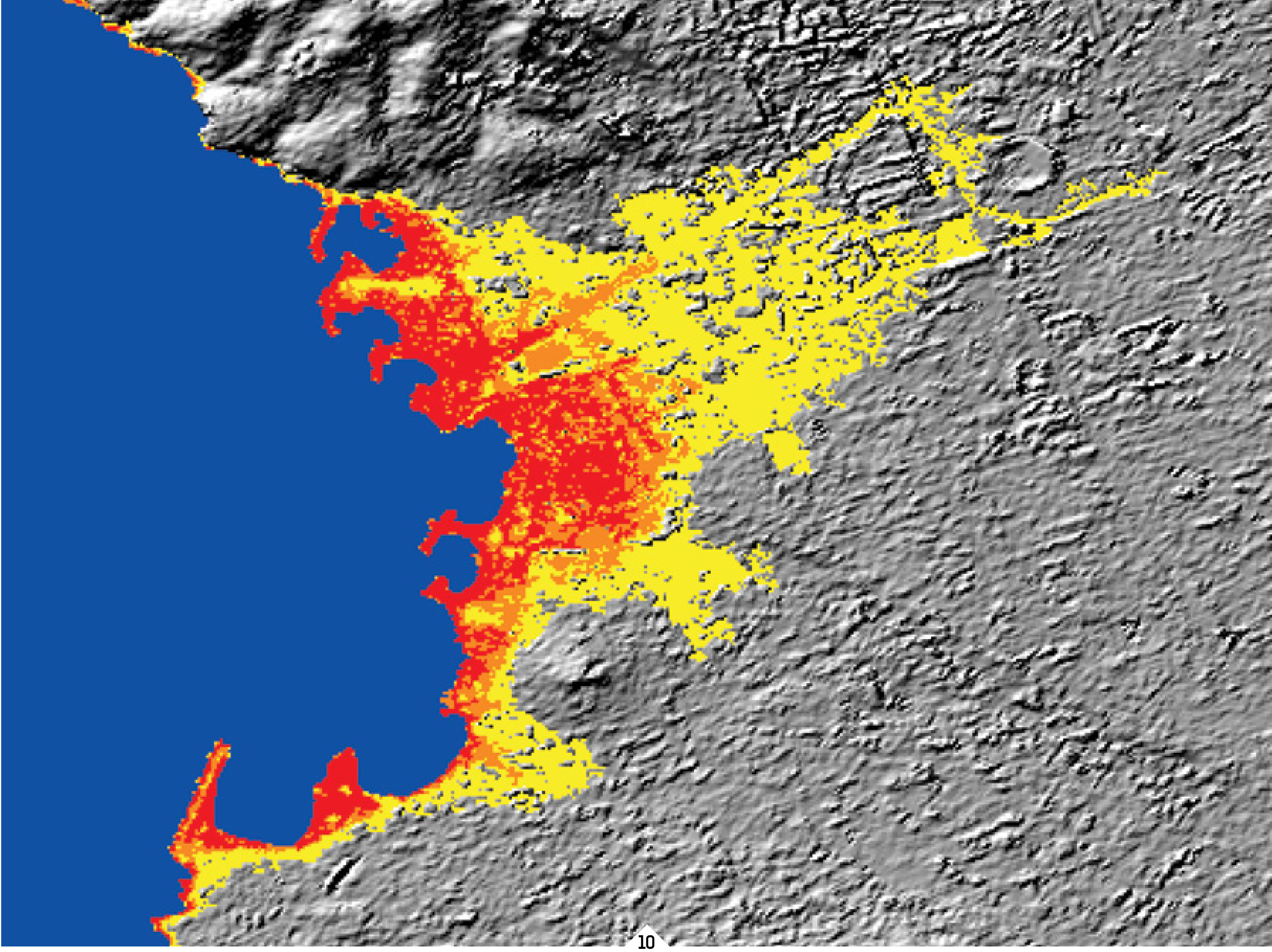
one's ability. In order to do that effectively, however, one needs good partnerships. This means ensuring access to data at normal times at an affordable cost, getting rapid assistance during an emergency with actual data, helping with the creation of regional/national policies on data-sharing, improving the capacity of end users to understand and utilize the data that they are being given, and doing sufficient outreach to the end users as well.

AIRBUS' JOERG HERRMANN SHARES OVERVIEW

Finally, the panel wrapped up with remarks from Mr. Joerg Herrmann, who is the head of EDRS SpaceDataHighway Business Development, Airbus Defense and Space. He spoke briefly about the interest the European Commission has in disaster topics, as it has recently placed the issue of emergency response on its agenda. He discussed the Copernicus program of the European Union, which is shored up by the Sentinel satellite constellation. He showed some imagery from Sentinel-1, a synthetic aperture radar satellite which was launched in 2014, and discussed the Sentinel-2 program, whose two satellites will be launched over the next year and are intended to primarily support agriculture, forestry, and general food security efforts. In addition, the WorldDEM product of Airbus is useful for predicting sea-level rise and for many other uses. See ***Figure 10***. Mr. Hermann pointed out that due to the importance of information latency for quick disaster response and mitigation, they have added a data relay capability so they can get the information more quickly to the end users. This is intended to provide near real-time transfer of data.

One question raised by the audience was the concept of responsibility: when a disaster happens, who is in charge and who pays for mitigating and responding to it? Mr. Kodanaz said that DigitalGlobe has signed a memorandum of understanding with the United Nations Office for Outer Space Affairs (UNOOSA) to create broad platforms that will allow Earth observations and geospatial analysis to be better used by the United Nations.[4] He also said that when a disaster occurs, DigitalGlobe receives requests from dozens of first responder organizations all asking for the same



thing, so they strive to consolidate needs in order to be more effective. He also noted that crowdsourcing has been a game-changer for many; for example, when Malaysia Airlines Flight 370 disappeared in March 2014, they had millions of people trying to find the plane. The best way to manage this, he posited, was to train people ahead of time so that they know what is available and what they need to do.

Space's role in human and environmental security is crucial, and in fact, geospatial data can be quite literally the difference between life and death during a time of disaster. But in order to best use the information, it helps to know what sort of capabilities are available and to be comfortable with their interface prior to the stressful time of a natural disaster. Also, it is incredibly important to make sure that the space-derived data is given to the first responders in as rapid a manner as possible; furthermore, the data has to be in a format that is usable.

The international community has taken many excellent first steps toward ensuring that data which is needed can be shared in a timely manner. As we increase the chances of international cooperation, we also increase the chance of a greater number of survivors from future natural disasters.

Endnotes:

1. To see presentations from the salon itself, please visit http://swfound.org/events/2015/from-response-to-resilience-space-and-disaster-risk-management/.
2. https://www.disasterscharter.org/documents/10180/122798/International_Charter_Newsletter_Issue_10.pdf
3. For more information, please see http://www.digitalglobeblog.com/2015/04/26/digitalglobe-opens-access-to-satellite-data-to-support-disaster-response-efforts-in-nepal.
4. http://investor.digitalglobe.com/phoenix.zhtml?c=70788&p=irol-news-Article_Print&ID=2020491

Studying Sea-Level Rise and Pollution

Geospatial Community Offers Big-Data Analysis

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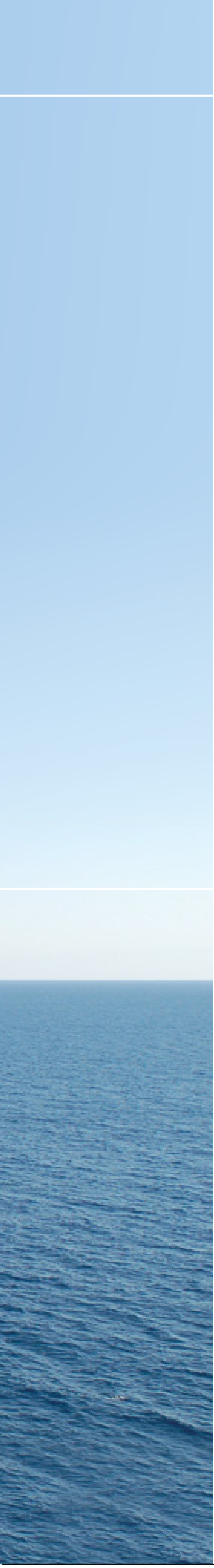
The maps, current ones and others projecting a decade, a quarter or half century and more ahead, are alarming, no matter what the cause of that alarm.



Louisiana loses 30 miles of wetlands to the Gulf of Mexico every year – a football field every 37 minutes. Eighty-one miles of roadway from Miami-Dada County to Palm Beach, Fla., would be under water if sea level goes up one foot, and it's forecast to rise as much as seven inches in the next 15 years, two feet by 2060, according to the Southeast Florida Regional Climate Change Compact.

The Navy is spending $460 million to replace or upgrade 14 piers already degraded by rising tides in Hampton Roads, Va., according to the World Resources Institute. Dennis Bushnell, chief scientist at NASA's Langley Research Center, forecasts sea-level rise that will make "the waterfront hotels in Virginia Beach hazards to maritime navigation."

A 2014 report by Responding to Climate Change in New York, being used by the New York State Department of Environmental Conservation, predicts a sea-level rise of as little as 15 inches at the low end of the spectrum, but as much as six feet at the high end by the end of the century. Six feet is the approximate amount of water driven by a Category 2 hurricane. When it moved ashore in nearby New Jersey, Hurricane Sandy was a Category 2 storm.

That's just sea-level rise.

The World Health Organization says seven million people a year worldwide die because of the effects of air and water pollution, the cause of climate change and sea-level rise, according to the preponderance of scientists who have studied the issue.

More and more data come in about the effects – if not always the causes – of sea-level rise and air pollution, and it's becoming clear that studying those effects to trace them back to their causes is something the Geospatial Community is well equipped to do. The community plays in the big-data analysis ballpark, using tools developed for the military in its migration from single-source intelligence to multimodal data gathering and analysis, and enhanced by industry that is finding new ways to use geospatial information to drive its bottom line.

STUDYING ENVIRONMENT IS EASIER, HARDER

It's more than just let's-chart-sea-level-rise-and-see-what-we-can-deduce-from-that, though that is certainly part of the answer. It's about applying what the military has done in combining layers of data from signals intelligence, even social media, on the ground; to levels of sensors carried by Unmanned Aerial Systems; to satellite imagery, all amalgamated to offer a picture called situational awareness in near real-time to soldiers on the ground whose lives depend on it.

In some ways, studying pollution and sea-level rise is easier because the time pressure isn't as acute. But in other ways it's harder, because miscalculations can cost us the Earth.

In the military, data is more concentrated, because wars tend to be fought in regions. Even World Wars are a mixture of regional conflicts. But studying sea-level rise and pollution effects on the environment shouldn't be limited to regions, though it's being done that way in many places. Impacts of pollution in China in its rise in Gross Domestic Product from $1 trillion to $10 trillion (U.S. dollars) in 17 years can be felt by its neighbors and in the United States. Ice melt at both poles impacts sea levels thousands of miles away. The issue is global, and requires worldwide attention and massive big-data analytical capability.

So, then, big data gets bigger, and the analysis becomes more complex, taxing tools and technology that the geospatial community has become adept at developing in a solutions-driven continuum.

The volume of data can be staggering. DigitalGlobe's WorldView-3 satellite, launched in August, can collect images on 680,000 square kilometers of the Earth every day and sends 1.2 gigabytes of data back to the planet every second.

Lidar and 3D imaging measure vanishing ice sheets to determine how they will feed the sea. Weather forecasts are ongoing and constantly changing worldwide. NASA's "A-Train" constellation of six satellites carrying 15 sensors has been sending back data for more than eight years. The sensors overseen by the National Oceanic and Atmospheric Administration (NOAA) are in a constant state of flux, and the data they send out is too overwhelming to be analyzed in one place by one organization, so much so that universities, commerce and other entities are welcomed to use it for analysis.

That's just U.S.-based sensors, their numbers being spurred at least in part by the publicity and political pressure that comes in the aftermath of devastating storms such as Hurricanes Sandy and Katrina.

Much of the rest of the world is coming on board.

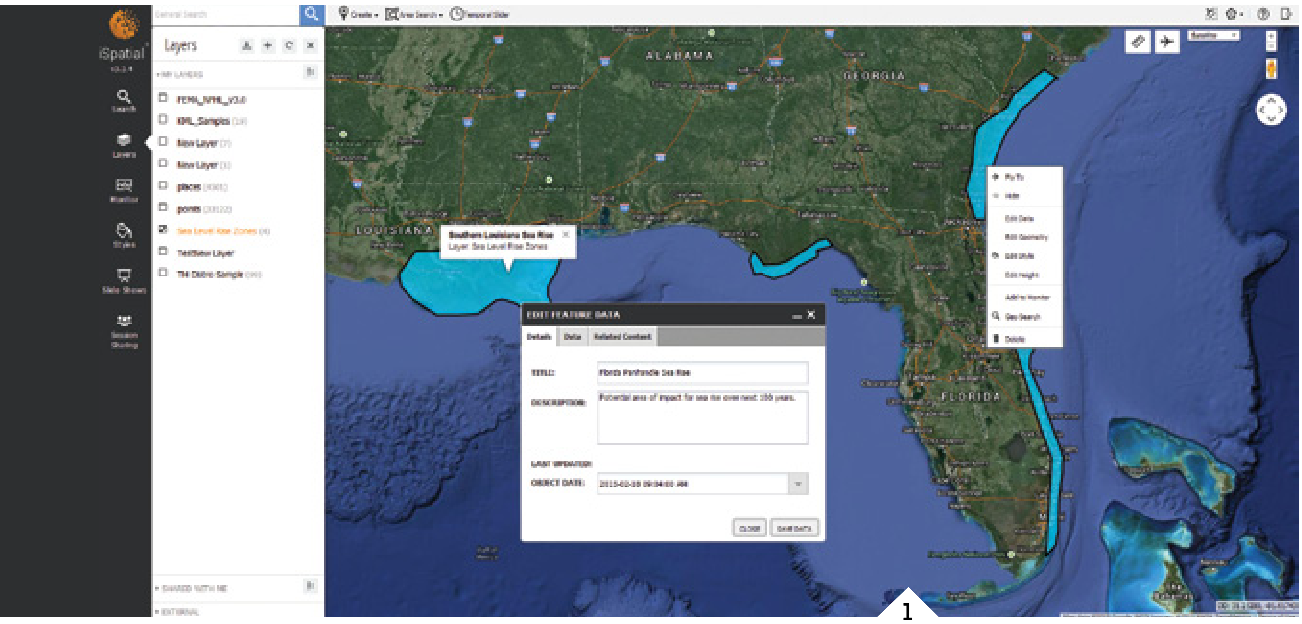


FIGURE 1. This screen shot shows possible sea-level rise in the southern U.S., with affected areas in the Florida panhandle and Louisiana. This is a mock-up of zones around areas where there could be encroachment of the ocean over time, from iSpatial, a product of Thermopylae.

WORKING IN THE DARK

But that world is a big place, and at times it seems scientists are feeling around in the dark about climate change, much as in the parable of three blind men in a room, each touching a different part of an elephant and trying to come to a consensus about the animal's identity.

In the case of sea-level rise and pollution, about climate change, you can get 100 scientists together and each can offer different answers to various parts of the issue because of their varying fields of study. It's a scenario often seized upon by skeptics, and by politicians who control the wherewithal necessary to conduct a comprehensive, definitive study of the issue – not just of its effects, but also the causes.

It's time for a more concentrated effort, with big-data analytics harvesting input from an army of sensors – an effort much like that used to map the human genome to determine causes of genetic-based illnesses and diseases and allow us to grow closer to eradicating many of them.

SOBERING STATISTICS

David Lary is analyzing big data at the University of Texas-Dallas with his THRIVE (Timely Health indicators using Remote sensing and Innovation for the Vitality of the Environment) program that charts sources and predicts effects of air pollution. Using the World Health Organization figures of seven million deaths a year because of pollution, and other figures showing that 25 million Americans have asthma problems that are exacerbated by air quality, Lary has enlisted help of the Veterans Administration as well as various hospitals and other sources of the medical community to chart pollution trends, trace their sources and use big-data analytics to predict areas of diminished air quality.

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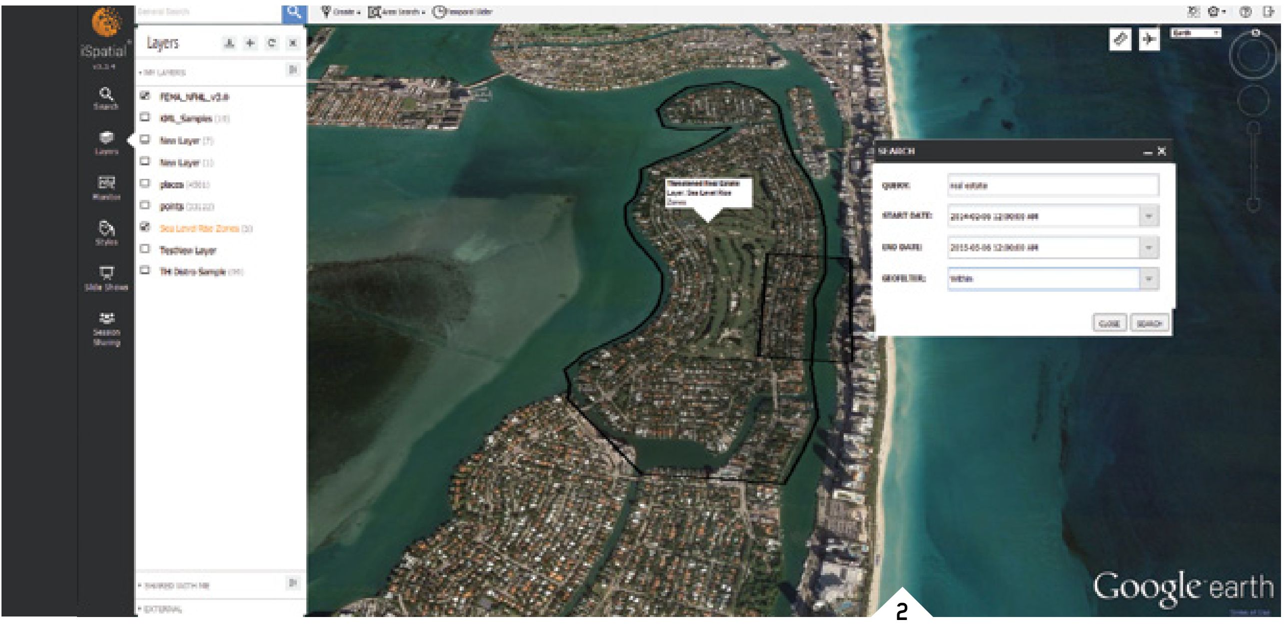

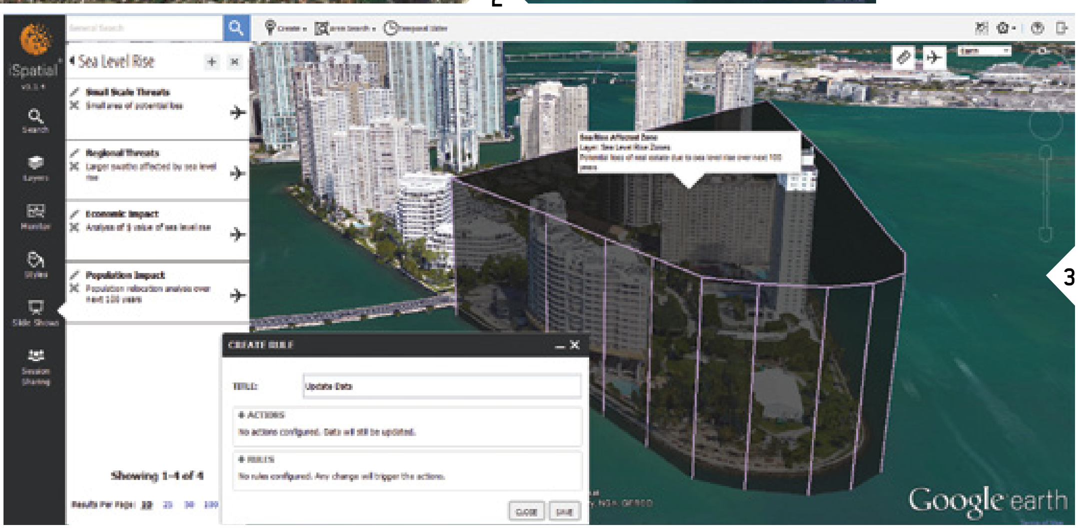

◄▼ FIGURES 2-3. Sea-level rise predictions for Miami, Florida, as shown in iSpatial.

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"For asthmatics, the difference between an ordinary day and a very bad day can be a trip to the emergency room," he said in a 2014 presentation at US Ignite. With that in mind, he is trying to use data to help hospitals know when to increase emergency room staffing to deal with anticipated pollution-caused asthmatic attacks, to alleviate suffering and quite possibly save lives.

The study can be extended, Lary added, to include fire and drought applications.

The military can be impacted in both, because of its involvement in disaster relief and the extent to which drought can drive population migration, a potential match to ignite armed conflict. About 40 percent of the Earth's population lives within 60 miles of the planet's coastlines, according to the United Nations. With rising seas driving people inland, and with drought-stricken land awaiting them, the path to conflict is littered with landmines.

So, too, is commerce potentially impacted. Without remedy, land losses to sea-level rise and erosion would include the "boot" of South Louisiana by the end of the century, according to interactive, layered maps generated for The Lens and ProPublica. That land includes half of the United States' petroleum refineries. See ***Figure 1***.

LEVERAGING HELP FROM INDUSTRY

The need for computing capability to drive geospatial big-data analysis can be fed by a concept called the "Industrial Internet" by General Electric. The Industrial Internet refers to integration of a vast network of sensors and software and the tools to

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make them work together to find solutions.

That capability also can be fed by the Internet of Things, in which an array of sensors is created as parts of the devices they drive, from appliances to service-related products. Lary sees asthematics becoming individual sensors to monitor the causes of outbreaks. The military operates on a mantra, "every soldier a sensor."

Smartphones are getting smarter and more prolific. There are two billion in use worldwide now and their number is forecast to be six billion by the end of the decade. Apple sells more iPhones every day worldwide (378,000) than there are babies born (371,000). Those smartphones carry a GPS chip and can be sensors to help monitor environmental change.

So data comes from more sources and in more directions. It is growing faster than the combined means to exploit it.

Geospatial is a huge part of the solution. So, too, is the Internet and Social Media. New and emerging techniques become tools to assist in developing and solving the problem.

On the horizon, you're going to see industry – utilities, electrical, oil and gas, transportation, rail, maritime – pushing the highwater mark of the Internet of Things and the Industrial Internet. As they do that, they are going to have to increase their investment around solutions dealing with big-data analytics to get value from all of that data. Efforts such as solving the issues surrounding climate change are going to be beneficiaries of that investment in new technology, because the questions are similar.

WE'RE IN THIS TOGETHER

The global economy has global problems. So does the global environment, and the two are meshed in ways that are becoming inseparable as new treaties are forged to handle international commercial competition. Environmental concerns have become part of these agreement negotiations, which means that verification means also are going to have to become a part. Those means will have, at their root, the kind of big-data analytics that have become the technological foundation of the geospatial community.

What can make it all work is an understanding that the problems are scientific, before they are political, and scientific problems don't have to be like people in a dark room trying to identify an elephant by touch. You can turn on the lights with scientific problems, and big-data analysis spawned by the geospatial community can be the switch.

It can bridge the maps of the present with those of the future, helping determine why the present is the way it is, and how society can make that future better.