Our commitment is unwavering. Day in and day out, our 800+ dedicated and talented employees go to extraordinary lengths to provide the best IT services possible, so our customers are free to concentrate on their mission. We are the largest IT/IS provider for one of the nation's leading intelligence agencies, and one of the top 20 IT contractors for DoD. Yet we're agile enough to meet your rapidly evolving needs. NJVC provides a full lifecycle of secure, innovative IT/IS solutions for some of the world's most demanding customers. With a passion for doing things faster, better and smarter–and the technical expertise to deliver–NJVC is driven by your mission.

NJVC
Driven by Your Mission

www.njvc.com

Imaging NOTES

EARTH REMOTE SENSING
FOR SECURITY
ENERGY AND
THE ENVIRONMENT

Spring 2009
Vol. 24 No. 2

Imaging NOTES
LAUNCHES
LBx
JOURNAL

Sub-Meter Sats from Spot Image

DEMOCRATIC CONVENTION SECURITY

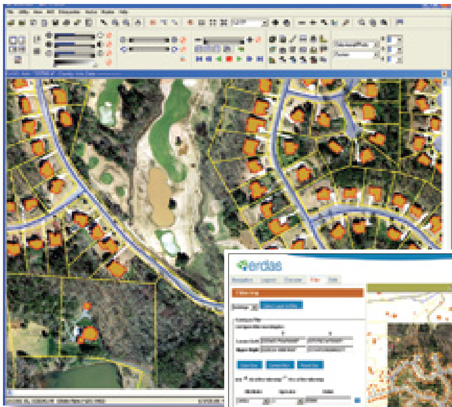
MONITORING TREATIES

CLIMATE SENSORS

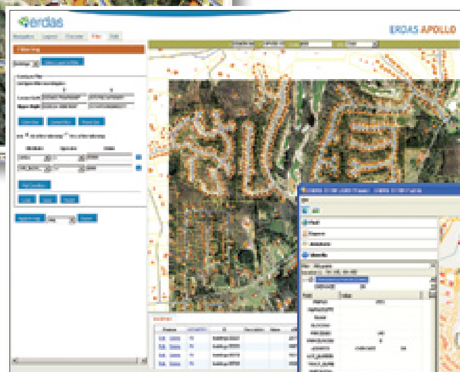
Go ahead...

Take all the credit.

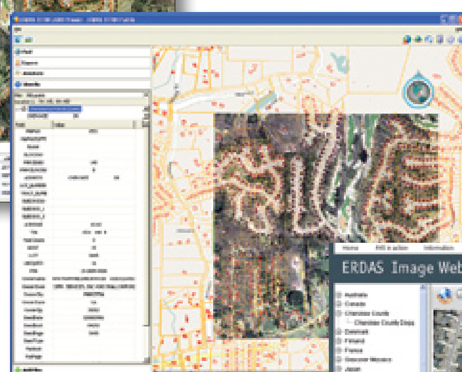
(We won't tell anyone.)



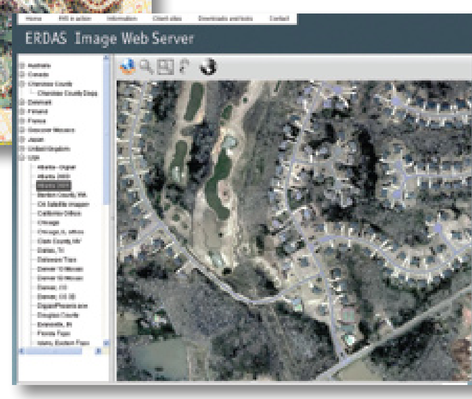
Author your data



Manage your data



Connect with other users



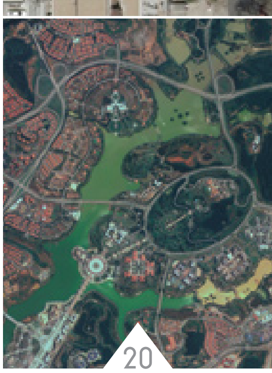
Deliver your information

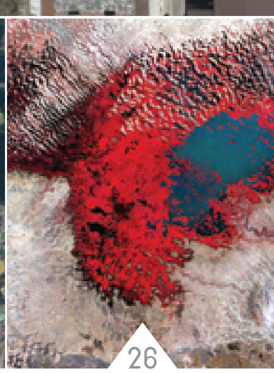
Transform all of your data into information with ERDAS' interoperable portfolio of solutions. With industry leading products, including ERDAS IMAGINE®, LPS, ERDAS APOLLO, ERDAS TITAN and ERDAS Image Web Server, we do all the "heavy lifting" for you and let you take all the credit! Whether you need to author, manage, connect or deliver your geospatial information, ERDAS can easily handle your geospatial workflows, including:

- Image Analysis & Exploitation
- Photogrammetric Data Production
- Interoperable, Standards-based Enterprise Data Management
- Desktop Data Sharing and 3D Visualization
- Image and Vector Data Delivery

erdas
The Earth to Business Company

Find out more by visiting **www.erdas.com** or contacting us directly at **info@erdas.com** or **1 877 GO ERDAS.**





Spring 2009

CONTENTS

>COLUMNS

>FEATURES

Kuwait City

COVER IMAGE

Kuwait City is shown here, on Sept. 17, 2005. Kuwait City is the capital and largest city in Kuwait. It is in the heart of the Middle East, with Iraq to the northwest, Saudi Arabia to the south, and Qatar, Bahrain and the UAE to the southeast along the coast of the Persian Gulf.

The image was taken by Taiwan's FORMOSAT-2 (F2), which has 2-meter panchromatic and 8-meter multispectral imaging capabilities. The satellite was designed for daily coverage over Taiwan, which allows for daily coverage in orbit over both coasts of the U.S. and other important areas of the globe, including the Middle East. F2 has a 9:30 a.m. equatorial crossing, enabling it to capture morning imagery before the clouds gather in some tropical zones.

The image is also featured on page 20, with the article about Spot Image's current capabilities and plans for the future. Spot Image Corp. has exclusive distribution rights in North America to imagery from FORMOSAT-2, which was launched in 2004.

Imaging NOTES

Spring 2009 / Vol. 24 / No. 2

OUR MISSION

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

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

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

PUBLISHER/MANAGING EDITOR
Myrna James Yoo
myrna@imagingnotes.com

EDITOR
Ray A. Williamson, PhD
ray@imagingnotes.com

COPY EDITOR
Bette Milleson

ADVERTISING DIRECTOR
Colleen Gormley

CREATIVE DIRECTOR
Jürgen Mantzke
Enfineitz LLC
jurgen@enfineitz.com
www.enfineitz.com

EDITORIAL CONTRIBUTIONS

Imaging Notes welcomes contributions for feature articles. We publish articles on the remote sensing industry, including applications, technology, and business. Please see Contributor's Guidelines on www.imagingnotes.com, and email proposals to editor@imagingnotes.com.

SUBSCRIPTIONS

To subscribe or renew, please go to www.imagingnotes.com, and click on 'subscribe.' If you are a current subscriber, renew by locating your account number on your address label to enter the database and update your subscription. If you cannot go online, you may write to the address below.

Imaging Notes (ISSN 0896-7091) Copyright © 2009
Blueline Publishing LLC
P.O. Box 11569, Denver, CO 80211
303-477-5272

Maximize the Value of Your Imagery

Quickly get imagery to people who need it with the ArcGIS® Server Image extension.

"When we tested ArcGIS Server Image extension, we found designers, technicians, and digitizers were all very pleased with the processing time. It was twice as fast, in some cases even faster, than previous systems."

Cindi Salas
GIS Manager
CenterPoint Energy

The ArcGIS® Server Image extension helps organizations manage large catalogs of rasters and imagery to make imagery available to more people in less time. Dynamic mosaicking and on-the-fly image processing allow users to quickly serve multiple imagery products from one set of source imagery, reducing data redundancy and storage requirements.

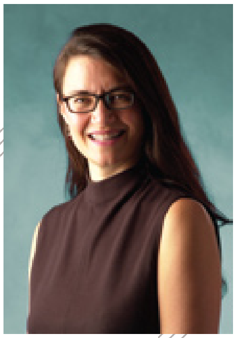
For more information, visit **www.esri.com/image**
or call 1-888-373-1353.

For ESRI locations worldwide, visit
www.esri.com/distributors.

Treaty Monitoring, Climate Sensors, and State/Local Government Emergency Planning

Dear Remote Sensing Professional,

We are thrilled to have a new partnership, announced in our Winter issue, with the Secure World Foundation, which promotes the development of cooperative and effective use of space systems for the protection of Earth's environment and for human security. *Imaging Notes* will continue its coverage of relevant issues, and our searchable archive of articles is now free online.



In our new Secure World Foundation Forum, Editor Ray Williamson points out that accurate debris positional data is much needed commercially, demonstrated by the February collision of the commercially owned Iridium-33 satellite with the defunct Russian Cosmos 2251.

LBx Journal will be the only independent media resource bridging the geospatial solutions companies and the emerging business end user. Join us in July at www.lbxjournal.com.

This issue of *Imaging Notes* also includes articles about the use of satellites for monitoring environmental treaties, an update on climate sensors, the Spot Image constellation of satellites (including Pleiades plans), and security for the National Democratic Convention in Denver.

Monitoring international climate treaties is not simple. Using earth observation data has become more popular in the last ten years or so, as the number of treaties has increased and the contracting parties seek easier ways to monitor compliance and effectiveness of treaties.

For example, on page 28, a NASA Aura satellite image shows the size of the ozone hole at its peak in September 2007, the month when it usually peaks each year. The size of the hole was about average for recent Septembers, but it is increasing over time.

The article on climate sensors on page 33 also shows information about ozone monitoring, with a chart on page 37 showing upcoming gaps in the U.S. Ozone Monitoring Program. There exist many excellent climate sensors, and yet there are still so many challenges with continuity and standards.

Spot Image has ambitious plans for new satellites to launch, including Pleiades-1 in 2010, the company's first of two sub-meter imaging satellites. SPOT-6 and -7 are planned for 2012 and 2013. Funding for these satellites is private, which will be an industry first, as no other satellite of this scope has launched without public funds.

Spot Image Corp. has distribution rights in North America for S. Korea's KOMPSAT-2 and Taiwan's FORMOSAT-2, the latter of which provided the image for this issue's cover of Kuwait City.

Emergency planning for the Democratic National Convention in August 2008 required the coordination and partnership of state, local, regional, utility and federal governments, including the USGS and NGA. This story, with 3D and LiDAR images, begins on page 14.

Our Next-Gen Mapping column, always focusing the discussion on making imagery more commercially viable, discusses the price of a pixel—from major motion picture pixels to gigapixel technology.

Finally, *Imaging Notes* is proud to announce that we have launched a spin-off publication (really a spin-off of the Next-Gen Mapping Column!), *LBx Journal*, which is a multi-media resource for geospatial companies that are expanding their customer base to the emerging business market, and for enterprises that are exploring the untapped business potential of location intelligence. Location-based "x" (*LBx*) is the recognition that most business processes are connected to location, whether they have to do with supply chain, transportation, distribution, or other aspects of business. You fill in the "x" with your business need.

The print edition launched in May at Where 2.0, an O'Reilly Conference on "all things digital mapping" with quite a cult following. Our rich interactive website will launch in July.

LBx Journal will be the only independent media resource bridging the geospatial solutions companies and the emerging business end user. Join us in July at www.lbxjournal.com.

Very Best Regards,
Myrna James Yoo
publisher@imagingnotes.com

Space Debris Positional Data Needed Commercially

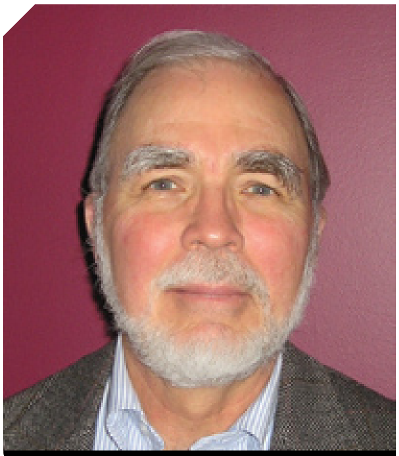
SECURE WORLD FOUNDATION FORUM

In the past, imaging satellite operators have generally not needed to worry much about the risk their satellites might face from collisions with other satellites or with orbital debris. More recently, however, they have begun to take notice of environmental conditions in Earth orbit. One immediate reason for increased interest in orbital safety is the February 10, 2009, collision of the Iridium-33 satellite with the defunct Russian Cosmos 2251 satellite. That collision created more than 800 pieces of debris 10 cm in length or above, in two clouds. Over time, these two clouds will slowly expand outward, threatening other working satellites that move in nearby orbits.

Because the destroyed Iridium satellite flew in a near polar orbit, debris from this collision now poses an additional hazard to some remote sensing satellites. The Canadian RADARSATS 1 and 2 have been cited as threatened by this debris.[1] Other Earth observing satellites are likely to be affected in the future.

Normal space operations unavoidably add debris to the space environment. In addition, fragmentations of spent rocket bodies in orbit and occasional explosions of old satellites add to the threat. Finally, anti-satellite tests by the Soviet Union and the United States in the 1970-80s and by China in January 2007 resulted in thousands of pieces of space debris. U.S. Air Force officials estimate that some 18,000 pieces of debris greater than 10 cm now circle Earth.

Collisions with debris are not the only concern, however. As more and more countries launch Earth imaging satellites into orbit, the sun-synchronous orbits that are valued for Earth observations will become ever more crowded, adding another concern to the safety question. As noted in an earlier column (Spring 2008), in July 2007, the orbit of NASA's Cloudsat satellite was shifted slightly to avoid the possibility of colliding with Iran's Singha remote sensing satellite.



RAY A. WILLIAMSON, PHD, is editor of *Imaging Notes* and Executive Director of the Secure World Foundation, an organization devoted to the promotion of cooperative approaches to space security (http://www.SecureWorldFoundation.org).

NASA was able to accomplish this task because NASA debris experts have access to the classified database of satellite orbital positions maintained by the U.S. Air Force. However, commercial and non-U.S. satellite operators do not have access to such high quality data and can use only the much lower quality data provided by the Air Force on an openly available website: Space-track.org. These data, while important for crude assessments of conditions in Earth orbit, are derived from the accurate data set through a set of algorithms and are not of sufficient quality to allow so-called conjunction assessments, calculations of the chances of collision with other objects in orbit.

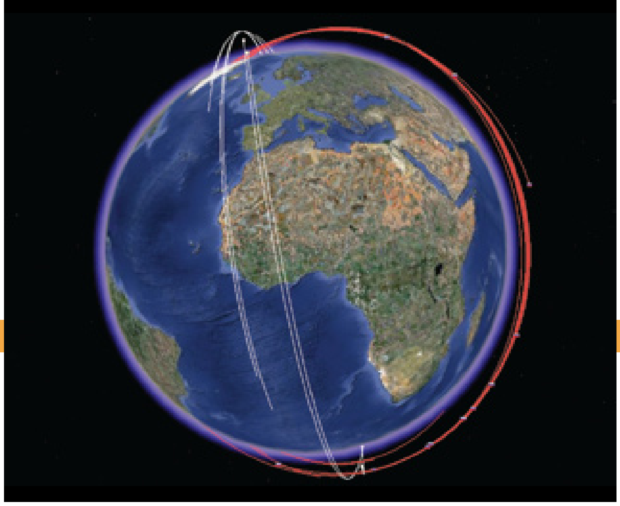
In fact, it turns out that Iridium, Inc., which operates a fleet of 66 satellites in low-Earth orbit, was not in the habit of calculating conjunction assessments because they do not have access to the high quality data that would make accurate assessments possible. Further, the Air Force, which routinely carries out conjunction assessments of its satellites and of NASA scientific satellites, does not have the resources to perform these calculations for all of the U.S. commercial satellites. The Air Force does, if requested, perform them for commercial communications satellite companies that operate in geosynchronous orbit when the companies need to maneuver or adjust the orbit of a satellite. However, the process, which is conducted under the so-called Commercial and Foreign Entities (CFE) program of the Air Force, is cumbersome and insufficient for handling all of the communications satellites, let alone all of the 900 or so satellites in Earth orbit.

Although until now, apprehension over debris and orbital crowding has primarily concerned the commercial communications satellite companies, the Iridium collision has made other satellite operators take notice. Without accurate positional data and the analytical tools to perform conjunction assessments, both companies and non-U.S. operators are at a strong disadvantage in avoiding the threat that debris and orbital crowding pose.

Other countries collect positional data on their own satellites and perform conjunction assessments on them. However, they have relatively limited tracking capabilities and have nowhere near the tracking capacity of the U.S. Air Force, which operates both radar facilities and optical telescopes to carry out the task.

As I have argued before in this column, space systems, especially GPS and Earth observing systems, provide essential services that support human security, especially in disaster mitigation and response, and in food, water and environmental security. As the world community depends more and more on these systems, it will

Commercial and non-U.S. satellite operators do not have access to such high quality data and can use only the much lower quality data provided by the Air Force on an openly available website: Space-track.org. These data, while important for crude assessments of conditions in Earth orbit, are derived from the accurate data set through a set of algorithms and are not of sufficient quality to allow so-called conjunction assessments, calculations of the chances of collision with other objects in orbit.



▲ **FIGURE 1**
On Feb. 10, 2009, an accidental collision occurred over 400 miles above Siberia between the privately owned communications satellite, Iridium-33, and an old, unused Russian satellite (Cosmos-2251). Celestrak provided tracking data for the debris, which was patched through to Google Earth by Robert Simpson using his Satellite KML code. The crash destroyed both satellites. The Iridium constellation of 66 satellites provides voice and data connections for satellite phones as well as other services. It has around 300,000 clients across the globe, including the U.S. Department of Defense and scientists at the South Pole. Image courtesy of Robert Simpson, www.orbitingfrog.com.

have to do much more to prevent future loss of Earth observing satellites from satellite-satellite or debris-satellite collision.

What can we do about the threat that debris poses to space operations? Unfortunately, at altitudes above 400 km, debris may stay in orbit for many years. At much higher altitudes, it will be there for centuries. Hence, the most effective ways to mitigate the threat that debris poses are to:

1. **limit the amount of debris released into orbit from normal space operations;**
2. **keep close track of all debris so it can be avoided;**
3. **begin to remove large debris, such as spent rocket bodies and defunct satellites, from Earth orbit; and**
4. **prevent the creation of new debris fields from anti-satellite weapons tests.**

Of these, countries are already taking steps to reduce sharply the generation of new debris and are beginning to consider a treaty to limit debris-causing anti-satellite missions. Although space agencies are now beginning to consider seriously methods to remove large debris from orbit, test missions are several years away. Hence, for the near term, close tracking of working satellites and the debris they may encounter is the most feasible mechanism to reduce the chances of accidental collisions.

This March, Secure World Foundation partnered with the Eisenhower Center for Space and Defense, the Center for Defense Information, and the Marshall Institute at Intelsat Headquarters in Washington, D.C., to explore options for improving space situational awareness (SSA) in Earth orbit. Representatives from the U.S. Air Force, the National Security Space Office, the European Space Agency, the commercial telecommunication satellite industry and others shared ideas and plans for reaching an international consensus on an SSA construct. Although no shared conclusions were reached at the conference, participants generally agreed that the time has come for broader sharing of accurate satellite and debris positional data and for mechanisms to pursue conjunction assessments for all working satellites.

These developments are very promising. Yet, as several papers at an April European space debris conference in Darmstadt, Germany, warned, unless the space community begins to remove larger pieces of debris from orbit within the next few years, we may face conditions where debris will continue to build and make certain orbits unusable. The problem here is that no one yet knows how to accomplish this removal economically and in ways that do not just exacerbate debris production. Hence, in addition to instituting and strengthening all of the other debris-reducing mechanisms, the space faring states need to turn up their research on cost-effective methods to remove orbital debris, especially in sun-synchronous polar orbits, which face the greatest risk from destructive collisions.

FOOTNOTE

1. *Megan Haynes, "Duo of Canadian Sats in Debris Danger,"* Satnews Daily, *March 23, 2009.*

The Price of a Pixel

NEXT-GEN MAPPING

If a picture is worth a thousand words, what is the value of a pixel? Pixels are sold in many forms: photographs, movies, video games. The entertainment industry has made monetizing pixels an art form. As pixels are all digital media, comparing the film and entertainment business to the I/RS business may be worthwhile.

The costs of production of a single feature film and of high-resolution imagery average approximately $1 million a day. However, Hollywood is a $25 billion industry and video gaming is another $25 billion, whereas the commercial earth observation and land imaging business, including value-added services, is estimated at $3 billion. Is entertainment really more "valuable" than knowledge of the planet that can improve and save lives?

To answer that question, consider another: What is the value of a pixel that has latitude, longitude, elevation, and various spectra associated with it? Clearly, the price one would pay for such pixels depends on the value of the image in addressing a business, governmental, NGO, or environmental need. As a backdrop, the value is free through Google Earth; to recover from a natural disaster, the value may be thousands of dollars (assuming that first responders use Google Earth and Maps and other virtually free tools); to build a new pipeline or commercial development project, hundreds of thousands of dollars; to find a new customer, millions of dollars; to address climate change, pandemics, natural resource scarcity and war mitigation, the image is priceless!

In a world where imagery is widely and freely available, it is rapidly turning into a commodity with a plunging price point. There is value in data quality–the accuracy, reliability, and timeliness of the image. But there is exponential value in tying imagery to specific business and operational goals. The customer need determines the value of any product or service. The context of the interest in imagery brings along with it a budget, and a need to use location intelligence.

How are these budgets developed?

How is the value of the pixel established?

Will the value of the intelligence associated with the pixel cause increased perceived value and therefore budgets?

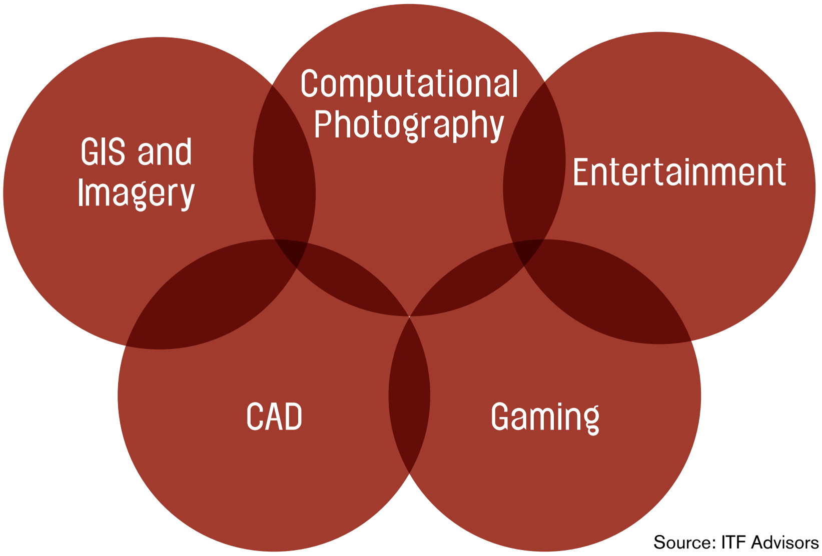
How does intelligence associated with a pixel drive up the value and therefore price of the image?

We have compared imagery to digital media (the entertainment use of pixels), whose moguls spend a lot of time thinking about associating value to their pixels–for example Disney, Sony, and Warner Brothers, all motivated by profit. This value chain takes an expensive set of pixels. For example, *Pirates of the Caribbean – Edge of the World* cost $300 million (and it is at risk of illegal copying and downloads, like all digital media and imagery). It creates "associated value" through the games, marketing, campaigns, on-line advertising pull through, books, theme parks, and various other value-creating connections. Disney has

▼FIGURE 1

This graphic illustrates the convergence of pixels taking place by spatial, entertainment and computer graphics industries.

THE PIXEL CONVERGENCE



Source: ITF Advisors

CRAIG BACHMANN & NATASHA LÉGER are partners in ITF Advisors, LLC, an independent consulting firm with a focus on next-generation strategy and on translating the increasingly complex new media business environment's impact on business models, markets and users.

▲ **FIGURE 2**
This is an xRez Studio diagram taken from the Diving Board of Half Dome, Yosemite Valley, illustrating the relative amount of image detail contained with past and emerging gigapixel formats.

just turned this third series of *Pirates of the Caribbean* into a $2.7 billion franchise.

The video entertainment industry also builds "value" by marketing the pixels as "high definition," and soon will market "3D." Obviously, these pixels are more valuable than simply the eye shadow on Johnny Depp—they create an experience that consumers are clearly willing to pay for, including all of the associated hardware upgrades required.

Why is one feature film's franchise the size of an entire imaging industry, when both rely ostensibly on the same result... delivering a picture? Perhaps the answer lies somewhere in the experience the customer seeks and the ability of the producer of the pixels to see across the entire value chain of that original image.

While it may not seem fair to compare entertainment pixels with spatial pixels, these two worlds are converging, for example, through computational photography, which involves computational imaging techniques that enhance or extend the capabilities of digital photography. Gigapixel technology as an example of computational photography appears to be at the intersection of satellite imagery, GIS, CAD, and entertainment when visualization is critical to meeting an organization's objective. See ***Figure 1***.

A gigapixel image is a digital image composed of one billion pixels, more than 150 times the information captured by a 6-megapixel digital camera. The technology for creating such high-resolution images involves stitching together thousands of high-resolution images, and placing an incredible amount of detail into the mosaic constructed. Eric Hanson, CEO of xRez Studio, a leader in gigapixel technology services, said, "Gigapixel imagery takes photography into a new paradigm that allows for the deep exploration of an image in an unprecedented way." See ***Figure 2***.

Visual effects professionals are not in the business of scientific accuracy when integrating such imagery as satellite images and digital elevation models. But the technology allows for a user experience that meets very specific business objectives, such as feature film backdrops and video gaming.

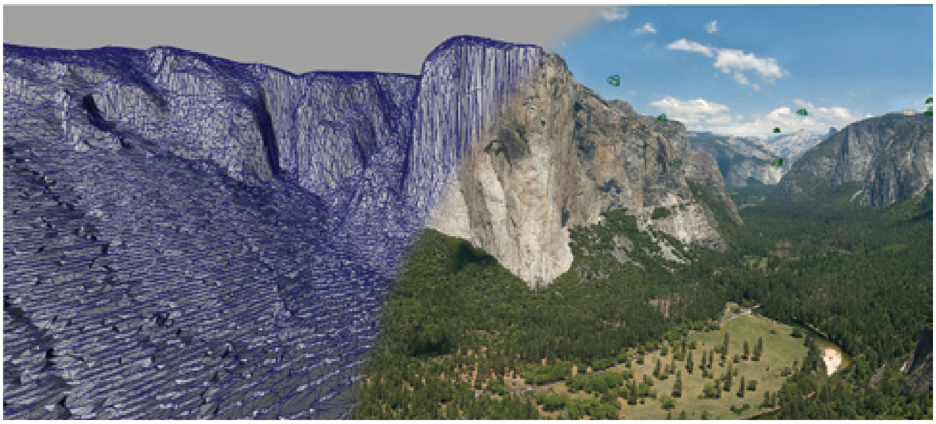
Looking towards more social and public safety goals, xRez Studio did a landmark gigapixel project for Yosemite National Park. According to Hanson, this was one of the largest terrestrial photography project in the world, which mapped 45 gigapixels of photography onto a 1-m DEM for an orthographic elevation view of the park, which was commissioned to help geologists study rockfall. "Yosemite Valley is inherently unstable geologically, and research is ongoing to know the mechanics of geologic faulting and release mechanics. The project has created an unprecedented datum of high resolution images of vertical cliff faces in the park," said Hanson. See ***Figure 3***.

The highest concentration of high-end computer graphics technology and professionals is probably found in the visual effects and feature film industry, and it seems that 99.9% of those computer graphics professionals don't see how to apply the technology beyond the entertainment field. If digital media are so powerful, why haven't they been applied in other areas? xRez Studios is exploring this gap and sees other applications in natural sciences, cultural heritage, and conservation efforts.

As much as there may be a big oversight in the visual effects industry on the applications of its technology beyond entertainment, there has been similar oversight in the I/RS industry on how to create greater value for its pixels beyond traditional users. Hanson said, "There's some value in creating the images, but when you take the images toward a goal, towards a solution... that's what gives it real value from a technical, social, and artistic perspective."

▼FIGURE 3

This is an xRex Studio 3D digital terrain model of El Capitan, Yosemite Valley, aligned to the perspective of a gigapixel image, which demonstrates the merging of the DEM with the gigapixel photographs.



Today, the I/RS industry relies on intermediaries (software providers, consultants, and value-added resellers) to "add the value" to meet traditional users' needs. Increasingly though, organizations are using the Internet to evaluate spatial imaging without intermediaries. The real question for I/RS providers looking to move beyond the government as the primary customer (cost plus model) to businesses as customers (value-based models) is how to create a commercial market for spatial pixels.

Digital media are about "connecting the dots" to form a value for which the customer will pay more than commodity prices. Ron Elsis, Principal of Geospatial Product Management Solutions, says "a satellite or aerial image alone does not provide a whole product for the majority of users in the commercial market. It is a piece, the organizing principle, of the overall puzzle necessary to provide a commercial customer with an answer to the problem they are trying to solve. The difference between Hollywood and I/RS is that Hollywood acts as the integrator, while the spatial pixel business is a project-based industry that focuses more on providing the component parts of an overall solution."

How does the value chain in I/RS evolve to build a pixel franchise based on knowledge of the planet instead of the appeal of entertainment?

We believe that there will be an ever increasing need for the I/RS industry to innovate and create a better understanding of the "the price of a pixel." This innovation will require:

a. **Understanding the customers and what drives their perspective of value;**
b. **Developing awareness of imagery substitution options;**
c. **Partnering with third parties to create solutions to address market needs;**
d. **Getting involved in the education and budget process of the customer.**

Emergency Planning for the Democratic National Convention

THE DRAPP DEMONSTRATES PARTNERSHIP AMONG LOCAL, REGIONAL, STATE, UTILITY AND FEDERAL GOVERNMENTS

MATTHEW KRUSEMARK, GISP
Geospatial Team Manager
Denver Regional Council of Governments
Denver, Colo.
www.drcog.org/drapp

MARK EATON
USGS Geospatial Liaison for Colorado
NSDI Partnership Office
Denver, Colo.
http://www.cr.usgs.gov/nsdi/Colorado

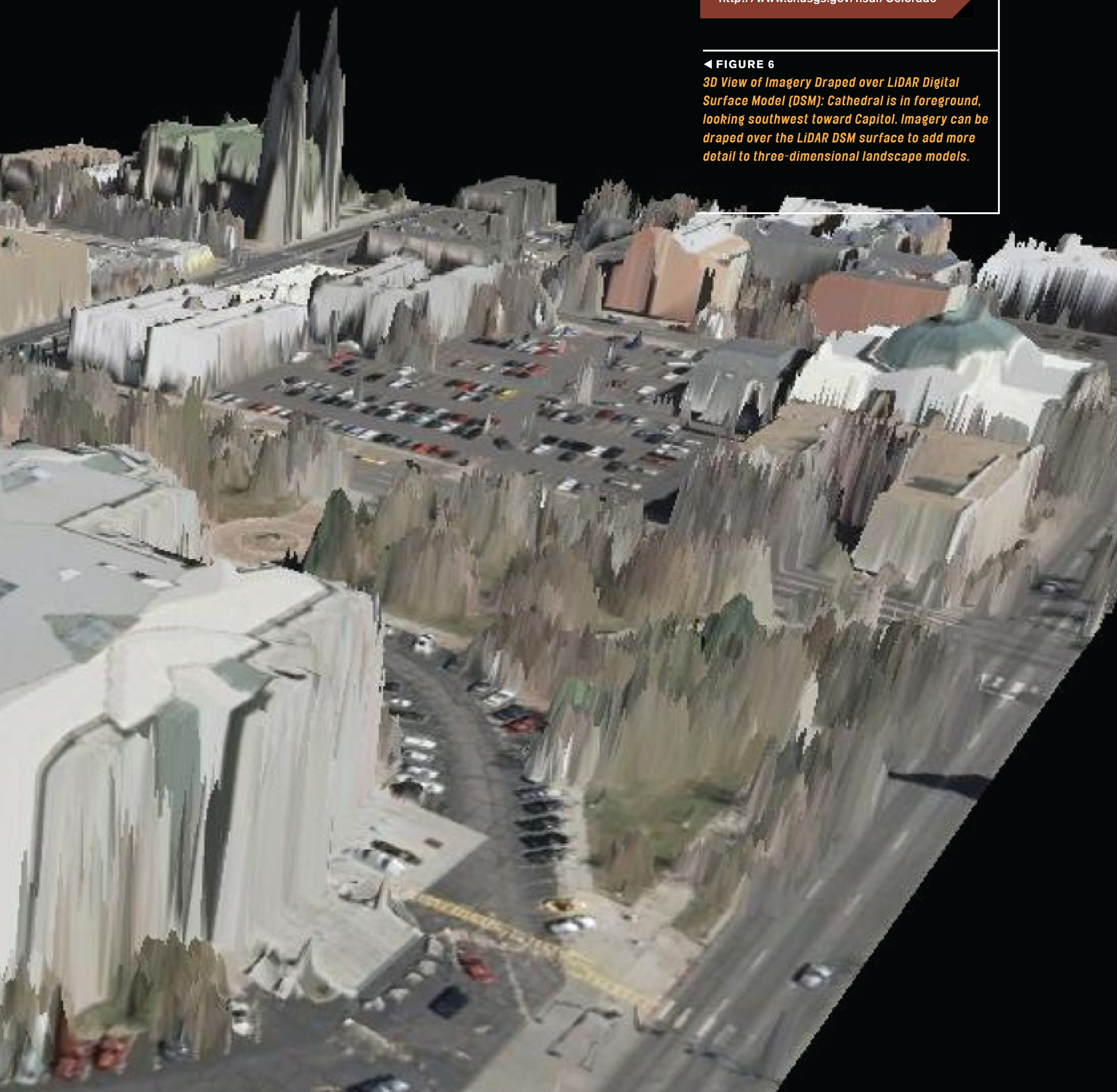


FIGURE 6
3D View of Imagery Draped over LiDAR Digital Surface Model (DSM): Cathedral is in foreground, looking southwest toward Capitol. Imagery can be draped over the LiDAR DSM surface to add more detail to three-dimensional landscape models.

When the federal government needed to acquire high-resolution imagery to support emergency preparedness and planning for the 2008 Democratic National Convention (DNC) in Denver, Colorado, it turned to the Denver Regional Council of Governments (DRCOG) for help. DRCOG has led the Denver Regional Aerial Photography Project (DRAPP), a consortium with 50-plus stakeholders, since 2002. As the Metropolitan Planning Organization for the Denver region, DRCOG brings 56 local governments, including towns, cities and counties together to address regional land use and transportation planning issues.

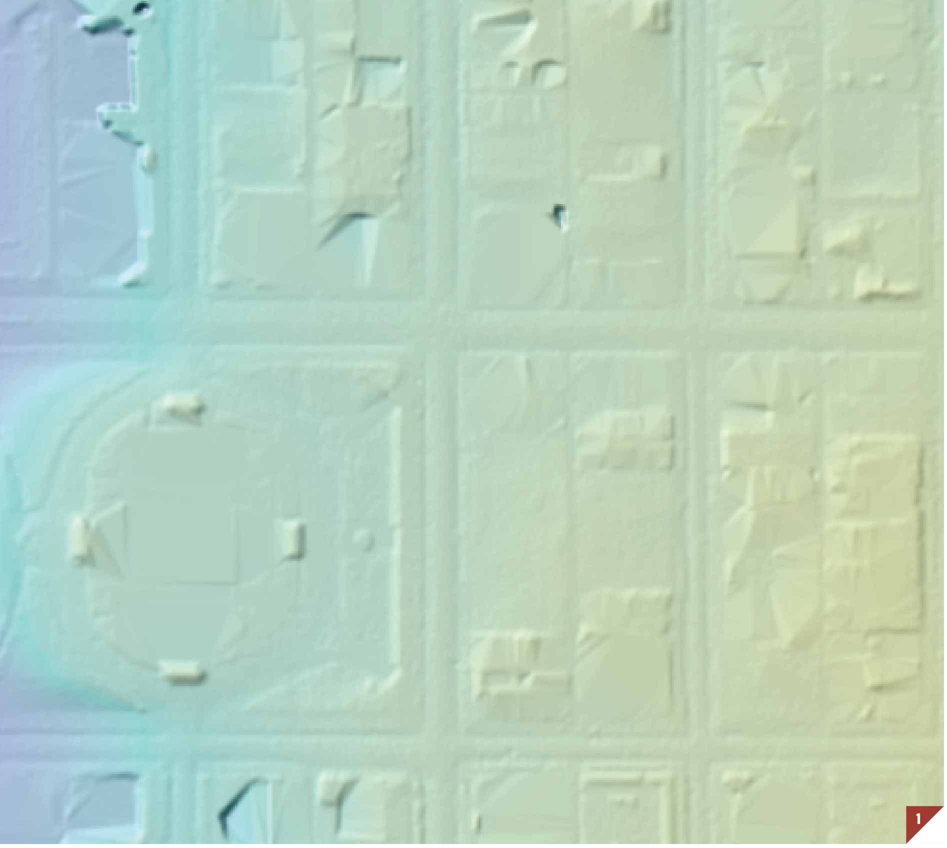
Previous DRAPP efforts in 2002, 2004 and 2006 involved DRCOG's member governments, partner agencies, the State of Colorado and the United States Geological Survey (USGS). Each project produced one-foot resolution natural color digital orthophotography that met the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I Specifications. DRCOG delivered the imagery on multiple hard drives shared among consortium members, in GeoTiff and Mr. Sid compressed format and in multiple mapping projections. The project area of interest generally ranged between 6,000 and 8,000 square miles.

National security issues associated with the 2008 DNC created new challenges for DRAPP participants working in the public safety arena and required coordination with federal government partners including the USGS and others. The USGS has been a key DRAPP consortium member since 2002 and has used the imagery for The National Map Program. This program acquires up-to-date imagery on a two-year cycle for the 133 Cities Urban Area Project over key metropolitan areas of the United States, which is critical for the U.S. Department of Homeland Security and other agencies for emergency response and preparedness.

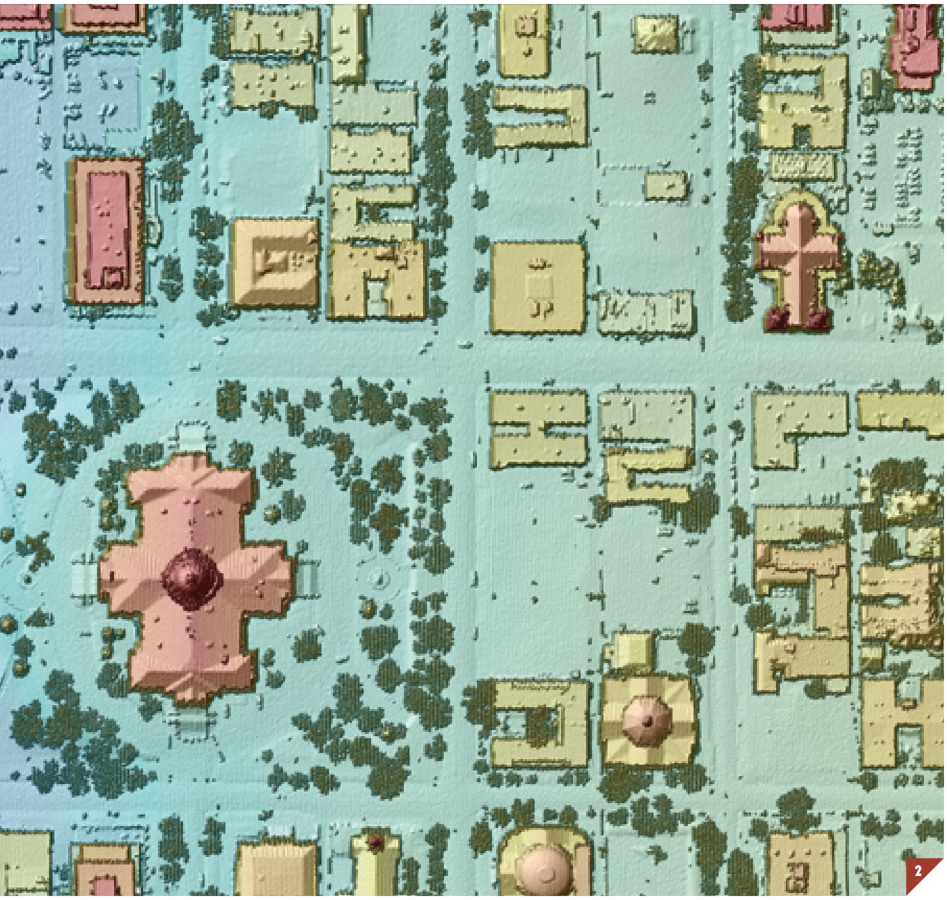
In addition to the USGS, the National Geospatial-Intelligence Agency (NGA) required high-resolution LiDAR (Light Detection and Ranging) along with the aerial imagery to support threat mitigation issues associated with the DNC. The USGS Geospatial Liaison for Colorado, Mark Eaton, worked in collaboration with NGA geospatial analysts, with DRCOG's Geospatial Team Manager, Matthew Krusemark, and with DRCOG's Customer Resource Support Division Director, Simon Montagu, to come up with the necessary business and technical requirements to meet regional, local and state government needs and to prepare for the 2008 DNC.

The USGS Colorado National Spatial Data Infrastructure (NSDI) Partnership office used this opportunity to collaborate with local partners, especially for acquisition of LiDAR data, which, unlike aerial imagery with DRAPP, did not have a multi-year consortium built around the effort. With NGA paying for the bulk of the cost, the Denver regional GIS community was able to acquire very accurate surface and elevation information for their diverse GIS needs. Many local municipalities are utilizing the LiDAR data to update their base maps and their FEMA Digital Flood Insurance Rate Maps, among other uses.

Additional requirements that made the 2008 DRAPP project unique included higher-resolution six-inch, natural color orthophotography and a 60-day turn-around after initial aerial photo acquisition of an interim photo product. In the past, to meet an ASPRS Class I Specification, DRAPP had not delivered imagery until roughly ten months after initial acquisition. To prepare for the DNC, however, local and federal agencies needed imagery 60 days after acquisition. Due to the time constraints, the DRAPP Consortium decided to acquire 'interim' imagery at an ASPRS Class II Specification. This approach secured the imagery well in advance of the DNC event and provided the state, local law enforcement, private utility and federal emergency management agencies plenty of time to incor-



◀ **FIGURE 1**
Bare-earth LiDAR Digital Terrain Model (DTM): LiDAR DTM data is derived from the unfiltered digital surface model (DSM) LiDAR via a proprietary process that removes buildings, vegetation cover, and other objects. These high-resolution LiDAR DTM datasets are analogous to USGS digital elevation models (DEMs), which reflect bare-earth topography at a lower spatial resolution.



▼ **FIGURE 2**
All-Returns LiDAR Digital Surface Model (DSM): LiDAR DSM data has been processed from truly "raw" LiDAR returns, but reflects the earth's surface as the sensor first sees it, and thus contains buildings, trees, and other objects. Note that this LiDAR is of high enough resolution to capture vehicles (rectangular objects on the streets and in parking lots). DSM elevation data is useful for obtaining building and tree heights, and can be used in conjunction with imagery to make realistic 3D models of the landscape.

porate the data into their public safety and emergency preparedness systems.

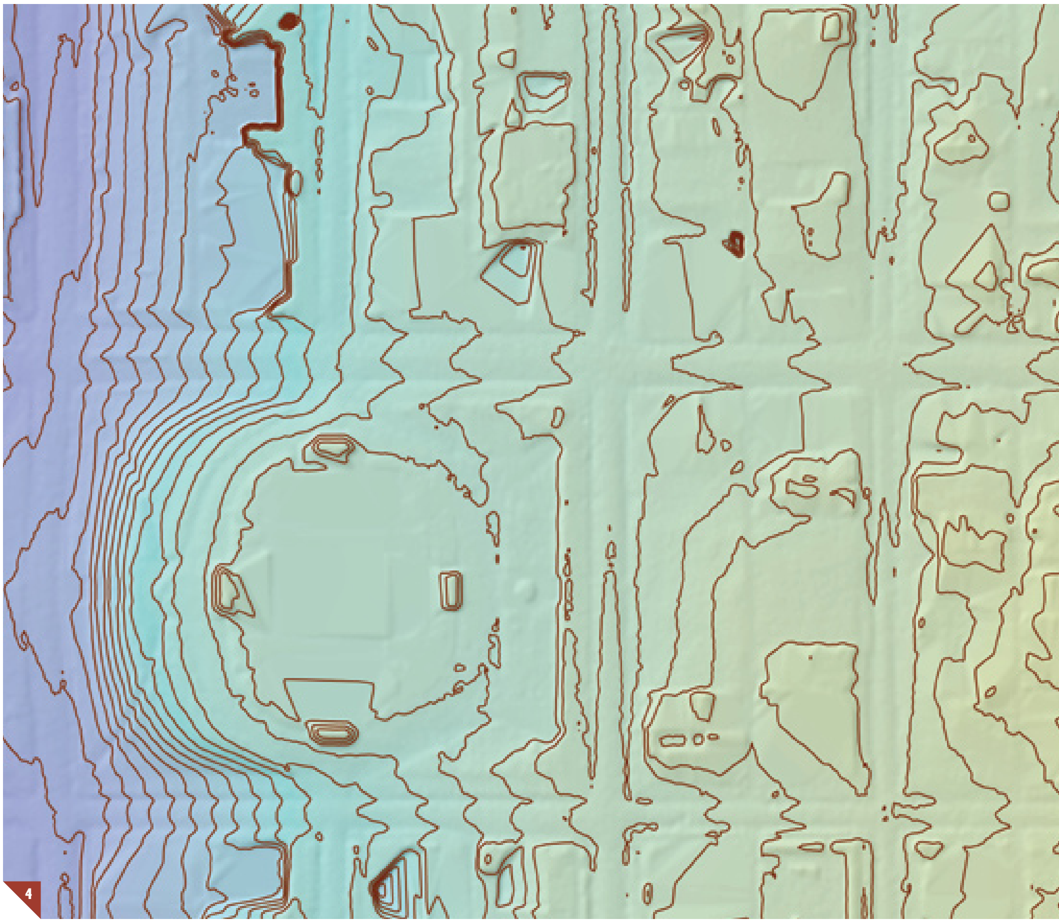
Development of the acquisition requirements for both the orthophotography and the LiDAR projects allowed DRCOG and USGS to work closely together to make sure all the business and technical requirements would be included, so that participants could take advantage of collaborative opportunities and avoid redundancy. Although the LiDAR and imagery acquisition efforts were performed separately, the control that was used to orthorectifiy the imagery was also used to assure the quality of the LiDAR data. Also, the LiDAR data was provided to the DRAPP vendor, with the potential of enhancing the orthorectification surface model. See ***Figures 1-6***. Both projects benefited from this collaborative effort.

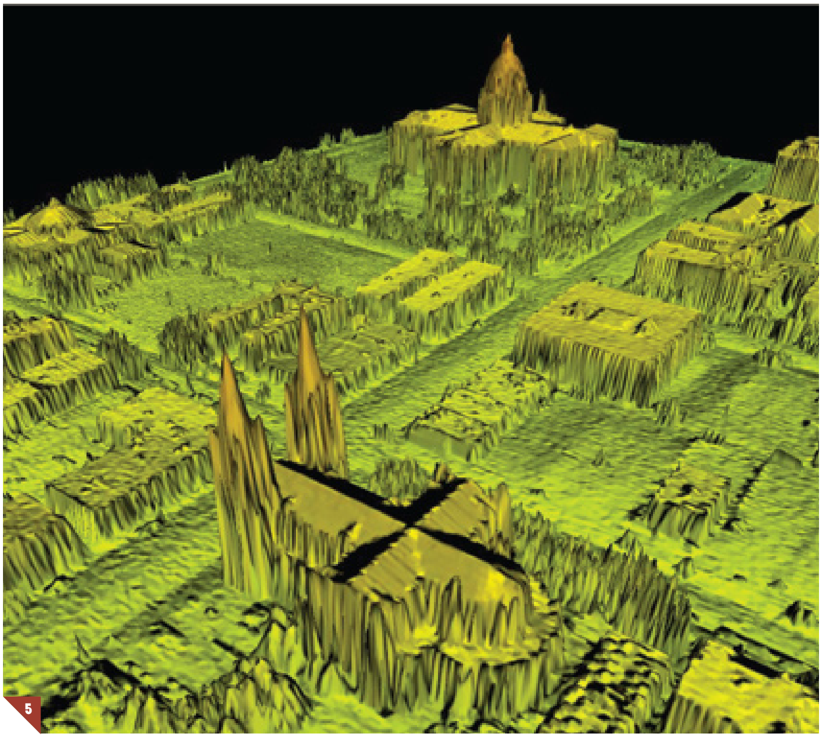
In addition to delivering data on hard drives, DRCOG also served up the 2008 DRAPP imagery to consortium members via an Open Geospatial Consortium-compliant Web Mapping Service (WMS). The WMS was secure, with a username and password required to access the interim imagery. Consortium members could thereby access

imagery immediately using a variety of desktop and server GIS software solutions that would support the consumption of a WMS.

These combined datasets have shown a high level of correlation and accuracy, thus providing two valuable datasets at a very affordable cost to the various stakeholders. The combined cost share between the two projects (USGS National Map Program and the NGA LiDAR data collection) totaled approximately $1.6 million. The acquisition, processing, quality assurance and project management work was performed by five different vendors and managed by DRCOG and the USGS.

The five vendors that performed this work include Bohannan Huston, Inc. (Albuquerque, N.M.) and their subcontractor Surdex Corporation (Chesterfield, Mo.) who were contracted to provide digital mapping services and geospatial products in support of the 2008 DRAPP. Technical project management was provided by an ASPRS Certified Photogrammetrist (CP) from Jacobs Engineering (Denver, Colo. office) and final orthophotography product and survey control quality assurance/quality control (QA/QC) was performed by the project's data acceptance testing (DAT) vendor, IntraSearch, Inc. (Greenwood Village, Colo.). LiDAR acquisition and mapping services for the USGS and NGA and local partners for the DNC





◀ **FIGURE 3**
Natural Color Georegistered Imagery: This high-resolution aerial imagery (6-inch pixels) was collected within a few weeks of the LiDAR acquisition, and shows a great level of detail for urban planning and other applications. Although this imagery has not yet been ortho-rectified (removing "building lean" so that all objects appear as if the observer was directly above), it is geo-registered to allow accurate co-positioning with other geospatial data.

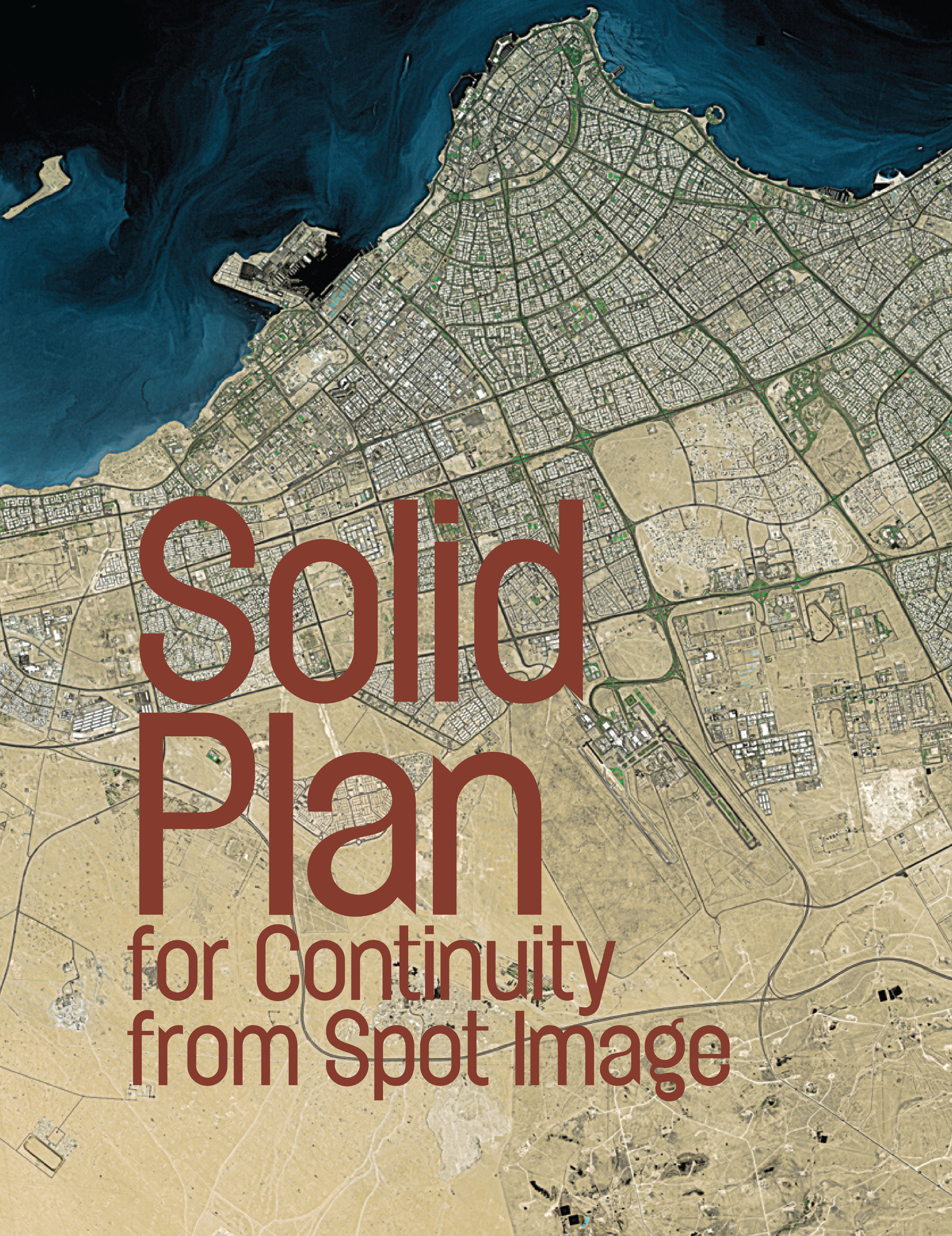
▶ **FIGURE 4**
2-Foot Contours Derived from Bare-earth LiDAR Digital Terrain Model (DTM): These contours were made from the LiDAR DTM and show the utility of the high-resolution LiDAR for urban planning, floodplain mapping, and other applications.

▶ **FIGURE 5**
3D View of LiDAR Digital Surface Model (DSM): Capitol building is in the foreground, looking northeast. The LiDAR DSM surface can be used to visualize the landscape in various software packages that support 3D modeling.

efforts were performed by Sanborn, Inc. (Colorado Springs, Colo.).

The combined efforts of both of these projects included over 50 partners all achieving the benefits through collaborative GIS partnerships. The 2008 DRAPP effort and the DNC data acquisition continue to strengthen the relationships and collaborative partnerships among local, state, regional, utility and federal agencies in the Denver metropolitan region.

Solid Plan for Continuity from Spot Image



FIRST SUB-METER SATELLITE FOR SPOT IMAGE: PLEIADES-1

The SPOT remote sensing satellite program is poised to add an important new chapter to its 23-year story of successful commercial operations. In 2010, the Spot Image Group will launch the first of two sub-meter imaging satellites, known as Pleiades, marking the program's first foray into the very high-resolution Earth observation market and adding new capabilities to an already robust constellation of existing satellites.

"The demand for high-quality imagery with spatial resolution in the 50-cm range for urban, defense, insurance and mapping applications is nearly limitless," said Antoine de Chassy, President and CEO of Spot Image Corp. (Chantilly, Va.). "We will serve this market with the same combination of advanced imaging technologies and innovative product delivery mechanisms that is the hallmark of the SPOT program."

De Chassy is quick to add that the Spot Image Group has no intention of abandoning the enormous mid- to high-resolution satellite imagery market that it created with the launch of SPOT-1 in 1986. Early in 2008, the Spot Image Group started the SPOT-5 follow-on program, with SPOT-6 and -7, ensuring continuity of the SPOT line of satellites well into the next decade. See ***Figure 1*** on page 22 of the SPOT constellation. The funding for these two satellites will be private; the final financial package is expected to be finalized soon. This will be an industry first, as no other Earth observation satellite of this scope has been financed by the operator and private funds.

The Spot Image Group, led by Spot Image SA of Toulouse, France, currently operates three commercial satellites, SPOT-2, -4 and -5. Plans call for SPOT-6 and -7 to be launched in 2012 and 2013, respectively. Joining the SPOT constellation next year will be Pleiades-1 followed by Pleiades-2, in 2011. In addition, the group maintains distribution rights to imagery from the Taiwanese FORMOSAT-2 satellite and the South Korean KOMPSAT-2 satellite.

"Our growing constellation of satellites, complemented by distribution arrangements with other system operators, provides an impressive selection of spatial detail, spectral information and revisit capability to meet the needs of end-user applications in every segment of the commercial geospatial industry," said de Chassy.

Planning the Pleiades Constellation

Development of the Pleiades satellites began in 2001 with funding from the governments of France and other European nations. The first Pleiades, which is scheduled for delivery to the launch pad in French Guyana later this year, and its twin will offer several new capabilities designed to complement, and to distinguish themselves from, the SPOT satellites. The most notable differences will be the resolving power of the imaging

KEVIN P. CORBLEY
President
Corbley Communications
Winchester, Va.
www.corbleycommunications.com

EDITOR'S NOTE
This article is one in a series of the high-resolution commercial satellite companies.

◀ **FIGURE 5**
High-resolution imagery and daily revisit capabilities make FORMOSAT-2 an ideal solution for change detection applications. This image of Kuwait City, taken on Sept. 17, 2005, is an example of the high quality 2-m imagery FORMOSAT-2 provides.

sensors and addition of a blue band for natural color imaging. See ***Figure 2***.

"We entered the 1-m market with KOMPSAT-2 last year," says Nicolas Stussi, Director of Services and Business Development at Spot Image Corp. "We will make another major leap forward next year with the launch of our first Pleiades satellite, when we will be able to offer 50-cm color products on a worldwide scale."

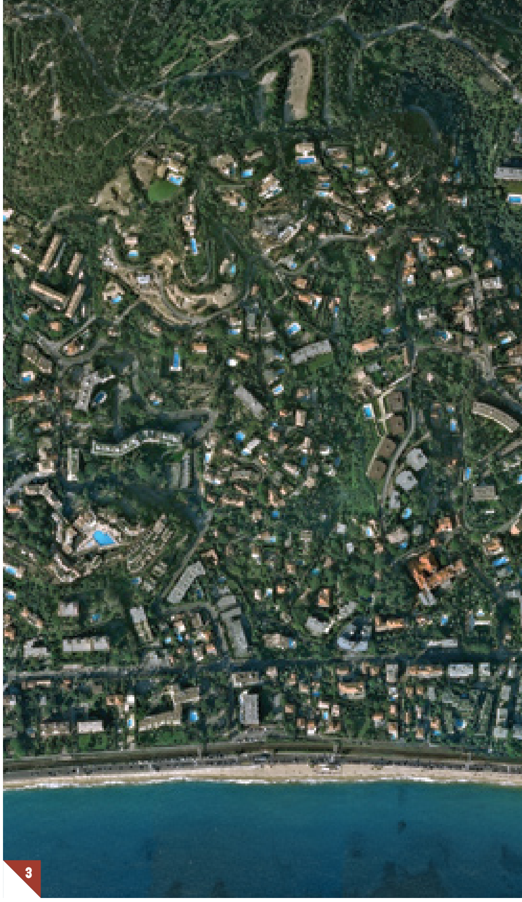
With 95 percent of their imaging capacity—over 1 million km^2/day for the two satellites—dedicated to commercial clients, each Pleiades satellite can deliver 0.5-m color products in 20x20 km scenes. The standard product will be a 50-cm ortho-rectified color image combining the ground detail from the panchromatic sensor with the spectral information from the multispectral bands. The customer will receive the complete set of bands: blue, red, green and near-infrared. Thanks to precise knowledge of satellite pointing and high-quality digital terrain models extracted from stereo pairs, location accuracy of ortho-image products is expected to be around three meters without the need for ground control points.

The Pleiades satellites were designed and built together to function as their own mini-constellation providing daily revisit, which is an extremely important capability for many very high-resolution imagery applications. When Pleiades-2 joins the first in space by mid-2011, the two satellites will travel in offset orbits to image the same point on the Earth's surface every two days at the equator and less than 24 hours at points above 45 degrees of latitude.

The frequent revisit cycle of Pleiades is in part due to the agility of the satellite. Each satellite will benefit from four Control Moment Gyroscopes (CMG) that will allow the satellites to pitch and roll forward, backward, and side-to-side up to 45 degrees, while preferably remaining within 30 degrees to keep the pixel size better than 1 meter. The ability to do this quickly means the satellite can acquire a multitude of separate or contiguous point targets covering up to 5,000 km^2/minute in a single pass. Alternatively, each satellite can acquire long strips of imagery with 20-km-wide swaths.

Each Pleiades satellite also will offer a strip mapping capability, expanding the collection swath up to 140 km, by acquiring several contiguous data strips on a single pass. This mode of collection will allow acquisition of contiguous areas up to 21,000 km^2. See ***Figure 3*** for sample image.

The Pleiades ground segment has been designed to accommodate better the needs of very high-resolution imagery users. In particular, time elapsed between request and delivery will be counted in hours and not in days, especially in times of emergency. To achieve this, Pleiades' tasking plan will be refreshed three times a day—every eight hours. This quick tasking is expected to be greeted enthusiastically by clients whose applications involve incidents and events that occur on short notice, such as natural or man-made disasters.



▲**FIGURE 1**
An illustration of the SPOT constellation of satellites – SPOT-2, -4 and -5: Imagery from the SPOT satellites range from 20-m B&W to 2.5-m color. Spot Image compliments this constellation with 2-m imagery from FORMOSAT-2 and 1-m imagery from KOMPSAT-2.

▲**FIGURE 2**
An illustration depicting one of the two identical Pleiades satellites to be launched beginning in February 2010. Pleiades will deliver a standard 50-cm orthorectified color product and will be equipped with direct tasking capabilities that will enable the satellite to be tasked up to 40 minutes before acquisition.

▲**FIGURE 3**
A simulated image of the Cannes, France, seashore as it will be seen by Pleiades. 95 percent of Pleiades's resources will be dedicated to the commercial market, allowing more users access to sub-meter imagery.

Spot Image will also offer a direct tasking capability for Pleiades, providing the ability, in case of emergency, to directly task the two satellites. "With the direct tasking capability, we will put the joystick into the hands of our customers, allowing them to task each satellite up to 40 minutes before the actual pass," says Stussi. Up-load of the tasking plan to the satellite will be done either by SPOT Image's main ground receiving station, or directly by the user's ground receiving station. The user will benefit from having a better knowledge of local weather and cloud conditions right before scheduling a collect, which will enable them to adjust the satellite pointing accordingly.

Thanks to the high agility of the satellite, Pleiades will also have the ability to collect same-pass stereo and tri-stereo imagery. Digital Elevation Models derived from such stereo data will prove to be even more precise and accurate than the already highly accurate 3D products Spot Image is currently offering with its Reference3D DTED Level 2 product.

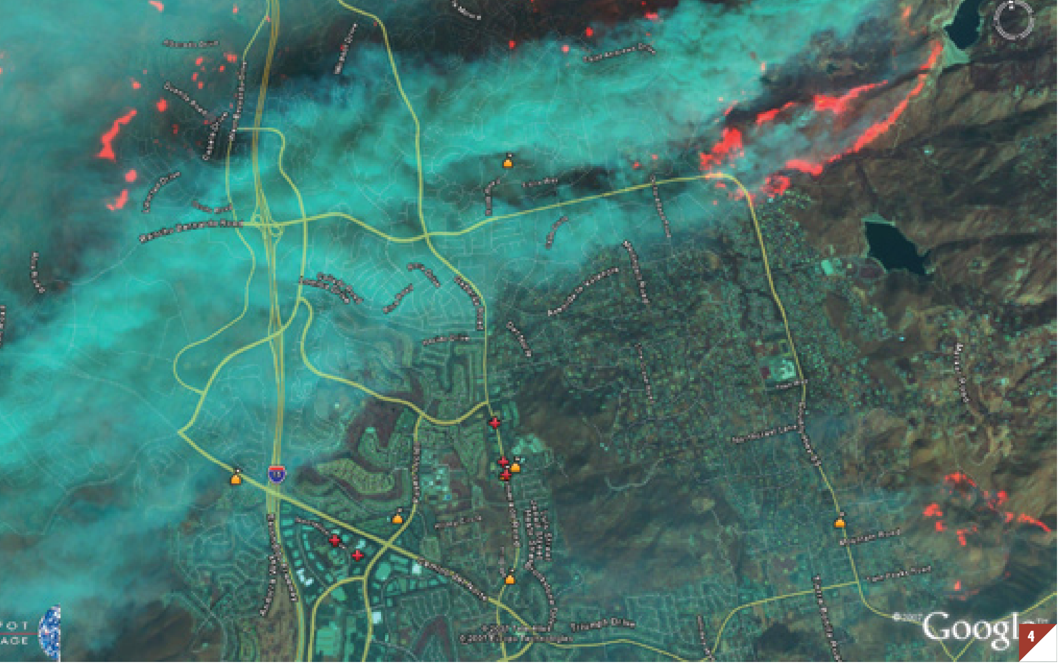
"While the Pleiades satellites have been developed to work in tandem with each other, they have also been designed to complement the SPOT constellation as a whole," said Stussi. "A multi-satellite constellation of remote sensing platforms operating at different spatial resolutions is a very powerful asset. We are already seeing great interest from our clients in acquiring mid-resolution SPOT imagery over broad areas combined with half-meter scenes over specific targets—all in a single project or application."

More SPOT Sats Coming

The SPOT satellite program is widely credited with igniting the commercial satellite imaging revolution more than two decades ago. Today, these satellites continue to be critical for high-quality imagery, digital elevation models, wide-area mosaics and other geospatial information products derived from mid- to high-resolution satellite data. SPOT imagery has become the mainstay data set in environmental, natural resource, agricultural, forestry, urban planning and other applications that benefit from a rich combination of spatial detail and spectral information content.

Launched in 2002, the SPOT-5 satellite was considered a breakthrough, high-resolution imaging platform providing 2.5-m spatial resolution and 10-m multi-spectral data in the green, red, near- and mid-infrared bands. Setting SPOT-5 apart from its predecessors is the High Resolution Stereoscopy (HRS) sensor, an instrument dedicated to collection of stereo pairs on a single pass.

Reference3D is SPOT's premier product developed from HRS stereo pairs. Reference3D combines a Digital Elevation Model, a 5-m ortho-rectified image and eight quality masks to provide users with a complete geospatial base product. This product has been utilized by many Ministries of Defense around the world, including the U.S. government, to fill in data gaps in the Shuttle Radar Topography Mission global elevation data set, which sought to map surface elevations



for the entire Earth. SPOT-5 has collected more than 110 million km^2 of cloud-free stereo pairs ready for processing into Reference3D products, and over 35 million km^2 of off-the-shelf DEMs are ready for delivery.

SPOT-2 and -4 continue to collect data for commercial applications. Their spatial resolution is 10-m panchromatic and 20-m multispectral, and their 60x60-km scene size is identical to SPOT-5. With the 60-km-wide swath, the SPOT program seems to have found the ideal scene size for mid-resolution applications. The scene is considered large enough for many regional geologic, environmental and natural resource uses, while remaining small enough to be cost-effective for localized logistical applications.

According to Stussi, the foremost goal of the SPOT program dating back two decades has been to develop the commercial market for satellite imagery. "Our main focus is now to ensure a continuity of service for the 2- to 10-m resolution market we have being developing over the past 23 years. With SPOT-6 and -7, we will ensure continuity of services to our customers up to at least 2020."

Design of the two new SPOT satellites began last year in France by EADS Astrium, which obtained an 81 percent majority stake in Spot Image SA by purchasing shares formerly held by CNES, the French Space Agency. Along with its 60-km swath, SPOT-6 and -7 will offer an improved 2-m spatial and 8-m multispectral resolution. Clients can also expect to see enhanced positional accuracy in the SPOT-6 and -7 data sets, including a greater revisit rate and improved collection capacity worldwide.

Spot Image predicts that the majority investment in Spot Image by EADS Astrium Services is a precursor of new opportunities to come for the Spot Image Group and its clients in the next few years, leading up to SPOT-6 and -7. In the past two years, SPOT has focused efforts on delivering a variety of new services based on the satellite-derived information, most notably leveraging the Google Earth viewing environment. With a services company now the majority owner, SPOT is expected to place an even greater emphasis on finding new and innovative ways to deliver data more quickly to customers in formats that are easier to use.

FORMOSAT-2 and KOMPSAT-2

In terms of overall value to specific applications, the spatial and spectral resolving capabilities of an imaging satellite are followed closely by its revisit cycle. Rapidly changing events such as environmental disasters—floods and wildfires, for example—require frequent monitoring so that emergency personnel can respond accordingly and deploy assets where they are needed most. Because no single satellite can be everywhere at once, catastrophic situations highlight the advantages of a multi-satellite constellation.

"There are certain events where clients want data every time our satellites pass overhead, even if spatial resolutions are different," said Drew Hopwood, Project Manager for Spot Image Corp.

Hopwood cited the devastating 2007 California wildfires as an example of using FORMOSAT-2 (F2) imagery (see ***Figure 4***). The commanders of fire crews needed to have multiple images of fires spread over large areas every day to try and keep their teams ahead of the flames. They called on Spot Image Corp. to bring all of its resources to bear on the situation. Anticipating needs such as this, Spot Image had already made arrangements to back up its own three satellites with marketing and distribution agreements involving other remote sensing operators.

In North America, Spot Image Corp. has exclusive distribution rights to imagery from the Taiwanese FORMOSAT-2 satellite. Launched in 2004, F2 has 2-m panchromatic and 8-m multispectral imaging capabilities. Because the satellite is designed to provide daily coverage over Taiwan, its orbit does not allow image acquisition worldwide. But for those areas it does overpass—such as the East and West Coasts of the United States—daily acquisition is the rule. Another interesting difference F2 offers is a 9:30 a.m. equatorial crossing, which enables it to capture morning imagery before the clouds gather in some tropical zones.

In addition to calling on F2 during the California wildfires, SPOT has tasked the satellite to acquire imagery for agricultural and coastal monitoring. Hopwood also noted that SPOT offers a cost-effective, turn-key monitoring service in which F2 acquires continuous images over a target specified by a client that wants to detect some type of change in surface conditions or features over time. The client can check the images via a dedicated web portal and purchase only the images that contain the information they want. ***Figure 5*** on page 20 shows Kuwait City, taken by F2.

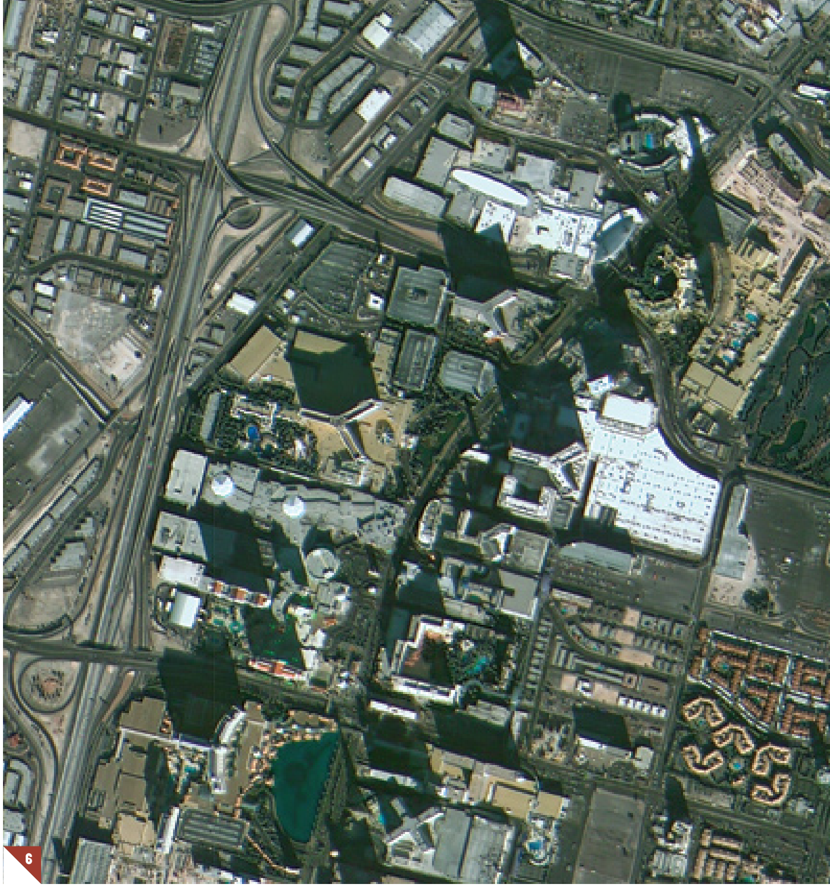
To further supplement and complement its existing constellation of satellites, Spot Image Corp. recently obtained distribution rights to the South Korean KOMPSAT-2 satellite. This satellite will enable SPOT to begin cultivating its market for very high-resolution imagery in anticipation of Pleiades. KOMPSAT-2 acquires 1-m panchromatic and 4-m multispectral in four bands (red, green, blue and near-infrared). Unlike most optical satellite platforms, it follows a south-to-north acquisition orbit.

"Most of the interest we have seen so far in KOMPSAT-2 data has been for urban applications where very small objects are being mapped in municipal environments," said Hopwood. See ***Figures 6 and 7***.

To derive the most value from all available resources, Spot Image has developed an integrated collection management solution to support combined collections from SPOT-2, -4 and -5 as well as FORMOSAT-2 and KOMPSAT-2. SPOT ground receiving stations can also be equipped with a standard, turn-key hardware and software solution to acquire and utilize imagery from all available platforms.

Summarizing the ability of the Spot Image Group to meet the needs of a diverse base of current and future geospatial information customers, de Chassy said, "With five healthy satellites in orbit and four more under development, SPOT will be serving the mid- to very high-resolution imagery markets with an unprecedented combination of frequent revisit and large-area coverage well into the next decade." «

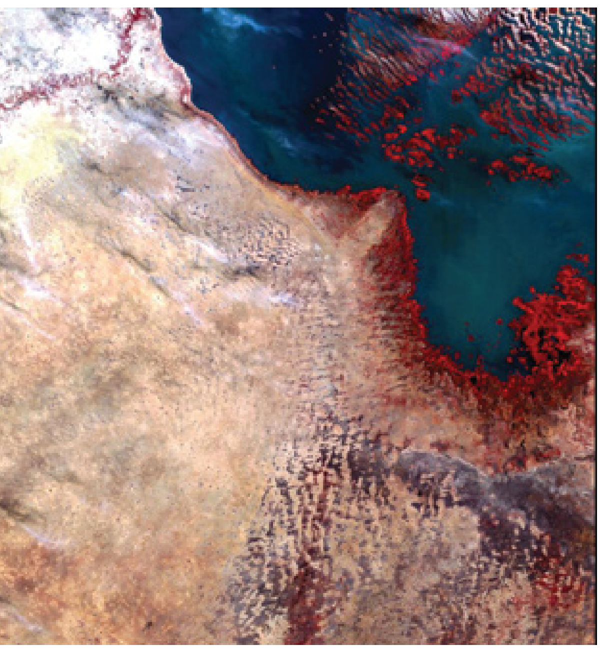
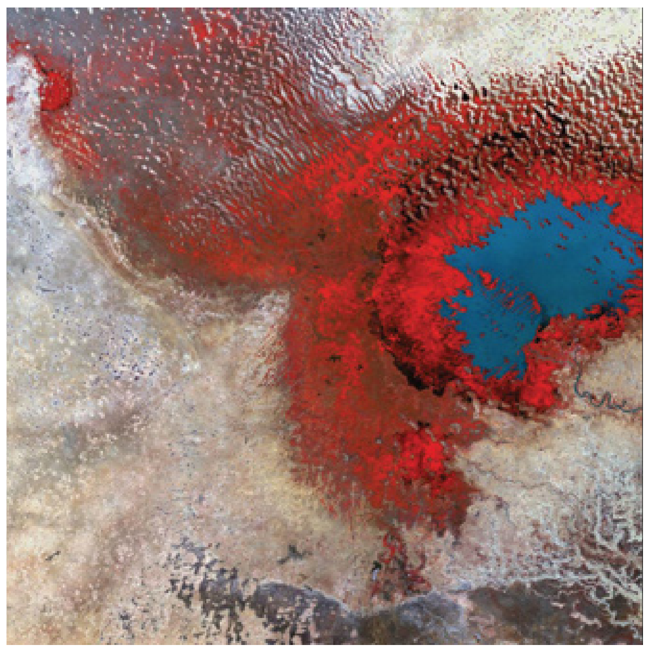
◀ FIGURE 4
In October 2007, as wildfires wreaked havoc in southern California, Spot Image acquired this image with SPOT-5, embedded it within Google Earth and distributed it to emergency responders to help them locate and access the fire damage.



▶ FIGURE 6
Along The Strip in Las Vegas, NV, huge hotels and casinos rival each other with their bold architectural designs as seen in this KOMPSAT-2 image acquired on Feb. 20, 2007. KOMPSAT-2 with 1-m imagery is a very high resolution solution for civilian and commercial markets.

▶ FIGURE 7
This KOMPSAT-2 image of the beautiful city of Putrajayan, Malaysia, was taken on Apr. 21, 2007. KOMPSAT-2 combines 1-m imagery in 15-km swaths with a large acquisition and storage capacity to make it an ideal solution for mapping of large and small areas.

Monitoring International Environmental Treaties

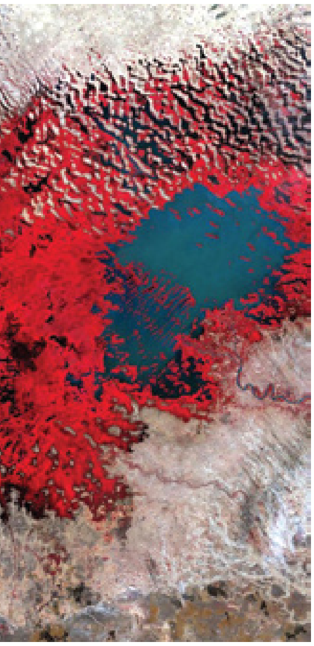




USING EARTH OBSERVATION DATA

The interest in Earth observation (EO),

or remote sensing, as a tool for monitoring international environmental treaties, also known as multilateral environmental agreements (MEAs), stems from parallel developments in the areas of Earth observation and international environmental diplomacy. Remote sensing technology and the rapid growth in the number of environmental treaties since the 1972 Stockholm Conference on the Environment have evolved on separate paths, converging only in the last ten years.

On the one hand, instruments are being launched with ever more impressive capabilities, and vendors are looking for new markets. On the other, the number of treaties in force is constantly increasing, and contracting parties are looking for easier ways to monitor not only their own and third party compliance, but also treaty effectiveness. The proliferation of MEAs has produced a new demand for environmental data and for better understanding of the socioeconomic processes and government policies that affect the environment. EO data are critical to understanding Earth systems and human impacts on those systems, and can ultimately contribute to the design of improved policy instruments.



Satellite EO data can measure a multitude of phenomena, from ocean temperatures to forest health and from ice thickness in arctic regions to rainfall rate in tropical regions. Nations that now have remote sensing capabilities include the U.S., Canada, France, Europe (through the European Space Agency, ESA), India, Japan, China, Russia, Israel, Brazil, Argentina and Nigeria. Their satellite capabilities have sensors focused on the Earth's land, oceans, and atmosphere. Data products can be generated for monitoring habitat of migrating animals, for detecting change in forests, crops, deserts and urban areas, or for monitoring pollution in rivers and deltas. Atmospheric measurements are made of carbon dioxide, ozone, methane and aerosols, including smoke and ash from fires and volcanic activity. See ***Figure 1***.

Treaty Structures

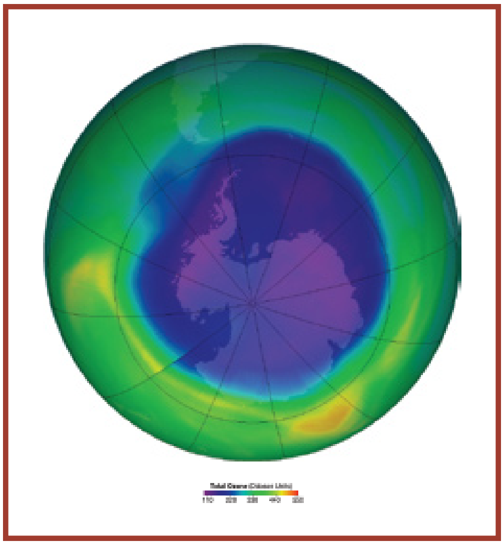
Multilateral environmental agreements are typically brief and formal documents that describe the problem being addressed, the commitments of the governments involved, and the institutional infrastructure to be created. They are commonly cast in the form of binding international treaties. Most MEAs create a series of international organizations to administer the agreement, such as secretariats and technical and scientific committees, and invest the power to alter and amend the treaty in a Conference of the Parties, which acts by consensus in almost all cases.

DR. SHAIDA JOHNSTON
Science and Technology Policy Consultant
Falls Church, Va.

◀ **FIGURE 1**
On the edge of the Sahara, the world's largest non-polar desert, lies a large freshwater lake. Lake Chad borders four countries in West Africa: Nigeria, Niger, Chad, and Cameroon. Lake Chad was once the sixth largest lake in the world, but persistent drought since the 1960s shrank it to about one twentieth of its former size. The lakebed is flat and shallow, so small changes in depth mean large changes in area. Even in normal times, Lake Chad was no more than 16 to 26 feet (5 to 8 meters) deep. As the lake becomes shallow, large wetland areas replace open water. These images were taken by Landsat 1, 4, and 7 on December 8, 1972, December 14, 1987 and December 18, 2002, respectively.

International conventions on environmental protection are receiving increasing interest from both policy makers and scientific disciplines concerned with trans-boundary problems. Today more than 350 unique MEAs govern the cooperation of the participating nation states in protecting our common environment. These MEAs range from the 1933 Convention Relative to the Preservation of Fauna and Flora in their Natural State, which has nine Contracting Parties, to the 1994 UN Framework Convention on Climate Change (UNFCCC), which has 189 Contracting Parties.

Only a few MEAs have external monitoring functions explicitly written into the agreements, and fewer still incorporate or depend on Earth observation (EO) data to verify effectiveness or monitor compliance. MEAs mostly use as monitoring mechanisms either nation-level self-monitoring techniques such as registering inventories in a central repository or database, or an internal state census of various biological species, rather than external bodies or observations.



▲FIGURE 2
Data from NASA's Earth-observing Aura satellite in 2007 show that the ozone hole peaked in size on Sept. 13, reaching a maximum area extent of 9.7 million square miles – just larger than the size of North America – which was about average when compared to measurements from the last few decades.

Parallels are often drawn between the international environmental treaties' regimes and the regimes of weapons and arms control treaties, especially when the concepts of compliance verification and monitoring are addressed. In general, the phases of treaty fulfillment are similar, but the objectives and governing structures are vastly different such that specific methods cannot be applied directly from one regime to another. The most important difference is that the objectives of the regimes are to effect change in the behavior of substantially different actors. For arms control treaties, the agreements are intended to affect the behavior of governments, and using sanctions can be effective to motivate compliance, while the environmental agreements attempt to affect the behavior of many private sector actors such as industries, consumers, and local farmers and villagers living off natural resources. These disparate actors are not necessarily motivated to change their behavior based on the enforcement of an international agreement, but providing incentives and information about the state of their environment may effect such change.

Forms of Monitoring

Compliance refers to a nation state's adherence to specific obligations under an agreement. A nation may take action to implement an agreement but still not be in compliance with those actions, e.g. not enforce the obligations under legislation due to lack of funding. A helpful distinction can be drawn between procedural compliance and substantive compliance. Procedural compliance concerns the fulfillment of obligations such as filing national reports, attending meetings, and other procedural requirements of an agreement, while substantive compliance involves fulfilling obligations specific to the intent of the agreement, such as emissions-reduction or conservation of species habitat.

Each MEA has its own regime for monitoring compliance. Almost all require some form of self-reporting. Traditionally, the incentives for states to report their own noncompliance are low, since such admission could lead to actions such as the imposition of sanctions. The situation changes when noncompliance is not necessarily considered the intentional act of a sovereign state but may be due to incapacity. Reporting a problem can lead other partners in the regime to look for remedies to overcome the difficulty, for example through a transfer of finances or technology. Using such a managerial approach, reporting noncompliance can be in the state's interest. The result of this new approach is a higher compliance record than with the enforcement approach.

Sanction mechanisms used within the arms control regime, based on the notion that states intentionally do not comply with treaty obligations, have proven largely ineffective for MEAs, and economic sanctions have become more difficult to apply since the international trade regime has become quite complex. One must take into account the abilities of states to comply when considering noncompliance. For example, under the 1987 Montreal Protocol to the 1985 Vienna Convention on the Protection of the Ozone Layer, given repeated evidence of non-compliance by the Russian Federation, not only were warnings given of potential suspension of trading rights, but financial assistance was offered through the Global Environment Facility (GEF) to improve data submission and implementation capacities. GEF funding was provided in similar circumstances to other former Soviet states. Emphasis was placed on improving the environmental management in those countries and highlighted the view that for MEAs, noncompliance is a problem to be solved, and not an action to be punished.

Successful monitoring of international commitments depends on the availability of data. Overall, national reports, which are the main source of these data, are becoming more complete, but the accuracy and comparability of data remain low in most cases. Environmental data, including EO data in these reports, would improve their quality significantly and provide the ability to quantitatively measure progress from one report to the next. The reliability problems of self-reporting are compounded by the fact that in most treaties the international body to which the information is submitted very rarely can take any independent action to confirm the national reports. There is no provision that authorizes objective verification of the data contained in national reports. Nor are there any automatic sanctions if reports are inadequate in content, are presented late, or are not presented at all.

Effectiveness is a measure of whether the objectives of a treaty are met. Effectiveness differs from compliance, although the two concepts are related. Compliance addresses whether an individual party to an agreement is meeting its obligations, while effectiveness addresses whether the agreement itself is achieving its negotiated goals. A state may comply with an agreement but the agreement may nonetheless be ineffective at achieving its objectives. For the Kyoto Protocol or its successor, for example, even if states fully comply with the requirements of the Protocol, it may still not be enough to stop climate change from occurring. The treaty would be ineffective. Yet, given the complexity of understanding the factors of effectiveness, compliance is often used as a proxy for effectiveness, since greater compliance generally leads to improvements in the environment. See **Figure 2**.

What is needed to measure effectiveness of an MEA is a set of quantifiable environmental indicators that show trends in environmental quality (atmospheric ozone, forest acreage and health, species counts for biodiversity, etc.). However, given that many MEAs are trying to address the complex interactions among different ecosystems on air, water, and land areas, a single indicator is difficult to develop. More significantly, MEAs rarely address all aspects of a given environmental problem, and instead tend to address one aspect of a larger environmental problem, possibly the largest contributing factor, but certainly not all of them.

Other sources of environmental problems and variations in domestic resources and implementation plans have a significant impact as well. Isolating the effectiveness of one MEA in mitigating a particular type of environmental risk is problematic. Also, aggregate data are gathered at the national level and reported in national reports for land-use, biodiversity, deforestation, protected areas, fresh water, pollution, and other concerns. Environmental quality in most of these areas, however is influenced by both domestic and external factors. MEAs, by definition, address global or trans-frontier effects, yet data are collected and assembled at the national level—a distinction that poses another problem for those trying to assess treaty effectiveness.

For MEAs, non-compliance is a problem to be solved, and not an action to be punished.

Objective Support for MEAs from OE Data

Public support is required to develop agreements that address global or regional-scale environmental problems and is influenced by the existence and public sharing of scientific data, including Earth observation data. EO data are unparalleled sources of information that convey environmental changes in a visually compelling way, such that they are extremely useful for raising awareness and developing the political support necessary to negotiate environmental treaties at the international level.

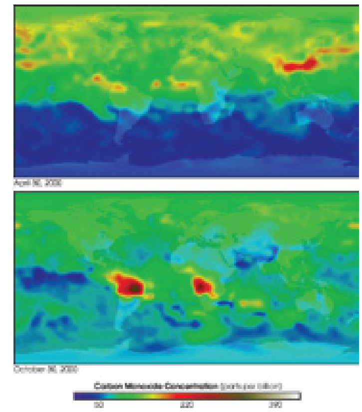
For monitoring MEAs, once negotiated, factors that contribute to the usefulness of using EO satellite data include existing MEA structures (reporting and assessment requirements, sovereign vs. common territory sensitivities, and technical capacity of the contracting parties), physical measurements of EO data (ozone, land surface reflectance, ocean color, etc.), data accessibility, and data continuity with future sensors and missions.

Environmental problems addressed in many MEAs are global in scale, and EO data are well suited to large-scale problems such as deforestation, preservation of polar regions, ocean and atmospheric conditions, and climate change. For treaties requiring monitoring of land resources or coastal areas, contention with sovereignty issues continues to be prevalent. States are particularly sensitive about the availability of data on their economic resources and on activities related to their national security.

However, for MEAs dealing with atmospheric conditions and common spaces such as the oceans, EO receives little resistance and is often the only way of getting the measurements on the required scale to monitor the commons regularly. As atmospheric sensors improve in spatial and temporal resolutions, there may be more resistance to using the data for monitoring, since concentrations of atmospheric GHGs (greenhouse gases) can then be tied to specific regions or states. See ***Figure 3***.

Environmental assessments are critical to measuring treaty effectiveness as they provide data on changes in the environment. The Millennium Ecosystem Assessment (MA) is the latest in a series of global integrated assessments conducted to assess the state of the environment using EO data. The MA consists of a global scientific assessment as well as a number of smaller, more focused local, regional and national assessments. The primary users of MA results include the international ecosystem-related conventions—the 1992 Convention on Biological Diversity, the 1994 Convention to Combat Desertification, and the 1971 Ramsar Convention on Wetlands—and their contracting parties. A much wider audience of United Nations (UN), governmental and non-governmental agencies also have the potential to refine their policies and programs based on the assessment results. Global in nature and consistent across nation boundaries, EO data are integral to the effort.

To date, the Intergovernmental Panel on Climate Change (IPCC) has produced four comprehensive assessments of global climate change (1990, 1995, 2001, and 2007), covering scientific and technical information for researchers and policy makers. The data are gathered, modeled and reported by scientists from around the globe, drawing on EO data and historical and current records of ground-based measurements. Climate models are used to project impacts of current trends in climate change. The First IPCC Assessment Report, completed in 1990, played an important role in establishing the Intergovernmental Negotiating Committee for a UN Framework Convention on Climate Change by the UN General Assembly. The second assessment report, Climate Change 1995, provided key input to the negotiations which led to the adoption of the Kyoto Protocol to the UNFCCC in 1997, and the 2007 report is driving the negotiations for the next Protocol to the UNFCCC.



▲ **FIGURE 3**
Carbon monoxide measurements from the Canadian MOPITT instrument on board NASA's Terra satellite show air pollution traveling through the atmosphere. The false colors in these images represent levels of carbon monoxide in the lower atmosphere, ranging from about 390 parts per billion (dark brown pixels), to 220 parts per billion (red pixels), to 50 parts per billion (blue pixels). Notice the immense plumes of the gas emitted from forest and grassland fires burning in South America and Southern Africa in the October image on the bottom..

Multilateral environmental agreements are evolving, open processes that are continually reviewing implementation and developing new measures to improve effectiveness. The number of MEAs, particularly at the regional and global level, will continue to grow, and Earth observation data can greatly contribute to the ongoing development and refinement of MEAs by assisting in problem definition and catalyzing action, by providing quantitative information in national reports to significantly improve their value both to the reporting nation and to the other parties of an agreement interested in compliance monitoring, and by providing global-scale environmental assessment to monitor treaty effectiveness.

Call for Registration

The 6th International Symposium on Digital Earth

— Digital Earth in Action

September 9-12, 2009 Beijing, China

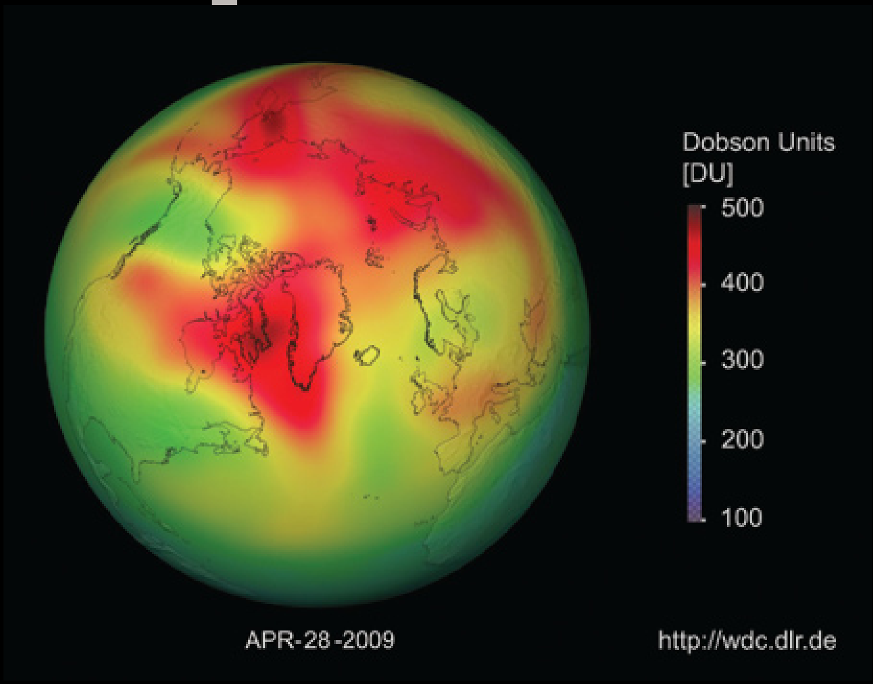
The 6th International Symposium on Digital Earth (ISDE6) will be held in Beijing, China in September 2009. The theme of ISDE6 is "Digital Earth in Action". ISDE6 is organized by International Society for Digital Earth (ISDE) and Chinese Academy of Sciences (CAS), and hosted by Chinese National Committee for ISDE and Center for Earth Observation and Digital Earth, CAS.

The series symposia of ISDE was successfully convened in China, Canada, Czech Republic, Japan and the United States every two years from 1999 to 2007. On the 6th International Symposium on Digital Earth, participants are encouraged to take the opportunity to review the progress of digital earth during the last decade and discuss the achievements of digital earth and its future developments. The main topics cover digital earth theory and technology, digital earth application, digital earth and global environmental change, earth observation, and digital earth education. The official language of ISDE6 is English. The online registration for the symposium has been available at the symposium website. Extra extended deadline of abstract submission can be requested to the organization directly. Your request will be considered on a case by case policy. For more details, please browse the symposium website: www.isde6.org.

We are heartfelt to invite you to the symposium. You will have an occasion to find out new developments and to get new ideas and products for research and production, meet your old friends and make new friends, and enjoy the best season of Beijing. You are also welcome to tour around China to experience its fast development and magnificent culture.

For more information contact: ISDE6 Secretariat
Prof. WANG Changlin, Ms. LIU Zhen
E-mail: ISDE6@ceode.ac.cn
Tel.: +86-10-58887297 / 58887298
Fax: +86-10-58887406
URL: www.isde6.org www.digitalearth-isde.org
Address: No.9 Beiyitiao Road, Zhongguancun,
Haidian District, Beijing 100190, China

Climate Sensor Update



▲**FIGURE 2**
GOME-2/MetOp data showing Analyzed Total Ozone Columns from DLR EUMETSAT. Image credit goes to the ICSU/WMO World Data Center for Remote Sensing of the Atmosphere. This link shows videos of this over time: http://wdc.dlr.de/data_products/SERVICES/GOME2NRT/movies/.

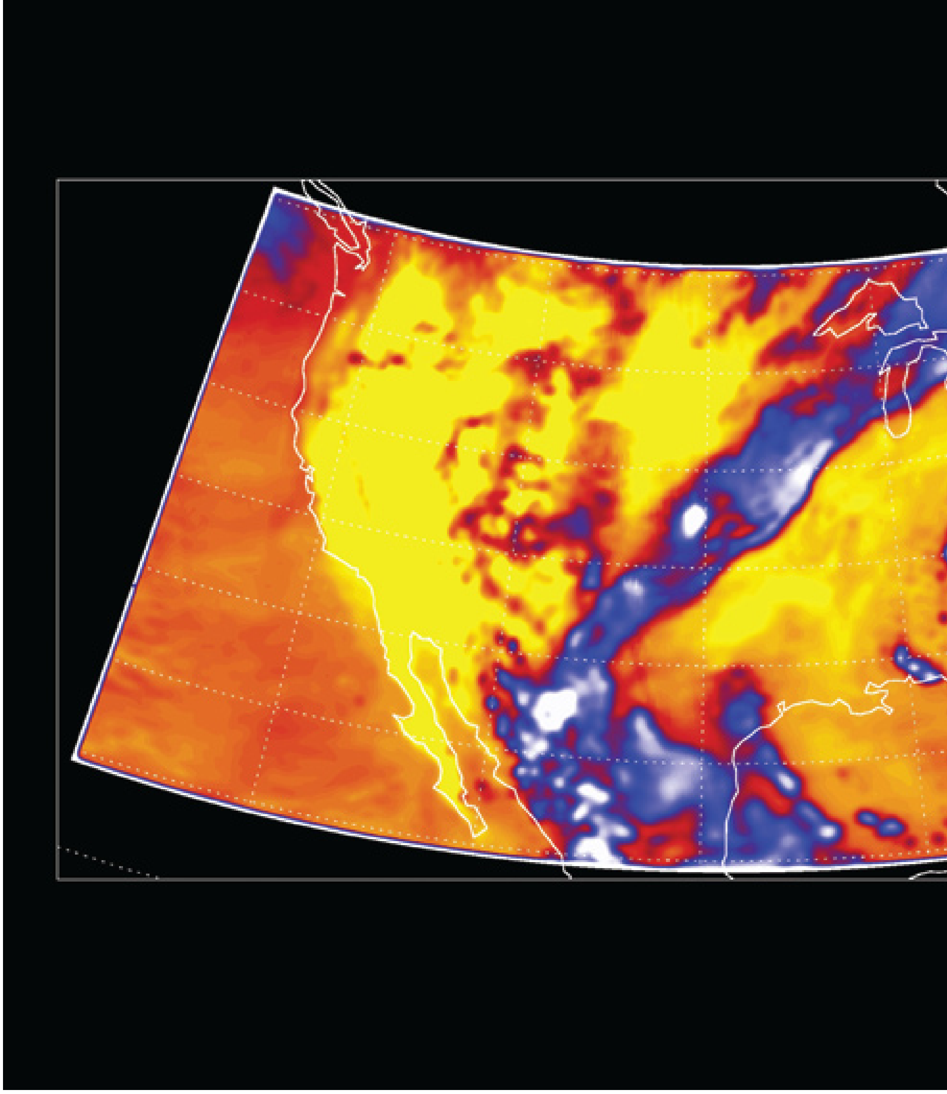
STILL NEEDED: STANDARDS AND CONTINUITY

TURNS OUT, THE TOPIC OF MONITORING climate change using climate sensors is not as straightforward as it might seem. In 1934, poet and critic T.S. Eliot wrote, "Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?" He might have been writing of the twenty-first century.

Dr. Alexis Livanos, Corporate Vice President and Chief Technology Officer for Northrop Grumman, may concur with the writer. In a speech he gave April 1st at the 25th National Space Symposium in Colorado Springs, Dr. Livanos said, "The solution must include the technical... Finding solutions to climate change will require space and other systems that include all the many types and generations of sensors, platforms and communications that space facilitates." Then he added, "...but also the non-technical; the familiar, but also the unconventional. It must be flexible and adaptable and provide a variety of information that allows decision makers to make intelligent choices."

KAREN NOZIK
Eco-writer
Boulder, Colo.
www.eco-writer.com

EDITOR'S NOTE
The April eNewsletter included a summary of the Earth Observations portion of the National Space Symposium. See eNews at www.imagingnotes.com.



▶ FIGURE 4
CERES (Cloud and Earth Radiant Energy System) measures the energy emitted by the surface and atmosphere of the Earth with longwave radiation. This image shows an oppressive summer heat wave (Outgoing Longwave Radiation) on August 2, 2006. The blue shows a cooling front, with orange and yellows showing hotter temperatures. Source: NASA Earth Observatory Website Image of the Day on 8/12/2006; Instrument: CERES/ Aqua; Credit: NASA image by Takmeng Wong with the CERES Science Team at NASA Langley Research Center.

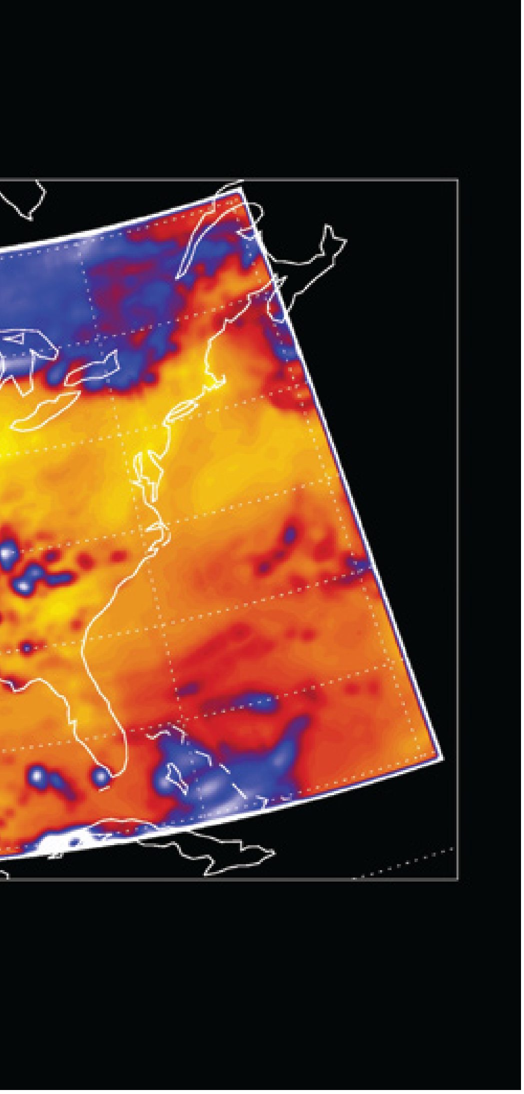
Climate sensors—yes, absolutely, almost everyone agrees they are important to controlling climate change. But that's just the beginning. The hard part will be figuring out what kinds of instruments we need, and then to help us decide whether to mitigate changes, or, if we're too late on such things as melting glaciers, then to help us adapt. Dr. Livanos said that the United States undoubtedly must address the impact of climate change using a multi-faceted approach.

Climate change could potentially affect every sector of society. A recent report from the Center for Strategic and International Studies estimates that $3 trillion of the U.S. GDP of $13 trillion is sensitive to climate change. Dr. Livanos used the $18 billion wine industry as his example, citing how the slightest increase in average temperature will have a devastating effect on the product and profits. He suggests partnering with the private sector industries that have the most to lose, for issue and policy advocacy. And think of any number of others: ski resorts, insurance companies, firefighters... even Wal-Mart (it's someone's job to decide how many raincoats to buy in southern Florida during the rainy season). With so many potentially affected, masses of industries certainly have a dog in the fight.

Reducing our vulnerability to these impacts depends not only upon our ability to understand climate science and the implications of climate change, but also upon our ability to integrate and use that knowledge effectively. We are only beginning to find the "knowledge we have lost in the information." The Orbiting Carbon Observatory satellite was the latest science mission in NASA's ongoing study of the global carbon cycle; unfortunately, it crashed earlier this year. It was to be the first spacecraft dedicated to studying atmospheric carbon dioxide, the most significant human-produced greenhouse gas and the principal human-produced driver of climate change.

Today, as Dr. Livanos pointed out at the Space Symposium, data collected on the ground comes from either a scientist who hand-counts species on site—one square meter at a time—or from a vast, space-based global view. This leaves a knowledge gap big enough to fly a satellite through in monitoring systems central to future climate change mitigation and adaptation efforts.

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) is the next generation of low Earth orbiting environmental satellites meant to meet the nation's needs for environmental measurements from satellites. NPOESS is a tri-agency Department of Defense, Department of Commerce, and NASA program that merges two environmental satellite systems into one in order to globally measure atmospheric, land and oceanic environmental parameters. NPOESS will circle the Earth approximately once every 100 minutes, providing global coverage, monitoring environmental conditions, collecting, disseminating and processing data about the Earth's



weather, atmosphere, oceans, land, and near-space environment.

NPOESS will collect a massive amount of very precise Earth surface, atmospheric and space environmental measurements from a variety of on-board sensors. This volume of data will allow scientists and forecasters to monitor and predict weather patterns with greater speed and accuracy.

Distinctions need to be made between observations predicting the weather, and measurements required to monitor and understand the Earth's climate. This is where the topic of climate sensors becomes complex. For starters, predicting weather requires a good set of observations at a single time; monitoring climate fluctuations calls for a longer time series of observations.

In general, two kinds of climate variations—short-term and longer-term—concern us. Short-term climate fluctuations depart from average weather conditions over a period of a month or more; these are referred to as climate variations. (Think of El Niños and droughts.) Variations in the weather and climate over the longer-term (decades, centuries, etc.) are generally referred to as climate changes.

Dr. Shaida Johnston, PhD, a remote sensing policy analyst, said the weather models have been in place for 50 years, are agreed upon, and work very well at predicting storms, anticipating hurricanes, etc. The climate models are much more theoretical, and are not yet in place.

Dave Jones, Founder, President & CEO of StormCenter Communications (Ellicott City, Md.) frames it this way: "Weather is what you get. (It's raining outside.) Climate is what you expect. (There will be snow in Colorado in January.) Climate is average weather over time."

Jones explains that in general, the weather is governed mainly by the atmosphere, its circulation and the processes within it, such as the formation of clouds and rain. Climate depends on additional atmospheric processes, including chemical reactions that determine the concentrations of important constituents such as ozone and methane, and processes that alter the Earth's

A FEW WEATHER AND ENVIRONMENT SPACECRAFT AND MISSIONS

NPP

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) is being developed as a mission precursor to NPOESS. NPP will also provide data continuity between the Earth Observing System (EOS) Terra and Aqua missions and NPOESS.

NPOESS

NPOESS, a tri-agency Department of Defense, Department of Commerce, and NASA program, merges two environmental satellite systems into one in order to globally measure atmospheric, land and oceanic environmental parameters.

GOES

The Geostationary Operational Environmental Satellite (GOES) system monitors dynamic weather events and provides prime observational platforms for tracking environmental conditions on the Earth's surface and in near-Earth space.

CALIPSO

The Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission is part of NASA's Earth System Science Pathfinder program dedicated to studying the impact that clouds and aerosols have on the Earth's radiation balance.

CloudSat

The CloudSat mission is also part of NASA's Earth System Science Pathfinder program. The new spaceborne radar is providing the first global measurements of cloud properties that will help scientists compile a database of cloud measurements, aiding in global climate and weather prediction models.

A FEW WEATHER AND ENVIRONMENT INSTRUMENTS

GMI

Under development is a conical-scan microwave radiometer called Global Precipitation Measurement-Microwave Imager (GMI). After its completion, the GMI will be integrated onto the Global Precipitation Measurement spacecraft with the Japan Aerospace Exploration Agency's Dual Precipitation Radar. Once operational, both instruments will make radiometric and radar measurements of precipitation around the world and will provide comprehensive data to produce global rainfall maps and climate research products.

SAGE

The Stratospheric Aerosol and Gas Experiment (SAGE) is a family of space-borne remote sensing instruments developed for NASA/Langley Research Center (NASA/ LaRC) to monitor the global distribution of aerosols and gaseous constituents. The Stratospheric Aerosol Monitor II (SAM II) flew on Nimbus 7 from 1978 to 1994. SAGE I flew on the Applications Explorer Mission 2 in 1979. SAGE II flew in 1984 aboard the Earth Radiation Budget Satellite.

QuikSCAT

QuikSCAT, an advanced Earth observation satellite, carries a scatterometer that records sea-surface wind speed and direction for global climate research. It was launched in 1999.

ICESat

The NASA laser altimetry mission – Ice, Cloud and land Elevation Satellite (ICESat)– was built by GSFC and launched in 2003. It accurately measures the elevations of the Earth's ice sheets, clouds and land.

Radarsat

Radarsat, launched in 1995, is Canada's first operational space-based synthetic aperture radar. Radarsat generates day-night, all-weather images of ocean surfaces and the Earth with spatial resolution as fine as nine meters. A primary objective is improving maritime safety by monitoring permanent and seasonal ice and evaluating other ocean conditions that can hamper shipping activities.

radiation budget such as the interactions between clouds and radiation. Climate depends also on the important interactions between the atmosphere and other components of the planet's climate system—the oceans, the land, the snow and ice cover, the biosphere—and the sun. Unfortunately, no single "environmental sensor" exists that can provide scientists with a critical single measurement of the Earth's long-term climate system.

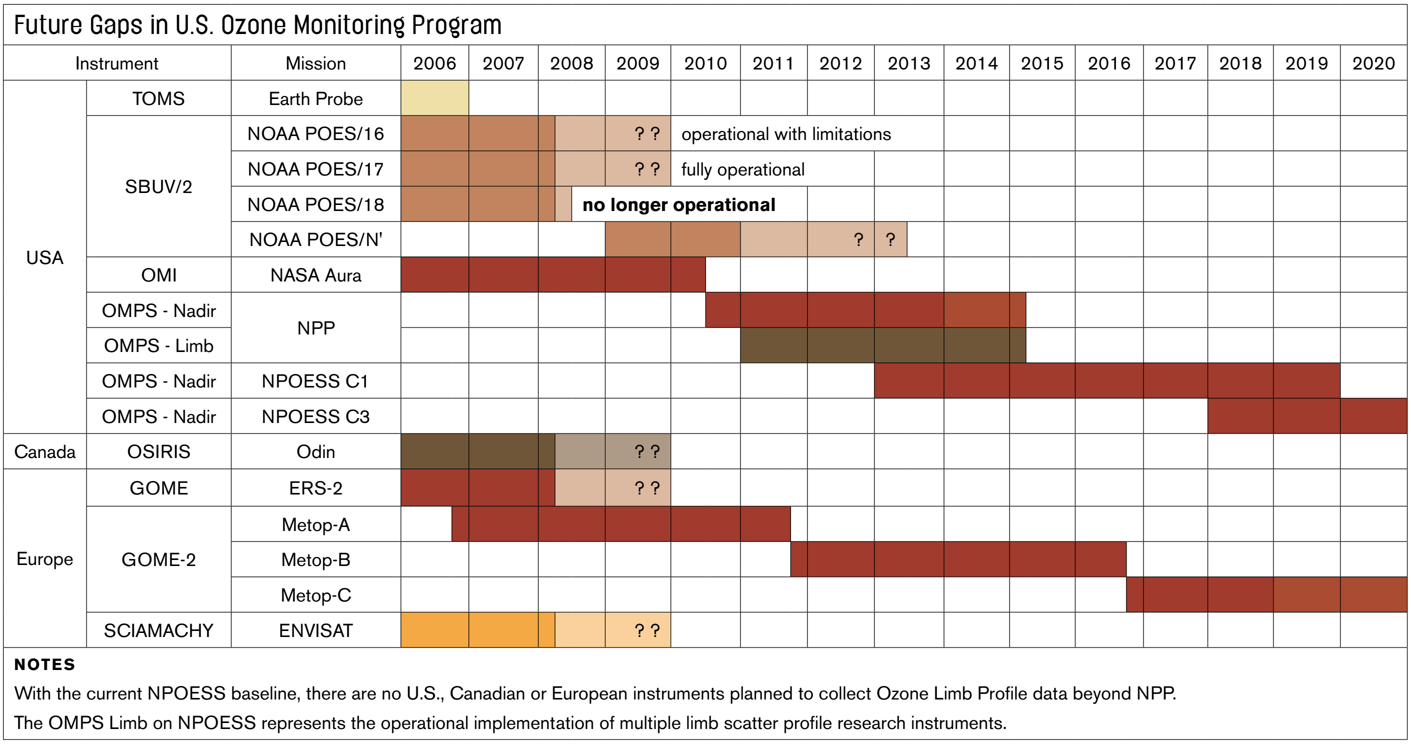
Dr. Shelley Petroy, PhD, Advanced Program Manager for Weather, Climate & Earth Sciences at Ball Aerospace & Technologies Corporation adds, "One of the issues for the last 20-30 years has been how to migrate a NASA science mission into a NOAA operational mission. With the release two years ago of the National Research Council's Decadal Survey for Earth Sciences, NASA and NOAA have kick-started a dialogue on exactly this issue—how do we anticipate which Decadal Survey Science Missions are best suited to transition to operations, and how do we accomplish this transition most effectively? NASA and NOAA leadership meet weekly to work through these issues and generate concepts. It's a great step forward."

Ball Aerospace has identified future gaps in the U.S. ozone monitoring shown in the chart in ***Figure 1***. ***Figure 2*** on page 33 shows Analyzed Total Ozone Columns from DLR (German Space Agency). ***Figure 3*** on page 38 shows OMPS (Ozone Mapping Profile Suite), the next operational ozone mission for the U.S., which is referenced in the Chart in Figure 1.

Dr. Leopold Andreoli, PhD, Director, Chief Scientist Civil Systems for Northrop Grumman Aerospace System agrees that if global climate change is anything, it is complex. "We are simply the measurers," he states. "The sun's radiation striking the Earth is the driving force for climate. The most basic measurement is energy entering the system, compared to energy leaving the system. Trying to measure climate change 1/10 of a degree over a decade requires extremely well-calibrated and stable instruments. We must continue to monitor, we must continue to measure, and we must create a worldwide collection system."

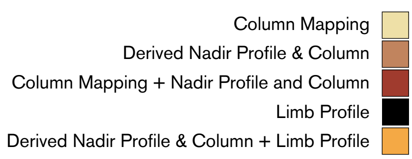
Satellites orbiting above the atmosphere are ideal for measuring the radiative energy streaming into and out of the earth-atmosphere system. But the expected travails associated with global climate change such as temperature increases or sea level rise represent difficult measurement challenges. Observations must be able to resolve very small variations and must be made continuously over a sufficiently long period of time. For accuracy, all sensors need to be calibrated against known standards.

The Open Geospatial Consortium (OGC) is an international consortium of industry, academic and government organizations working collaboratively to develop standards for geospatial and location services. Members of the OGC have approved a unique and revolutionary framework of open standards



▲ **FIGURE 1**

This chart shows the future gaps in the U.S.'s ozone monitoring program. Note that ozone mapping is really done by the international community, as several of these missions are European.



called Sensor Web Enablement (SWE) to exploit Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, Webcams, satellite-borne Earth imaging devices and countless others. According to Carl Reed of the OGC, the SWE will enable much more effective utilization of sensor information for use in policy.

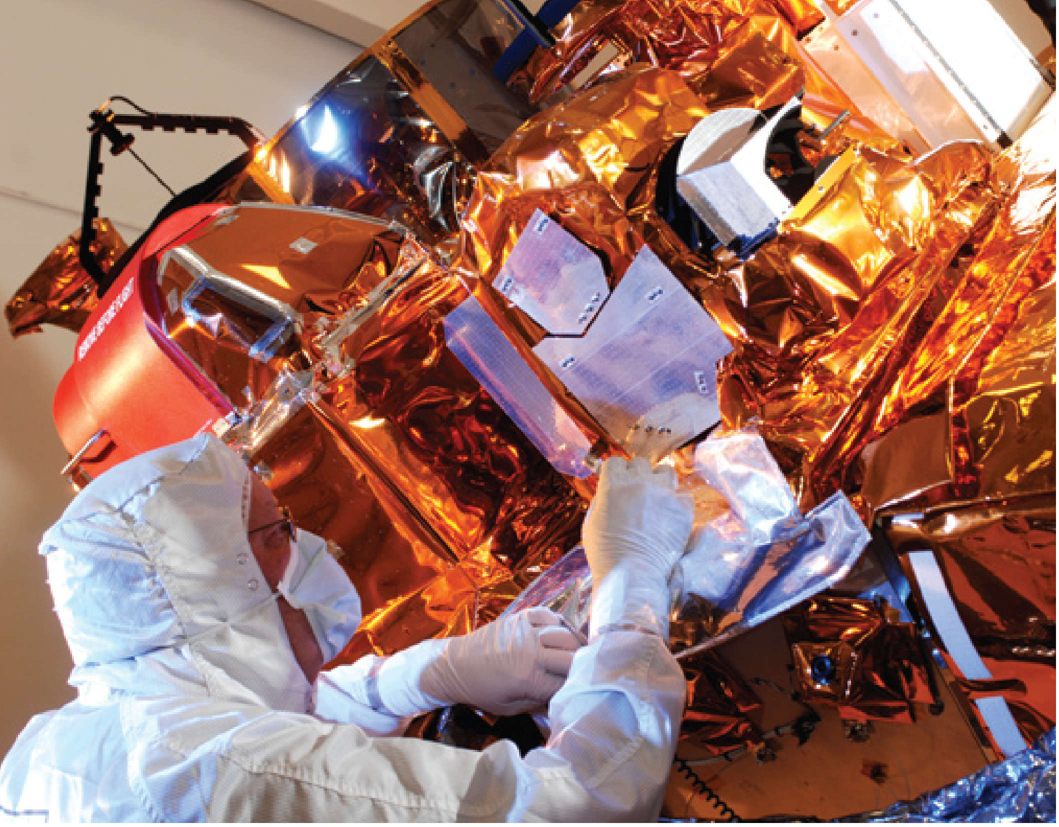
The voluntary consensus standards setting process, coupled with strong OGC support in domains that depend on sensors, will result in SWE specifications that will quickly become established in all application areas where such standards are of use. A number of these standards, such as the Sensor Observation Service, are already widely implemented.

Dr. Andreoli offers up Northrop Grumman's Clouds and the Earth's Radiant Energy System (CERES) as an example of measuring clouds and their impact on Earth's radiant energy. One of the most precisely calibrated radiometers ever to fly in space, the CERES instrument is measuring emitted and reflected radiative energy from the surface of the earth and the atmosphere. Previous space-based observations have shown that the role of clouds, which reflect, absorb, and trap radiant energy, is critical in maintaining the Earth's radiant energy balance. The balance is threatened by the build-up of carbon dioxide and other greenhouse gases in the atmosphere. An image appears on page 34 in ***Figure 4***.

The CERES experiment is flying broadband scanning radiometers on polar-orbiting and low-Earth-orbit inclined platforms. NASA's EOS Terra and EOS Aqua satellites each carry two broadband CERES instruments, one scanning crosstrack and one rotating while scanning. The rotating scan provides complete angular sampling for more accurate modeling of the scattering of reflected energy from target areas. Each scanner has three channels. A shortwave channel measures reflected sunlight (0.3 to 5 microns) to 1 percent accuracy; a longwave channel measures earth-emitted radiation (8 to 12 microns) to 0.3 percent accuracy; and a total channel (0.3 to >50 microns) accurate to 0.5 percent. Other instruments typically quote radiometric accuracies of 5 to 10 percent.

CERES must provide highly reliable data across platforms over the 15-year span that the instruments will fly. To ensure the highest quality data, CERES' sensors have been precisely calibrated using standards traceable to the National Institute of Standards and Technology.

"We need satellites that measure the essential climate variables (ECV's), and we need to agree on what the key variables are," says Dave Jones. "Observing long-term climate change requires instruments whose measurement characteristics do not change appreciably



▲**FIGURE 3**

OMPS (Ozone Mapping Profiler Suite) from Ball Aerospace will fly on the NPP (NPOESS Preparatory Project) as the next operational ozone mission in 2010/2011. OMPS consists of a hyperspectral UV, visible and near IR limb sensor, a wide-field hyperspectral UV nadir sensor, and a dual-redundant main electronics box. Integration and risk reduction testing of OMPS for NPP were completed in February 2009.

with time. The generation of satellite-based climate data records requires many inter-related activities and steps. These include inter-calibration of identical instruments carried on different NPOESS spacecraft as well as inter-comparison with similar instruments carried on other spacecraft such as NASA research satellites, development of processing algorithms, detection and elimination of systematic errors in data, generation of stable time series, validation of data products, reprocessing of data as improvements are made to processing algorithms, and quality control and analysis of data."

Measuring the required climate variables and doing so with the accuracy and long-term stability needed to detect climate variations and changes are major challenges for NPOESS. Satellite systems require that certain factors be minimized or accounted for in the creation of stable climate data records (CDRs). These include the biases inherent in the observing instruments, changes in instrumentation, satellite orbital drift, system calibration, sensor degradation, and system malfunctions.

Natural climatic cycles like the Arctic Oscillation further complicate the job of measurement and the job of prediction. Rob Mitrevski, Vice President and Director of Commercial and Space Sciences for ITT's Space Systems Division, agrees that we need broader capabilities, ground-based and space-based sensors over the longer-term, to draw conclusions. And he too calls for an integrated, coordinated approach among governments, industries, universities, and non-governmental organizations: "Ultimately this is a question of political will to drive the technology based on society's needs."

At the University of Colorado Conference on World Affairs on April 9, Dr. James Hansen, Director since 1981 of the NASA Goddard Institute for Space Studies (GISS), spoke to a standing room only crowd about climate threats to the planet and implications for intergenerational and environmental justice. Dr. Hansen has long held the belief that the most exciting planetary research involves increasing our knowledge of climate change on Earth, particularly changes caused by human influences on atmospheric composition. With colleagues at GISS and abroad, he is developing and applying global numerical models to better understand climate trends. Still, when asked about climate sensors being a key to solving climate change, Dr. Hansen said, "The crisis is because of inertia, both scientific (it takes a long time for the ocean to warm up) as well as political (there is a gap between what is understood and what is known.) Policies do not correspond with what is happening."

So, are climate sensors important to solving climate change? Yes, but standards and political will are still needed. If newer, more precise climate sensors tell us that the ice is melting faster than our previous models have shown, should we then also mobilize limited resources towards adapting to rising ocean levels instead of mitigating CO_2 levels?

It seems a lot of people concur with poet Eliot that wisdom stands a chance of getting lost in the knowledge. A smart guy named Albert Einstein once said that wisdom is not a product of schooling, but of the lifelong attempt to acquire it. As if to underscore the complexity of it, he also said, "Whoever undertakes to set himself up as a judge of Truth and Knowledge is shipwrecked by the laughter of the gods..." In the matter of climate sensors, perhaps the wise use of them is as important as the knowledge they provide.