Imaging NOTES

The World's Guide to Commercial Remote Sensing

Winter 2005 » Vol. 20 » No. 1

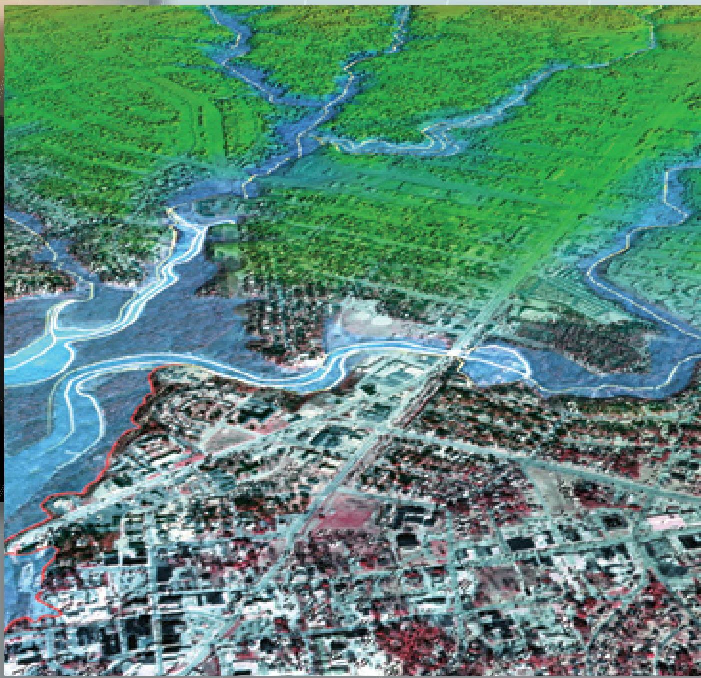
Military base management

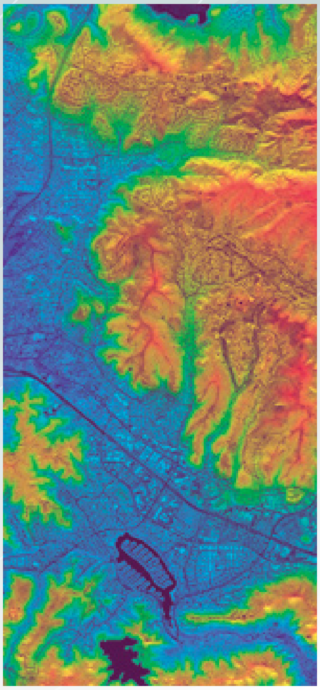
Maritime criminal surveillance

Making rapid response a reality

Holographic data storage

Vector-borne disease risk analysis





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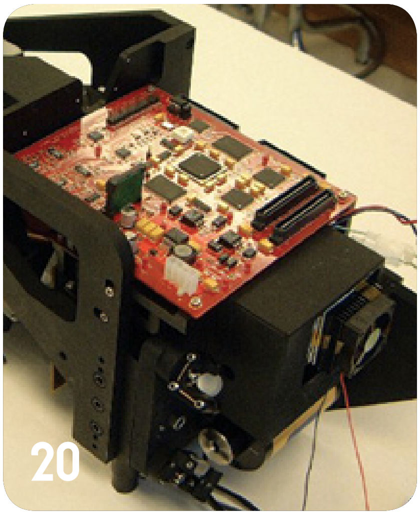
departments



features

The cover image reveals the Great Bend of Tibet's Yarlung Tsangpo River as it snakes its way, slicing deeply between two towering peaks in the eastern Himalaya. Rarely seen by western eyes, the Great Bend includes a set of powerful cascades, known as Hidden Falls and Rainbow Falls, which hold spiritual significance to the local people. The falls, un-navigable and deadly, guard the entrance to what is know as "The Lost Five Miles," a portion of the river canyon so remote that only the eye of a satellite can capture its full length.

Farther down the gorge, the Yarlung Tsangpo meets up with the Po Tsangpo, the confluence of which was the site of a major flood in June of 2000 due to massive landslides along a tributary that temporarily blocked the flow of the river. The release of this natural damn wiped out several bridges and scoured the canyon walls to a height of 150 meters. (Before and after images can be found on page 6.)

After descending at a rate ten times that of the Colorado River through the Grand Canyon, the Tsangpo reemerges in India as the Brahmaputra, joining with the Ganges, before spilling into the Bay of Bengal.

This 1-meter true color IKONOS image of the Great Bend was captured in May of 2000. South is up in order to enhance the interpretability of terrain relief. This image (along with others) was carried by a team of kayakers in February of 2002, as part of a modern day expedition to explore this remarkable region.

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Figure 1 *Imagery used for the 2002 image was captured in May 2000, prior to flooding that significantly changed the landscape. This is a 1-meter crop of the confluence of the Po Tsangpo with the Yarlung Tsangpo Rivers. Note that south is upward in these images, to better interpret terrain relief. When produced with north upward, the images seemed to reflect a river impossibly on the peak of the mountains.*

Figure 2 *This image was captured in November 2000, after the flooding from a landslide that occurred in June 2000. Three bridges are missing in this image. The team used an improvised cable-crossing at the location of "Bridge #3," which was probably not yet constructed when this image was taken.*

Hell or High Water

In a monumental kayak expedition in 2002, the legendary Tsangpo River of Tibet was finally, in an historic feat, successfully kayaked, using satellite imagery that served as an important map of the magnificent terrain ***(Figure 1)***.

About a month after this image was captured, a major landslide caused flooding of the river, changing the landscape and creating unexpected obstacles, such as washed out bridges and unrecognizable terrain ***(Figure 2)***.

Kayaking this river was previously attempted by four world-class paddlers in 1998. (That expedition was featured in the September/October 1999 issue of *Imaging Notes*.) It was sponsored by *National Geographic*, and was aborted after the tragic loss of one of its members 27 miles downriver. They made the huge attempt in early October, when the water flowed at 40,000 to 50,000 cubic feet per second (cfs).

The 2002 expedition was in January, when the water was coldest, but at its lowest level of approximately 15,000 cfs, after the monsoon and before the spring run-offs. The seven paddlers were led by Scott Lindgren, who had run rivers in the Himalayas for more than 10 years by age 30. Also along for the arduous land journey were 12 support team members and, at the beginning, 68 local porters.

These courageous kayakers paddled 95 percent of the water for 44 miles. The river dropped from an elevation of 9,800 feet to 500 feet in less than 150 miles, which is an average drop of 60 feet per mile. The Northeast Straights section of river dropped 250 feet per mile! In contrast, the Grand Canyon drops an average of eight feet per mile.

The satellite imagery was priceless for both the paddlers and ground crew. It provided much-needed security for the westerners, and the local porters literally knew where they were because the photo-real imagery was what they were used to seeing. They did not read topographical or traditional maps (of which the group had few), but their homeland was familiar to them from the images. "They were used to looking over the landscape from the vantage of high ridges," as was explained in Peter Heller's recently published book, *Hell or High Water*.

The book chronicles the drama, both on the river and on the shore, capturing tension and challenges between rocks and kayaks, Asian porters and western ground crew, and writer and paddler.

In describing the few white "blown out" sections on the "sat map," Heller wrote, "It was as if the sheer ferocity of the water stunned the digital code into a string of smitten zeroes. The satellite, from its safe distance of more than 400 miles into space, could snap a picture of the proud river goddess Dorje Pagmo, but it could not look into her heart or trace the entire length of her spine. The force and beauty of her uncurling majesty rendered entire sections incognito."

Satellite Imagery Debuts as Design

Satellite imagery made its artistic debut on opening night of a Canadian exhibition (commissioned and organized by the Vancouver Art Gallery) titled "Massive Change: The Future of Global Design," in October 2004.

This groundbreaking exhibition investigates the capacity, power and promise of design through a series of eleven general themes, from Urbanization to Energy to Wealth and Politics. Satellite images are displayed throughout the exhibit to educate and illustrate the fundamental role of design in all aspects of human life. Remote sensing is seen in the exhibit as having a profound effect on the potential for design to affect change on a global scale.

Samples of the exhibit are on the website, including "Urban Economies," found under "Design Economies."

Stunningly more accurate now than in 200 B.C. is this, from Quintus Septimus Tertullianus, "One thing is sure. The earth is now more cultivated and developed than ever before. There is more farming with pure force, swamps are drying up, and cities are springing up on unprecedented scale. We've become a burden to our planet. Resources are becoming scarce, and soon nature will no longer be able to satisfy our needs."

The exhibit also features satellite imagery within NASA's astonishing 'zoom-down' videos created by their Scientific Visualization Studio (SVS). The video simulates the experience of seamlessly zooming from outer space towards Earth's surface by combining data from MODIS, Landsat 7, and IKONOS imagery. To watch some of these videos at NASA's SVS site, go to: www.svs.gsfc.nasa.gov/stories/zooms/index1.html.

In January, the exhibition moves from the Vancouver Art Gallery to the Art Gallery of Ontario [AGO] in Toronto from March 11 to May 29, 2005, and then on to Chicago's Museum of Contemporary Art from September 2006 until December 2006. Other venues may include New York City and London.

See www.massivechange.com/inf_01.html and click on "Seeing is believing."

Satellite image of managed land: The pattern of management we apply to patches of land is clear from above. NASA's Terra satellite captured this image of the U.S.-Mexico border. Each segment is its own micro-managed system, unique from the rest, but alike in that it's regulated and designed. Image Courtesy NASA EOS, Terra Satellite.

Tsunami Raises Public Awareness of Imagery

The tragic tsunami in Asia has brought satellite imagery into the national consciousness like never before. This may prove to be the time when commercial use of imagery becomes more mainstream and accepted as an important tool for disaster response and other related applications.

Gleebruk, Indonesia *Above is a satellite image of Gleebruk, a village in the Aceh area of Sumatra, Indonesia, collected on April 12, 2004. Below is an image of the same shoreline collected on January 2, 2005, one week after the tsunami occurred. Images courtesy DigitalGlobe*

China's Rapidly Growing Strength in Remote Sensing

Recently I took part in an international conference in Beijing on remote sensing in archaeological research and heritage preservation. Supported by several Chinese research organizations, the conference was hosted by the Joint Laboratory of Remote Sensing Archaeology, with participation from the Chinese Academy of Sciences, Ministry of Education, and the National Bureau of Cultural Relics. The Institute of Remote Sensing Applications in the Chinese Academy of Sciences had a major role in organizing the event.

In addition to being extremely well-organized and managed, the conference illustrated the range of both archaeological and remote sensing studies that Chinese researchers are pursuing. It also demonstrated China's sophistication in analyzing remotely sensed data for archaeological purposes. China has stepped out strongly with a firm world leadership in remote sensing for archaeology and heritage preservation, establishing offices devoted to the subject in most provinces, and providing training in the Institute of Remote Sensing Applications.

The favorable impression I gained concerning China's recent progress in remote sensing was underscored when, following the conference, I was invited to visit the Institute to see the scope and depth of its work first hand. It is impressive, to say the least.

Located in Beijing near the site of the 2008 Olympic Stadium, the facility hosts several hundred researchers, students and staff in a setting overlooking the stadium venue, which is still a large hole in the ground. It is clear from the massive construction undertaken throughout Beijing that the Chinese intend to be ready with completed facilities in ample time for the 2008 event. They also seem to be working just as hard on their investment in remote sensing analysis and the development of new satellite systems.

In addition to the Institute of Remote Sensing Applications, China also supports several other government research institutes and numerous strong university programs in remote sensing. As its activities in the Joint Laboratory of Remote Sensing Archaeology indicate, it is attempting to bring remote sensing technology to bear on many aspects of its society.

China has a relatively long history in analyzing remotely sensed satellite data, having launched about 20 FSW-class recoverable panchromatic photographic cameras into orbit (reportedly 10-meter resolution) since the mid 1970s. In 1986, China opened a Landsat receiving station in Beijing. These capabilities were soon expanded to include the ability to collect SPOT, ERS, and Radarsat data. Today, you can find examples of nearly every kind of remotely sensed data available in China's laboratories and in the papers its researchers publish. China also has a robust program in developing sensors for aircraft platforms, including multispectral, hyperspectral, and SAR sensors.

Until recently, Chinese data users relied solely on data from U.S., European and Japanese satellites for multispectral imagery, but they have an active program to develop sensors and satellite busses, largely through cooperative activities with other countries. In 1988 it entered into partnership with Brazil to develop the China-Brazil Earth Remote Sensing Satellite, CBERS-2, which China launched in 1999. Also in 1999 Tsinghua University students and faculty built and orbited a moderate resolution smallsat in cooperation with the U.K. Surrey Space Technology Laboratories. These experiences have increased China's understanding of the development and operation of a digital, multispectral satellite, and of course have provided additional experience in processing and using such data for operational as well as for research purposes.

China's remote sensing experts are innovative, and are determined to improve both their analytical skills with data and their ability to create new, indigenous remote sensing systems. They are continuing the partnership with Brazil with the projected launch of CBERS-2B in 2006 and with a contribution to the four-member international smallsat Disaster Monitoring Constellation (DMC) in spring 2005. China's DMC satellite will carry the 32-m multispectral sensor common to all the DMC satellites, but also a 4-m pan sensor, putting China into the club of satellite owners who operate satellites capable of better than 5-m resolution. By 2010, Chinese space officials expect to have

orbited an entirely new generation of satellites for meteorology, environmental monitoring, and ocean surveillance.

As an important sign of its ambition to enhance its international reputation in remote sensing, China assumed the chairmanship of the Committee on Earth Observation Satellites (CEOS) in 2004 and in November hosted the 20th Anniversary Symposium of the organization. This put China in an excellent position to highlight its accomplishments for other CEOS members throughout the world.

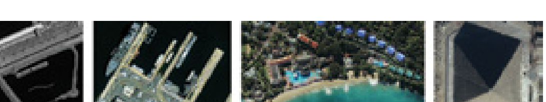
The United States needs to take note of China's expanded interests and seek to engage the Chinese in cooperative applications research. There is ample scope for cooperation in remote sensing in environmental and resource management subjects far removed from the sensitive military issues that have strained relations between the two countries.

Such cooperation would deepen U.S. knowledge of China's remote sensing efforts and give U.S. policymakers a better understanding of China's intentions in space. Besides, China has made intense efforts to reach out to European countries, to the European Union, and the European Space Agency in technical cooperation in a variety of space-related technologies.

Despite its recent progress, China still has a lot to do to catch up with its near neighbors, India and Japan in remote sensing capabilities. It lags far behind them not only in developing its own remote sensing systems but also in making use of the data to benefit its citizenry. Nevertheless, if it can maintain its current momentum, China will be able to catch up and perhaps surpass them within a decade or so.

RAY A. WILLIAMSON *is research professor of space policy and international affairs in the Space Policy Institute of The George Washington University, Washington, D.C. He is co-editor of* Commercial Observation Satellites: At the Leading Edge of Global Transparency, *ed., with John C. Baker and Kevin O'Connell (RAND and ASPRS: 2001).*

collected: 07 July 2004, IKONOS 4-meter | **Nantucket Island, Massachusetts**



A Vision of the Future

Military Base Installation Management

Steve Miller
Director, Defense Programs
Space Imaging
Reston, Va.
www.spaceimaging.com

The U.S. Department of Defense (DoD) is developing a new and distinctly different approach to how it creates and manages its geospatial information resources, to include geographic information system (GIS) and Global Positioning System (GPS) technologies, as well as the many spatial database holdings used to manage defense facilities. This approach is named the Defense Installation Spatial Data Infrastructure (DISDI).

The creators of DISDI envision an institutionalized process where installation geospatial data (in GIS, CADD, and imagery formats) are assembled, disseminated, and maintained in a fashion that supports validated DoD installation management and strategic basing decision missions worldwide. DISDI focuses on the business processes, people, and policies necessary to provide installation visualization and mapping capabilities, not on IT acquisition and IT development. DISDI is not a system, but rather a mechanism by which geospatial data stewarded at and by DoD installations can be shared with validated stakeholders to meet their critical installation visualization requirements. This article explores the history of DoD's efforts leading up to DISDI and how DISDI will better organize DoD's installation visualization capabilities.

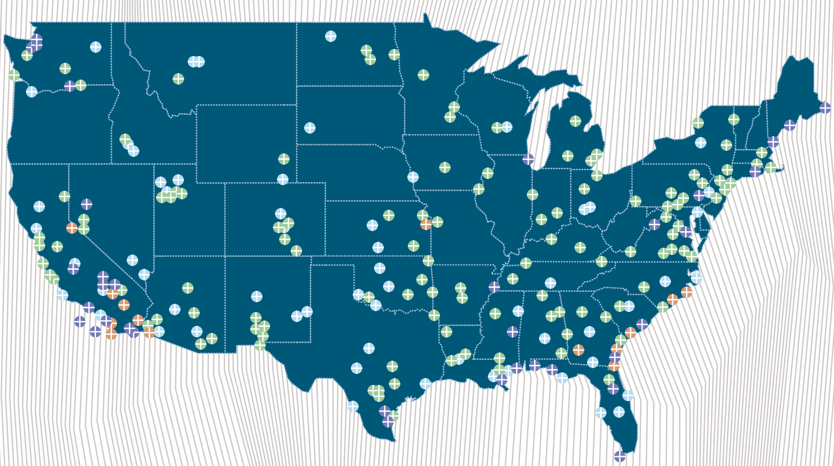


Figure 1. *Sampling of DoD Installations included in IVT.*

The DoD operates one of the largest and most far-flung property portfolios of any organization on earth. From humble origins over two centuries ago, its inventory of properties has grown to hundreds of thousands of properties (buildings, structures, and utilities) and sites all over the globe. The use of this land is as diverse as its size and distribution. Much of this property is used for activities with which any citizen can identify. DoD installations are "military cities" with housing areas, shopping centers, schools, medical clinics, and all the electrical, water, sewer, and surface transportation infrastructure to support them. There are also industrial areas where heavy equipment is built and maintained. Much of the land is allocated to large training areas in rugged and undeveloped regions. Finally, there are vast airspace and seaspace zones where the DoD performs essential readiness training. See ***Figure 1*** for holdings in the continental U.S. A summary of DoD property holdings illustrates the breadth of the installation management challenge:

- 586,962 structures worldwide (according to the Fiscal Year 2003 DoD Facilities Assessment Database)
- 522,724 of these are owned structures worldwide
- Over 5,500 locations worldwide
- Over 29 million acres of land worldwide
- Sites where over three million people live, work, and train every day
- $646 billion total value of buildings, structures, and utilities, using 2004 construction cost metrics

From early in the last century the DoD and successor organizations have maintained a sizable workforce of experts to manage these facilities in a way that maximizes use of taxpayer dollars and supports the DoD mission of maintaining fully trained and equipped units capable of defending the country. The four principal services—the Army, Navy, Air Force, and Marine Corps—have been the largest landholders and have traditionally carried most of the responsibility for the stewardship of defense properties. From the early 1900s the tools of the trade have included survey instruments used to gather data that was recorded on paper maps. Information on buildings was represented by architectural plans and site plans, again all on paper. All this data was stored locally at the base; very little of this information was available to other stakeholders when required.

This basic kit of technology and processes served DoD engineers well for most of the 20th century. Then, in the 1980s and into the 1990s, a number of enabling technologies emerged that rapidly redefined how facilities management information was generated, stored and viewed. The paper-driven processes gave way to geospatial information resources to include geospatial databases and technologies, such as GIS and GPS.

GIS rapidly became a common technology employed at DoD installations for managing these "military cities." GIS capabilities were often built around a loose set of requirements set forth at the installation itself and always reflected the local procurement practices and customizations needed by specific bases for dealing with the unique units they hosted and the geography in which they resided. This evolved by the late 1990s into a patchwork of systems and data. Much of the data for similar functions was stored in different proprietary standards, depending on which type of commercial GIS system was used. Getting data from one system to another was a costly and time-consuming process. Since data resided locally in a stove-pipe system, other critical stakeholders at the component and departmental echelon never had access to the "big picture" when required, to support strategic decision-making activities. This was a situation ripe for rationalization to better serve business needs and reduce costs.

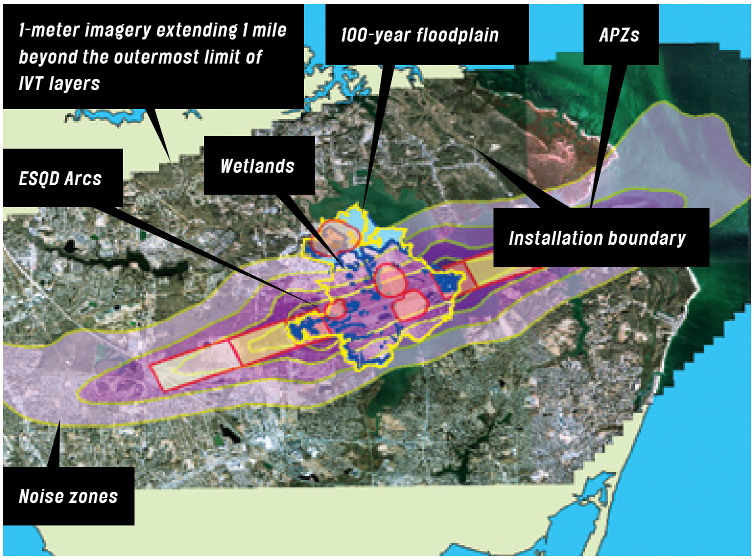


Figure 2. *The eight layers rendering a common installation picture in the DoD Installation Visualization Tool, supporting DoD BRAC 2005 installation visualization requirements.*

One of the first attempts to better organize the management of installations using GIS and related technologies was the USAF's GeoBase program. The GeoBase program was established in 2001 to exploit best practices for managing geospatial data across large organizations, and to establish policy, business processes, and architectures that better exploit installation geospatial information resources for installation management. Colonel Brian Cullis (USAF) was the principal architect for the GeoBase effort which began as a post-doctoral concept at the USAF Academy's Institute for Information Technology Applications. He had studied many early implementations of GIS programs that had been abandoned due to inflated and unrealistic goals, excessive cost-to-benefit ratios, and user reluctance to adopt, based in part on an overemphasis on the technology versus the enterprise mission processes. The GeoBase program was implemented in a way to avoid these earlier mistakes. The idea was to characterize geospatial information resources as part of the larger enterprise information environment, rather than as an asset relevant only to the engineering and public works mission. The program set modest and achievable initial goals and built incrementally on that foundation. The fundamental output of this new process was a common installation map which could be used to satisfy multiple business needs. The idea was to make it once and use it many times, building on what was already there. This plan reduced duplicative costs and improved the situational awareness of the two primary customers, facilities managers and warfighter planners. To accommodate this new strategy, the Deputy Chief of Staff for Installations and Logistics created the Headquarters Air Force Geo Integration Office (HAF GIO), led by Colonel Cullis, within the Pentagon's Air

Force Civil Engineer staff. Because of its success, this program has become a model within DoD for other efforts to organize and rationalize facilities management of GIS data.

Enter IVT

The Installation Visualization Tool (IVT) program was initiated by the Undersecretary of Defense for Acquisitions, Technology and Logistics in 2003 to visualize DoD installations via a common geographic information system (GIS) capability. IVT was designed to support the DoD Base Realignment and Closure (BRAC) 2005 process by supplementing internal DoD analysis with the capability to visualize mission realignment potential. The USAF was designated the lead service, given its success in implementing GeoBase principles. IVT included the assembly of eight "layers" of geospatial data chosen to help visualize base realignment constraints and opportunities. The layers were:

> "IVT was designed to support the DoD Base Realignment and Closure (BRAC) 2005 process by supplementing internal DoD analysis with the capability to visualize mission realignment potential."

1. *1-Meter orthorectified imagery of the installation and area within one mile of the installation.*
2. *5-Meter orthorectified imagery of the areas beyond the base, and areas beneath military training routes and special use airspace.*
3. *Installation boundaries*
4. *100-year floodplain boundaries*
5. *Accident Potential Zones (APZs) on and around runways and other landing zones*
6. *Noise Zones at various decibel levels*
7. *Wetlands boundaries*
8. *Explosive Safety Quantity Distance (ESQD) areas*

The base images were supplied by Space Imaging, LLC. The other six layers were prepared and provided by "data stewards" who are usually the local installation owners of that data. See ***Figure 2***. Managed by the HAF GIO, the IVT program sought to take advantage, as much as possible, of existing service GIS data investments. As with GeoBase, the standards were set by a central authority, but the responsibility for collecting and maintaining the data was implemented at the service and installation level. Metadata was a critical component of the IVT capability; each geospatial data set was accompanied by an associated metadata file documenting the sources used to create the geospatial features, data currency, accuracy, and contact information for the local data steward at the installation or service regional echelon. The IVT metadata conforms to the Federal Geographic Data Committee (FGDC) Content Standards for Digital and Geospatial Metadata. IVT data conform to the CADD-GIS Technology Center Spatial Data Standards for Facilities, Infrastructure, and Environment. A rigorous quality assurance and quality control process was established to ensure the highest possible accuracy and fidelity of the installation-provided data, thereby ensuring the most accurate maps possible. Each data set was provided with signature from the base commander, stating that the data was the best available, and a rigorous chain of custody process was established to ensure modifications were made to the data upon delivery by the installation.

The 1-meter and 5-meter resolution imagery utilized in IVT was acquired by the IVT Office via the National Geospatial-Intelligence Agency (NGA) Commercial Imagery Program. FGDC metadata was authored for each image scene by DoD IVT staff, thereby ensuring that all imagery met Federal metadata requirements.

Defense Installation Spatial Data Infrastructure (DISDI)

It was only a matter of time before the practical value of the Installation Visualization Tool would lead to new efforts to expand the visualization scope to include the balance of geospatial features across the installations and environment sectors. The DISDI office was created and staffed in July of 2004 and is located within the Business Transformation directorate, which reports to the Deputy Undersecretary of Defense Installation & Environment (DUSD/I&E). Colonel Cullis was assigned as DISDI Executive Manager in July 2004. Some of this office's initial challenges include:

- *Begin the process of building a coherent strategy for defining requirements for I&E geospatial data from* *across the many DoD missions that would benefit from such visualization capabilities;*

- *Appreciate the breadth of geospatial data holdings already acquired by the services by employing portfolio management techniques mandated by federal legislation;*
- *Draft policies to help shape the protocols and standards for I&E geospatial information resources so they are acquired in the most cost-effective manner and also comply with the emerging I&E and DoD business enterprise architectures, respectively;*
- *Identify and nurture partnerships with contributing defense, federal, national, and civilian commercial service and data providers.*

The DISDI program is gaining wide support since it now offers a new focal point for building business processes between data providers such as the NGA and the U.S. Geological Survey with the respective services' I&E geospatial infrastructures. It enables the congressionally mandated requirement to share GIS data across services and agencies. It facilitates the acquisition of data one time, and then distributing and reusing the data as needed by a multitude of internal customers. Also, DISDI will build on the considerable GIS data investment already made by the services. See ***Figure 3***.

Col. Cullis stated, "The DISDI initiative presents a great opportunity to demonstrate how a large federal agency can successfully integrate diverse geospatial information resource investments across the Army, Navy, Marine Corps, Air Force and National Guard Bureau cultures to yield a much more efficient and effective standards-based infrastructure sustained by local stewardship. It's surprising what you can accomplish when you focus on what geospatial information requirements the many services have in common rather than the differences."

In building on the success of IVT, the DISDI program will be expanded to include a focus on providing high quality, relevant DoD installation geospatial data to validated DoD, federal, and other users and stakeholders, for all DoD installations worldwide in support of various missions including homeland security/homeland defense, real property management, and environmental compliance and planning. In response to these critical visualization requirements, the scope will certainly be increased beyond the limited visualization capabilities included in IVT for the BRAC 2005 community. The enabling IT distribution architecture will also be expanded, with close coordination between the respective enterprise architecture efforts now underway both at the NGA and the DoD's Installations and Environment business domain.

Just as DoD is in the throes of transforming itself to more effectively address modern threats, the installation management community within DoD needs to do the same to support more cost-effective facilities management. The DoD has begun a sweeping review of its overseas basing structure, which is still largely configured to deal with the Cold War. Many are predicting momentous changes out of this review. DoD is now realizing the importance of having accurate, timely, and relevant installation maps and geospatial data to support the full breadth of installation management and strategic basing decision-making activities. DISDI can contribute substantially to this review by helping facilitate access to installation geospatial data in an organized, governed, and consistent fashion, while ensuring compliance with all relevant DoD and Federal information sharing and information security policies and protocols.

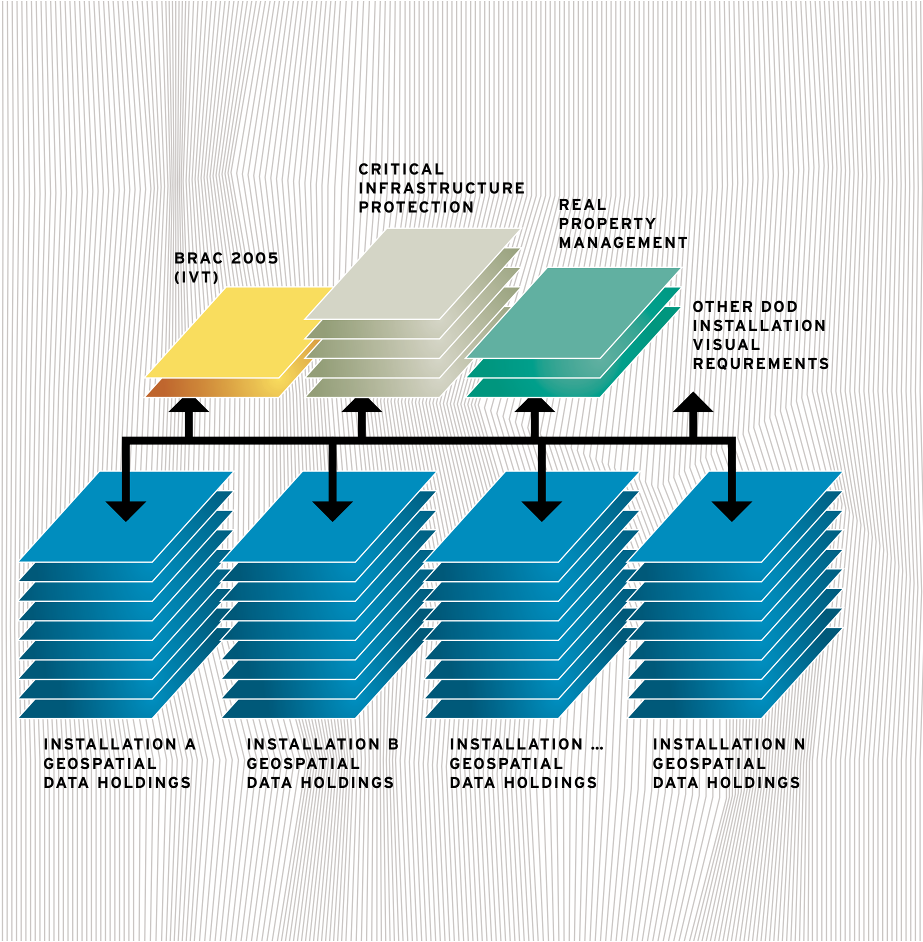


Figure 3. *The Defense Installation Spatial Data Infrastructure (DISDI) enables access to relevant installation geospatial data in support of various DoD missions and visualization requirements.*

Figures provided courtesy of the Department of Defense.

> Deploying within 12 hours, then bringing response time to three hours versus 10 was incredible, and the team hopes to further save critical time by deploying within six hours and bringing response time to 1.5 hours.

ARIES: Making Rapid Response a Reality

The ARIES ground component is an all-terrain, transportable and quickly deloyable system which receives data from the ARIES aircraft downlink, produces geospatial data products and provides additional built-in communications for voice and video data.

New combination of technologies has revolutionary impact.

ANNE MIGLARESE
CEO/President
TERRY BUSCH
ARIES Program Manager
EarthData
Frederick, Md.
www.earthdata.com

Airborne Rapid Imaging for Emergency Support (ARIES) is a response and recovery mapping and communications system inspired by emotion in the most trying of times. Having managed the collection, processing and production of digital orthophotography, LiDAR (Light Detection and Ranging) and thermal data to support first-responders in the rubble of the Sept. 11 World Trade Center attacks, EarthData Chair Bryan Logan recalled, "Deployment in 12 hours and map production in 10 hours set industry records, but the haunting sight of first-responders using a whiteboard to map real-time conditions at Ground Zero made it obvious that there had to be a faster solution."

To make a difference, EarthData envisioned melding existing mapping, downlink, and communications technologies into one system that would dramatically reduce the total time from system deployment through data collection and final data delivery. At Ground Zero, mountains of rubble, underground fires and totally unpredictable conditions redirected rescue and recovery operations constantly, confirming that the landmark data-production time of 10 hours alone was far too long to be of maximum utility to the responders. From lessons learned from this national tragedy, EarthData set a goal of developing a mobile system that would deploy to anywhere in the United States within six hours, collect data from multiple sensors simultaneously, then put data in first-responders' hands within three hours of acquisition - a monumental task.

FROM CONCEPT TO REALITY

Through a grant from the Department of Homeland Security, Office for Domestic Preparedness, EarthData was able to develop the system to make the dream a reality.

To move ARIES from concept to demonstration, EarthData assembled a team of industry leaders: Raytheon Solipsys to contribute its advanced mobile communications technologies as a ground station; Trex Enterprises to contribute its rapid downlink technologies; and EarthData to contribute the system foundation in the forms of its rapid-response experiences, program management, suite of airborne sensors, fleet of aircraft, and mapping technologies. With an immediate goal of three hour data production and a vision of near-real-time data delivery, the team designed ARIES to consist of five primary components:

- The airborne component includes the aircraft and sensors necessary to support emergency response, plus the onboard data recorders, positional data equipment and downlink antenna system.

ABOVE: *The ARIES air component collects color digital imagery, LiDAR, and thermal data and sends the data over a 1-gigabit-per-second direct downlink to the ARIES mobile ground processing center.*

TOP, RIGHT: *The ARIES communications tower, seen in the foreground, supports direct Internet connectivity, wireless networking, radio communications and satellite broadcast reception. Designed as a portable capability, all ARIES communication gear travels with the ground station and can be assembled instantly. The ARIES ground component, or production and communications center, can be seen in the background.*

- The ground component enables multiple-station image processing and dissemination in an all-terrain configuration that has self-contained power and air conditioning, large-screen displays, and multiple data sources for crisis management applications.

- The datalink component consists of an ultra-high-speed millimeter-wave wireless air-to-ground communications link between the sensor aircraft and the ground component and has the tracking capability required to maintain these links for the required downlink periods. The datalink currently operates at a 1.2 gigabit-per-second transfer rate at a range of approximately 10 kilometers.

- The storage and exploitation component uses a commercial off-the-shelf-based (COTS-based) system for rapid image processing, orientation and orthorectification. Portable workstations process raw data from multiple sensor types rapidly and efficiently into the required products.

- The dissemination component gets geospatial products into the hands of first-responders, situation commanders and decision-makers and is designed to provide interoperability with federal gateways such as the Geospatial One-Stop as well as other federal, regional and state systems.

THE PICATINNY DEMO — PROVING THE CONCEPT

On Nov. 17, 2004, Phase 1 culminated successfully in a live system demonstration at the Picatinny Arsenal in New Jersey. The demonstration simulated a full-scale mission to collect data over the entire arsenal (approximately a 15-square-mile site) during a seven-flight-line 1-hour collection with digital camera, LiDAR and thermal sensors recording simultaneously. Following collection, the plane orbited the arsenal at an altitude of approximately 5,000 feet about six kilometers from the site. The datalink system automatically located the aircraft, and a link established a 1.2 gigabit-per-second transfer of the five gigabytes of data directly from the aircraft into the central storage system within the ARIES ground shelter.

The LiDAR data was processed within 1.5 hours; the resulting 2.5-meter digital elevation model was used to create an orthorectified mosaic with 50-centimeter ground sampling distance in approximately 45 minutes. Concurrently, the thermal data was processed as an overlay layer to match the LiDAR and optical outputs. As soon as it was produced, the data was published via internet, wirelessly, and placed in a real-time visualization environment with tracking capability.

As the demonstration concluded, the ARIES connection was tested at the Picatinny Arsenal's emergency operations center to ensure data flow to a command and control element. Several more steps are under way to assess the data integrity as the data rolls from ARIES into the decision-making matrix for all responders.

Deploying within 12 hours, then bringing response time to three hours versus 10 was incredible, and the team hopes to further save critical time by deploying within six hours and bringing response time to 1.5 hours.

GEOSPATIAL DATA IN EMERGENCIES

While ARIES was conceived in response to the Sept. 11 terrorist attacks, it is not solely a terrorist response system. Quite the contrary, natural disasters occur multiple times per year, so ARIES' greatest contribution will be in response to hurricanes, tornados, earthquakes, fires and the like. ARIES can create a foundation for applications such as mapping corridors for rebuilding transportation infrastructure; monitoring changes of subsidence in rubble, or of collapsing structures; locating underground fires; imaging the degree and areas of destruction along tornado paths; planning evacuation and supply routes for areas threatened by hurricanes; and recording path shifts and resultant life and property threats of wildfires, to name a few. In all environments, near-real-time geospatial data and real-time communications amid rapidly changing and unpredictable conditions contribute to responders' safety and recovery efforts. ARIES is designed to deploy quickly and to function continually until crises are past. In this context, ARIES' potential speaks to lives instead of statistics.

ONLY THE BEGINNING

ARIES must evolve with new technologies and changing needs if it is to fulfill the vision of serving citizens and responders during national and international emergencies. The ARIES partners are committed to maintaining that state of preparedness. Possible Phase 2 system improvements include a downlink pod that can snap onto aircraft to increase options for aerial platforms and capacity, and for customized software and hardware that will expand interoperability. Increasing options reduces bottlenecks and obstacles caused by incompatibility among components, thus also significantly speeding total system function. Phases 3 and 4 will involve nationwide implementation, training, system upgrades, processes, and procedures to sustain the system into the future.

THE VISION

Beyond engineering enhancements, the vision for ARIES is to provide a nationwide system in which the United States would be divided into "joint task force regions" based on the current federal regional configuration used by the Federal Emergency Management Agency (FEMA). Each region would be assigned at least one commercially owned and operated aircraft fitted with appropriate sensors and download capability and with one or more ARIES mobile ground stations.

During non-crisis times, the regional aircraft and sensors would work on normal commercial airborne remote sensing projects, as presently is the case. In addition, these private-sector airborne assets could be contracted to collect more up-to-date data in strategic or vulnerable geographic areas as mutually agreed upon among the federal, state and local government agencies. In the event of a disaster, the rapid response data collection aircraft would be deployed to the site.

Not even sophisticated disaster prevention plans lessen the need for timely information presented in an easy-to-use format, and the quicker the response, the more likely lives would be saved, property damage would be accurately assessed and recovery actions would proceed with accurate information. ARIES responds to these requirements with mobile, onsite geospatial data processing centers capable of integrating "before" and "after" data to create multiple tiers of products with related analyses. These products range from near-real-time lower-accuracy high-resolution maps to those of extremely high accuracy, which are also high resolution. As described, this model also would employ a web-based database to enable first-responders to interrogate the data and make requests or advise other responders even from thousands of miles away.

Unfortunately, disasters, whether natural or intentional, are a fact of life. Fortunately, ARIES promises to speed response and to provide detailed near-real-time geospatial data and communications that enable concerted, coordinated effort among data providers, crises responders, situation commanders, and policy decision-makers at domestic and international disaster sites. ARIES may become a national asset to serve citizens and first-responders when they need help the most, and people will no longer be haunted by the vision of a whiteboard as the fastest means to deal with emergencies in real-time.

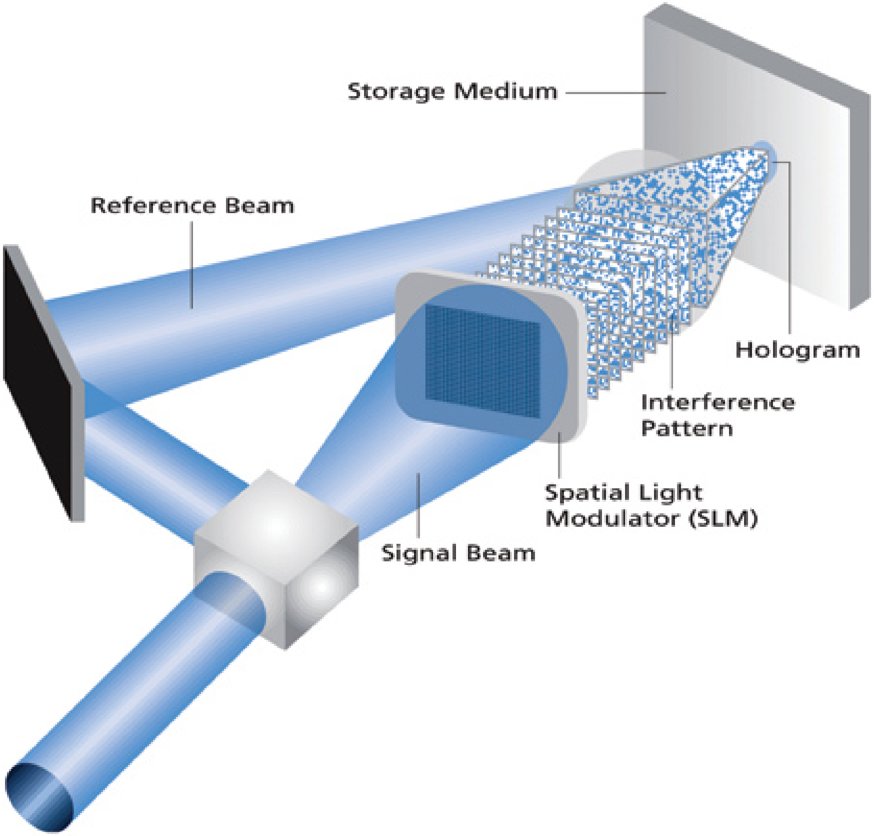


Figure 1: Recording a hologram, or index modulation

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Holographic Data Storage

New Technology Meets Exponential Growth Needs

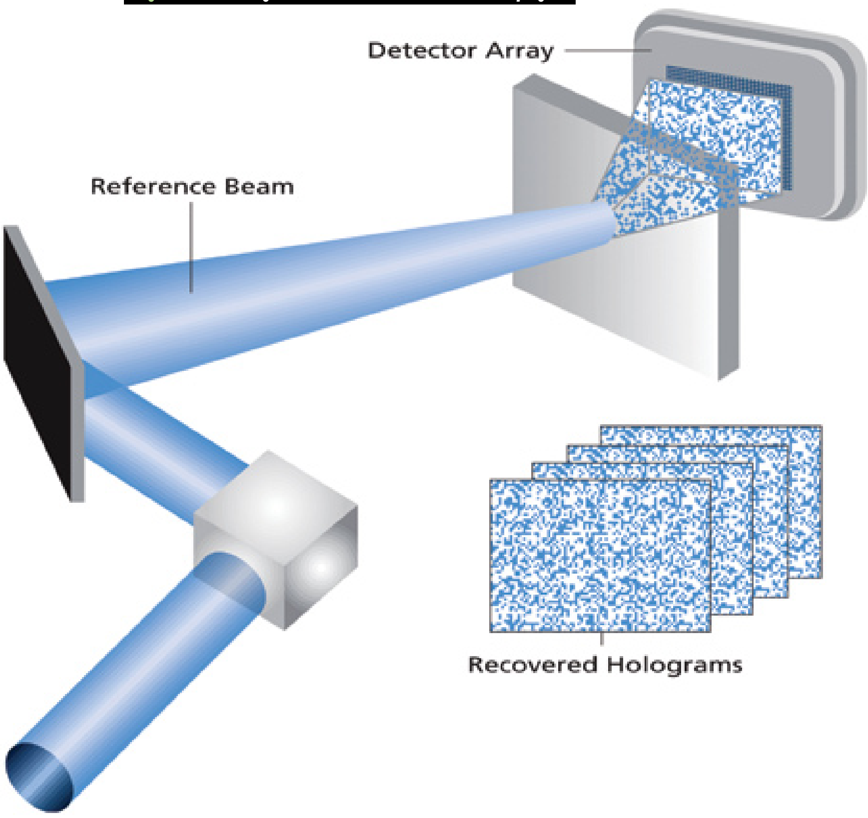

Figure 2: Reading data via a reconstructed data page

The pressures on today's data storage technologies are tremendous. According to a study at University of California at Berkeley, more new information is predicted to be stored in the next several years, than in all of previous recorded human history combined.

High-resolution satellite imagery, high-definition video, and full body scans are just some of the applications that are driving this exponential growth in data storage requirements. Add the compliance regulations in many industries that require long data archive retention periods, and that specify the manner in which data must be protected, accessed, and archived, and the scope of the data storage problems becomes enormous. How will the petabytes of data be stored and protected?

Even as storage needs are increasing exponentially, technology improvements in current magnetic and optical data storage systems are saturating. Physical barriers that limit their theoretically achievable storage densities and data transfer rates frustrate advances. Holographic Data Storage (HDS) is a technology that makes possible storage densities that exceed the barriers of traditional magnetic and optical recording. HDS has the capability to meet and exceed the expected storage demands well into the 21st century.

A series of innovations that solve the fundamental problems associated with the development of high-density data storage as implemented via holographic technology have been developed in the past several years. These include the creation of a commercial holographic storage material, and development of key holographic recording techniques. The National Technology Alliance funded the development of the photopolymer recording material, the automation of media manufacturing, and the development of system electronics, data formats, and electronic and logical interfaces in the holographic drive to be used by the National Geospatial-Intelligence Agency (NGA).

RECORDING DATA

Unlike conventional storage technologies that record and recover data bit by bit, holography allows a million bits of data to be written and read out simultaneously. The primary advantage of holographic storage comes from using the volume of the media and not just the surface to store information.

Light from a single laser beam is split into two beams—the signal beam, which carries the data, and the reference beam. The data are encoded onto the signal beam by a spatial light modulator that translates the bit stream of 0's and 1's into an optical "checkerboard" pattern of light and dark pixels. The data are arranged in an array or page of ~1 million bits. The hologram is recorded in the storage medium at the point of intersection of the reference beam and the data-carrying signal beam. See ***Figure 1***. By varying the reference beam angle, wavelength, or media position, multiple holograms are recorded in the same volume of the medium, vastly increasing the data density.

READING DATA

In order to read the data, a reference beam with characteristics identical to that used to store the data diffracts off the index modulation (hologram), reconstructing the stored data page. The reconstructed data page is imaged onto a detector that reads all of the one million bits on the data in parallel. This parallel recording and read out of data provides holography with its very fast transfer rates. See ***Figure 2***.

INPHASE'S TAPESTRY MEDIA

The major challenge to implementing holographic storage had been the development of a suitable storage medium. InPhase solved this issue by developing a new class of photopolymer materials that satisfy the stringent criteria for commercial viability. The material offers high dynamic range, high photosensitivity, dimensional stability, optical clarity, manufacturability, nondestructive readout and thickness, and environmental and thermal stability.

Typical photopolymers use a single chemistry for bonding molecules together to form the media and to perform the recording. The InPhase polymer system utilizes materials that use two distinct chemistries that are independent yet compatible. One chemistry is used to form the media and to control the mechanical, manufacturing, and archive life parameters. The second chemistry is used during the recording process. These two chemistries do not interact or interfere with each other, thus enabling high dynamic range with extremely good dimensional stability during recording. See ***Figure 3***.

In addition to developing a new class of materials, InPhase Technologies also developed the ZeroWave manufacturing processes, which enables the cost-effective fabrication of optically flat media and makes the media price-competitive for mass consumption. Hitachi Maxell, Ltd. (Tokyo), a key investor and development partner of InPhase, has developed a new light-tight cartridge suitable for the photopolymer material and is also developing high-volume manufacturing processes.

THE HOLOGRAPHIC RECORDER AND PLAYER

The next step in commercialization is the development of a drive system that records and reads the data. In October of 2004, InPhase built the world's first integrated holographic drive prototype that includes each of the primary functions of channel, mechanical, optical, and servo sub-systems. The completion of the prototype was enabled by InPhase's development of key recording techniques and by the availability of critical components. In the past, high-quality lasers were costly and unreliable. However, the 407-nm blue lasers used in other optical devices meet the requirements. CMOS (Complementary Metal Oxide Semiconductor) active pixel sensor arrays used in digital cameras are also available, as are digital micromirrors, and ferroelectric modulators used in digital TVs and projectors. These components are commercially available, or in some instances are being customized in cooperation with industry partners. Displaytech (Longmont, Colo.) is InPhase's partner for the spatial light modulator and the two companies have formed a joint development partnership funded by a grant from

> "The primary advantage of holographic storage comes from using the volume of the media and not just the surface to store information."

the Advanced Technology Program in the Department of Commerce, for the development of a modulator to be used in a 1.6 terabyte holographic recording device.

The first holographic drive prototype is based on write once read many (WORM) media, with a 50-year life and is an ideal fit for long-term archive applications. The system records and reads data using a 407-nm laser into 1.5-mm thick photopolymer recording material which is in a 130-mm disk format. See ***Figure 4***. The media cartridge is loaded and unloaded automatically using a loader mechanism developed for InPhase by Alps Electronics (Tokyo), an InPhase investor and development partner.

The prototype records 1.3 million bits of data in one page and 80 to 130 pages of data are recorded in a single location in the disk. See ***Figure 5***. Each data page is recorded at an unique angular address separated by .1 degrees. A collection of data pages is referred to as a book and additional data density is achieved by significantly overlapping the books of data. This polytopic recording method invented by InPhase has demonstrated a capacity of one hundred gigabits per inch squared. The average exposure time per page is under 10 milliseconds achieving a 6MB/s transfer rate at density.

The prototype system serves as the mile marker on the path to commercialization of holographic storage. The InPhase family of holographic drives and media will range in capacity from a minimum of 200 gigabytes to 1.6 terabytes with transfer rates from 20 MB to 120 MB per second. The first generation Tapestry drive product will come to market with a minimum capacity of 200 GB and a 20 megabytes-per-second transfer rate.

Holographic technologies will enable the highest density removable media with transfer rates much faster than other optical devices. Ultimately, the technology will be integrated into a multitude of products ranging from enterprise solutions to consumer devices. The long-term vision is that holographic technology will take on a prominent role in the storage landscape, addressing the highest demands in human history.

***Figure 3:* Storage media with two distinct chemistries, independent and compatible**

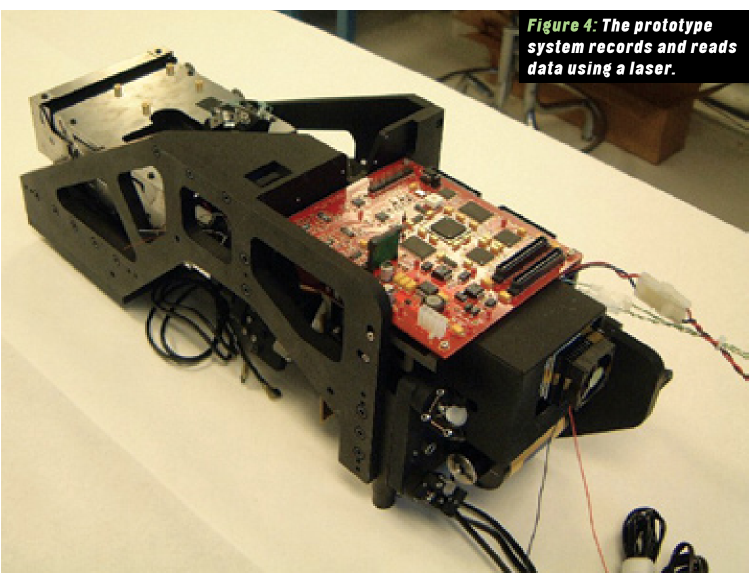

***Figure 4:* The prototype system records and reads data using a laser.**

***Figure 5:* Example of a 1.3-megabit data page**

Predicting Risk of Vector-borne Disease

Figure 1: ***Anopheles gambiae mosquito, which transmits the malaria parasite, courtesy of CDC.***

Mosquitoes, Malaria and Worms

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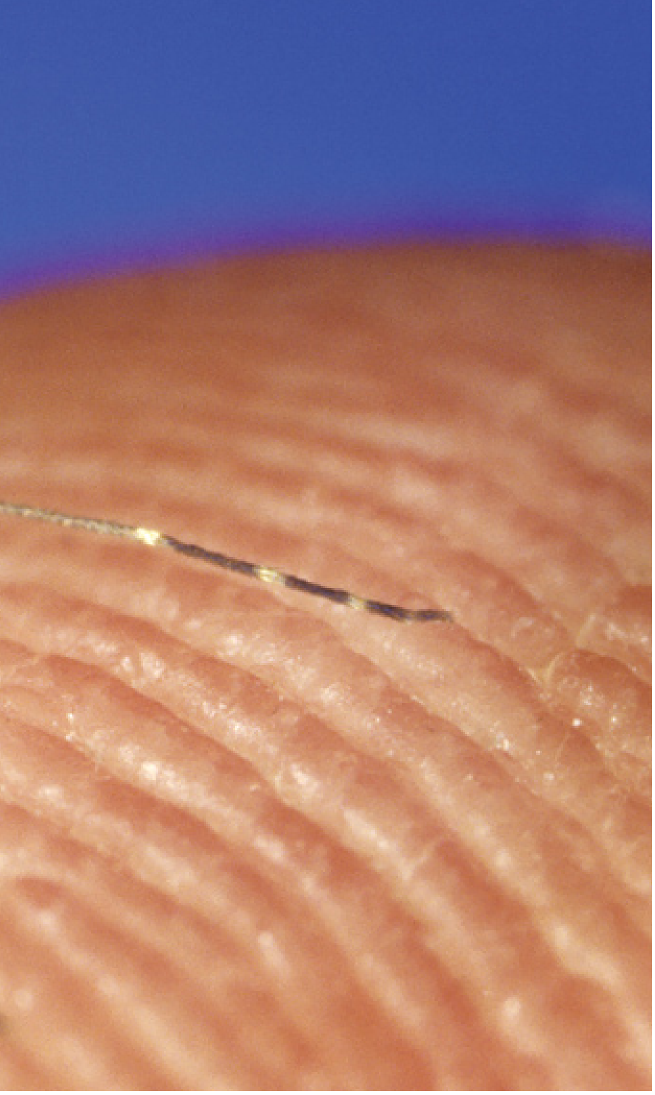
Mosquito-borne infectious diseases, including malaria, dengue and West Nile, are among the chief concerns for global public health. Remotely sensed data is now being used to predict the risk of vector-borne disease worldwide.

Currently, the annual death counts due to vector-borne infectious diseases (those transmitted by arthropods, including mosquitoes) are massive. Malaria alone accounts for more than 300 million acute illnesses per year with at least one million deaths annually, according to the World Health Organization (WHO). See ***Figures 1 and 2***. Dengue, also a mosquito-borne infection, has become a major international public health problem. WHO estimates that worldwide, mostly in tropical and subtropical regions, there may be more than 50 million cases of dengue infection every year. The 1999 emergence of West Nile Virus (WNV) in New York has brought the threat of infectious disease to the forefront in the U.S. WNV, although not accounting for the same high morbidity and mortality figures as other vector-borne diseases, has caused an increase in epidemiological surveillance in the U.S. and become a public health concern.

Vector-borne diseases take a heavy toll on the health of the global population. However, we are in the age of novel and cost-effective control strategies as governments and private entities are increasing their motivation towards disease prevention. Spatial analysis and remote sensing technologies are rapidly developing to complement international disease-control strategies. For example, WHO has called for the development of innovative methods for malaria surveillance and control (Najera 1989). Such development requires definition of the environmental determinants and epidemiological parameters that affect the patterns of the malaria vector distribution, the host distribution, and the risk of disease transmission. Remote sensing is increasingly being used as a tool to collect data about the environment that is applicable to vector-borne diseases.

Recognizing the aspects of the environment that lend themselves to disease transmission can be tough business. For example, the larval stage of the malaria vector develops in an aquatic environment. One strategy for reducing the numbers of mature malaria mosquitoes is treating aquatic areas with mosquito control products. However,



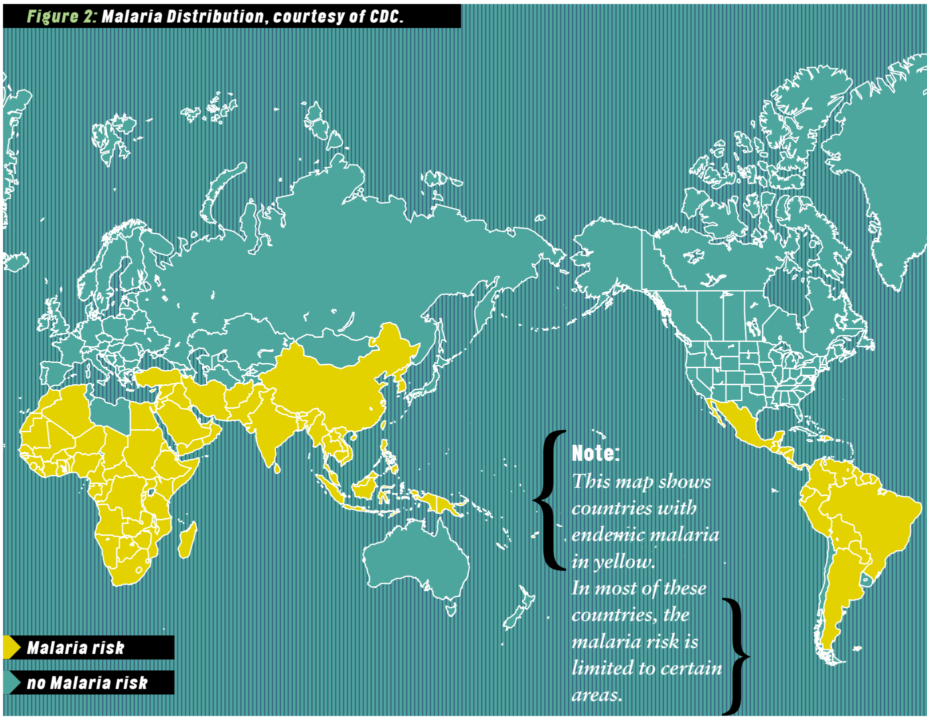


Figure 2: Malaria Distribution, courtesy of CDC.

locating these prime mosquito habitats is often not feasible due to high cost and time constraints. In addition, the land area under consideration may be too large for mosquito control technicians to locate all of the mosquito habitats. By utilizing remotely sensed data, scientists are able to collect information about the suitability of a specific landscape for the establishment of disease vectors. Remotely-sensed attributes of the landscape such as vegetation cover may act as indicators for disease risk.

A number of studies have used a remote sensing/GIS approach to analyze the risk of vector-borne disease. Several studies have then used the gathered data to design strategies to reduce the risk of vector-borne disease through mosquito control operations. For example, in California, both LANDSAT (USGS, EROS Data Center) and aircraft were used in a project to monitor rice fields for water quality, vegetation and mosquito abundance (Wood et al. 1991). The principal mosquito monitored was Anopheles Freeborni, also called the western malaria mosquito. Researchers observed that the Anopheles population peaked in August followed by a rapid decline in September when rice fields were drained before harvest. The remotely sensed data provided information about the 'greenness' of the rice fields. The research showed that the fields that 'greened up' earlier supported higher populations of Anopheles Freeborni larvae. In addition, rice fields that tended to have slower crop growth supported fewer mosquito larvae. Based upon remotely sensed data that was collected early in the mosquito season (June), researchers were able to correctly predict 81 percent of the rice fields that would support high mosquito numbers throughout the season. This early prediction of mosquito numbers occurred two months prior to peak mosquito abundance. Such early prediction provided by remote sensing data is very beneficial to mosquito control operations by determining which rice fields need focus for efficient mosquito control.

If the goal for this RS/GIS study in Californian rice fields was to use remote sensing data to gain a new perspective of mosquito dynamics, then this study achieved its purpose. However, we must consider the aspect of scale in these studies. The 30-meter resolution LANDSAT images were useful in the rice field study to resolve mosquito habitat within the fields. However, in a more heterogeneous landscape where the scale of mosquito habitat can be much smaller than 30-meter, an image of finer resolution is essential. For example, LANDSAT images may not be the most appropriate data for the study of urban malaria transmission or WNV (Castro et al. 2004). Important breeding sites for the vectors of urban malaria and WNV are often smaller than 10-meter and would thus require higher resolution imagery.

In 2003, an article was published comparing the usefulness of LANDSAT imagery with that of IKONOS to determine the location of mosquito larval habitats on a U.S. military base in the Republic of Korea (ROK, also

Figure 3: ***Schistosoma worm, courtesy of SCI and Environmental Health Perspectives***

Figure 4: ***IKONOS imagery of the northern region of the study area in Colorado***

known as South Korea) (Masuoka et al. 2003). Malaria had reemerged in the ROK in 1993 and this study was aimed at reducing the risk of malaria transmission to U.S. personnel. If larval habitats could successfully be identified, necessary mosquito control measures (using larvicide in aquatic habitats to kill mosquito larvae) could be used to reduce the risk of malaria. Both IKONOS and LANDSAT images were used to identify mosquito larval habitat on the military base. Following larval collection and image classification, researchers calculated land cover estimates of mosquito larval habitat based on both types of remote sensing imagery. Masuoka et al. found the IKONOS imagery was able to resolve small irrigation ponds more accurately than the lower-resolution LANDSAT imagery. They found that although these small ponds represented a minor portion of the total mosquito habitat, they were important mosquito breeding sites. The researchers concluded that for areas where small niche features represent the majority of mosquito habitat, high resolution imagery is necessary for correct identification of the habitats, and for the planning and implementation of a mosquito control program on the U.S. military base.

Just recently, published results of several other spatial disease projects have become available. Two of these projects have focused on urinary schistosomiasis, an endemic disease in many sub-Saharan countries in Africa. Human contact with the Schistosoma parasite often occurs during domestic activities like clothes washing and bathing in surface waters. S. haematobium invades the veins around the urinary tract in infected individuals. Bulinus snails, the important intermediate hosts of the Schistosoma parasite, are found in small water sources. ***Figure 3*** shows a Schistosoma worm.

Kariuki et al. (2004) used satellite imagery in their study of the spatial distribution of the Bulinus snails. In a companion study, Clennon et al. (2004) used the same image to study the distribution of human cases of urinary schistosomaisis and the transmission dynamics of S. haematobium. Demographic, parasitologic, and household location data were mapped for an area in the Coast Province of Kenya. All distances were calculated between houses and water sites to detect clustering of human schistosomiasis infection. Overall, the transmission pattern of urinary schistosomiasis was highly associated with the spatial distribution and abundance of Bulinus snails. The spatial and temporal variation of snail abundance generated by this research is vital for successful schistosomiasis control programs.

The Arthropod and Infectious Disease Laboratory (AIDL) at Colorado State University is utilizing IKONOS imagery for the study of disease vectors. As mentioned previously, the emergence of WNV has caused an increase in public health concern for mosquito vectors in the U.S. Colorado has been greatly affected by WNV, with 2947 human cases in 2003 and 225 human cases as of Oct. 6, 2004 (Centers for Disease Control and Prevention, or CDC).

The study area for our project is located within Larimer and Weld Counties of Colorado along the Front Range of the Rocky Mountains. Two satellite images incorporating urban, suburban, riparian and agricultural areas are being used for a base map. See ***Figure 4***. The main goal is to identify whether researchers can correctly determine mosquito habitats within the study area.

We trapped mosquitoes at a number of sample sites within the study area during the summer of 2004. The mosquito collection data will be statistically analyzed in relation to an unsupervised classification of the satellite images covering the study area.

Several mosquito species are found within the study area. Some of these mosquitoes are considered nuisances and do not transmit disease. Others, like the Culex species, are able to transmit WNV. AIDL proposes that satellite imagery will serve as a useful tool for identifying the habitat of a number of mosquito species within the study area. If this assumption is correct, the imagery may someday be used within a model to streamline mosquito control operations by targeting pesticide application to the identified prime mosquito habitats. Such a model has the potential to limit over-application or under-application of insecticides. A model based upon satellite imagery could reduce transmission of mosquito-borne diseases like WNV as well as reduce costs and limit unnecessary environmental exposure to pesticides.

Globally, vector-borne diseases are an imminent threat to healthy human lives. The field of remote sensing has developed along with vector-borne disease research to address the problem of disease. As technology increases and satellite imagery becomes more refined, the science community must continue to examine the usefulness of remote sensing in vector-borne disease research. The applications of remote sensing are immense and human health is at stake. Vector-borne disease must be controlled to increase the quality of international human health, and the capabilities of remote sensing will contribute to that control.

References

Castro, M., et al. (2004). **Integrated Urban Malaria Control: A Case Study in Dar es Salaam.** *American Journal of Tropical Medicine and Hygiene, 71 (Suppl 2), 103-117.*

Center for Disease Control (2004). **West Nile Virus Statistics, Surveillance and Control.** *Retrieved from www.cdc.gov/ncidod/dvbid/westnile/surv&control04Maps.htm*

Clennon, J., et al. (2004). **Spatial Patterns of Urinary Schistosomiasis Infections in a Highly Endemic Area of Coastal Kenya.** *American Journal of Tropical Medical Hygiene, 70(4): 443-448.*

Kariuki, H., et al. (2004). **Distribution Patterns and Cercarial Shedding of Bulinus Nasutus and Other Snails in the Msambweni Area, Coast Province, Kenya.** *American Journal of Tropical Medical Hygiene, 70(4): 449-456.*

Masuoka, P., et al. (2003). **Use of IKONOS and Landsat for Malaria Control in the Republic of Korea**. *Remote Sensing of Environment, 88, 187-194.*

Najera, J. (1989). **Malaria and the Work of WHO.** *Bulletin of the World Health Organization, 67:229-243.*

Wood, B., et al.(1991). **Distinguishing High and Low Anopheline-producing Rice Fields Using Remote Sensing and GIS Technologies.** *Preventive Veterinary Medicine, 11, 277-288.*

World Health Organization (2004). **Dengue Fact Sheet.** *Retrieved from www.who.int/mediacentre/factsheets/fs117/en/*

World Health Organization (2004). **Roll Back Malaria Fact Sheet.** *Retrieved from www.rbm.who.int/cmc~upload/0/000/015/372/RBMInfosheet~1.htm*

The author would like to thank Dr. Chet Moore and Keith Olson.

Figure 2 **Maritime traffic in waters off the coast of Singapore, IKONOS 1-meter color, March 2, 2002**

Making Waves for Maritime Criminals

Commercial Satellites Provide Unprecedented Ocean Surveillance Capabilities

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Maritime crime has been with us since man first ventured to sea. From the Phoenicians to the Vikings to the legendary 18th century buccaneers that have captured our imaginations, pirates have stalked the high seas preying on merchant vessels throughout history.

Maritime crime, however, is more than lore from another time and is not limited to piracy. Criminal offenses at sea remain a problem today and have tripled in the past decade, according to the International Maritime Bureau (IMB). An early 2004 IMB report indicates that worldwide pirate attacks increased in frequency and violence from previous years with a total of 445 attacks reported in 2003. See **Figure 1**. Apart from piracy, present day illegal activities at sea include drug trafficking, human smuggling, maritime fraud and terrorism, offenses against the maritime environment, and illegal fishing. The latter has become of serious concern to conservationists and international fishing industries as fisheries dwindle. In Australia's northern waters alone, about 150 illegal Indonesian fishing boats were apprehended this year and it is believed many more are avoiding capture.

The temptation of perpetrators to participate in maritime crime can be attributed, in part, to their knowledge of the difficulties that countries face in combating it due to inadequate legislation, lack of trained personnel and modern equipment, weak maritime law enforcement capabilities, and the sheer vastness of the ocean. Additionally, maritime offenses are often transnational by nature, with more than one national jurisdiction involved, further complicating law enforcement at sea.

In a move to address this latter issue, the United Nations Convention on the Law of the Sea (UNCLOS) was adopted in 1982 at Montego Bay, Jamaica. Critical to the UNCLOS conventions are articles defining the exclusive economic zone (EEZ) — an area, including the ocean floor, extending 200 nautical miles beyond a coastal nation's territorial sea.

The EEZ concept serves as an important milestone in building an international framework for maritime law, defining a coastal nation's sovereign rights and jurisdictions over the exploration and exploitation of marine resources within its EEZ. However, the articles do not authorize nations to limit passage through these waters, presenting law enforcement challenges for responsible nations — how to police such a vast area of ocean.

SURVEILLANCE FROM SPACE

Until recently, strategic maritime reconnaissance has been performed exclusively by airborne platforms or ship-based radars. The effectiveness of these methodologies is limited by the extent of coverage they are able to provide on a daily basis. Already an expensive proposition, these ocean monitoring approaches become cost-prohibitive for nations with large EEZs. The introduction of space-based surveillance complements existing maritime law enforcement assets and permits aircraft and surface ships to more effectively monitor and track suspect vessels as opposed to conducting broad ocean surveillance.

Low-cost, high-caliber synthetic aperture radar (SAR) earth imagery has been commercially available since 1995 when RADARSAT-1, a commercial space-borne SAR satellite, began providing 10- to 30-meter resolution imagery. Since that time, other commercial satellites have become available, including the European Space Agency's ENVISAT ASAR, and electro-optical (EO) systems such as the Indian Remote Sensing (IRS) 1C, 1D and RESOURCESAT-1, SPOT 2, 4, and 5, and IKONOS satellites that are capable of providing broad area imagery with resolutions of .82 to 20 meters.

In terms of coverage, these satellites can see vast areas of the ocean—the entire eastern coast of the United States, for example—in a matter of minutes. The swath width of a satellite is a function of resolution; the higher the resolution, the more narrow the swath width. Medium resolution commercial satellites such as IRS and SPOT provide wide swath coverage of 70 and 120 kilometers respectively, ideal for monitoring vast EEZs to detect and classify suspect vessels. A higher resolution satellite such as IKONOS at about one-meter resolution is better suited for "point targeting," allowing detailed analysis for positive identification of even smaller, faster craft often used for smuggling. The combination of these systems provides the ability to detect, classify, and identify vessels operating throughout the world. See ***Figures 2*** and ***3***.

Leveraging these satellite surveillance capabilities to combat offenses at sea requires a solution that provides rapid processing of the data from the time of image acquisition to the dissemination of reports to surface and air law enforcement units. OceanView, a maritime surveillance system jointly developed by Vexcel Corporation (Boulder, Colo.), a global remote sensing company, and the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) of the University of Miami (Miami, Fla.) addresses the need for such a solution, providing automated ship detection in real-time and at a fraction of the cost of conventional surveillance methods.

OceanView automatically locates ships and other maritime objects within the imagery provided by satellites. It is designed to operate within the processing queue of a ground system and to process image data as soon as it is required. The entire process, from data downlink to report generation, requires little human intervention and takes just under an hour for SAR data—half that for EO data. Once the satellite imagery has been received, the detection process begins with the separation of land data from water data. After this land mask has been established, the system detects objects in the ocean imagery, automatically pre-screening and removing detected objects situated near known stationary points, such as oil platforms. Remaining objects are assigned a ship prob-

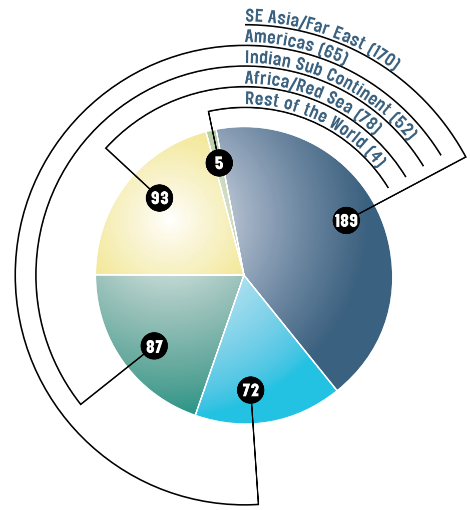

Figure 1 *Total reported incidents in 2003 by region. Numbers in brackets are for 2002.*

Figure 3 *Higher resolution satellites allow detailed analysis for positive identification of even smaller, faster craft like this, often used for smuggling.*

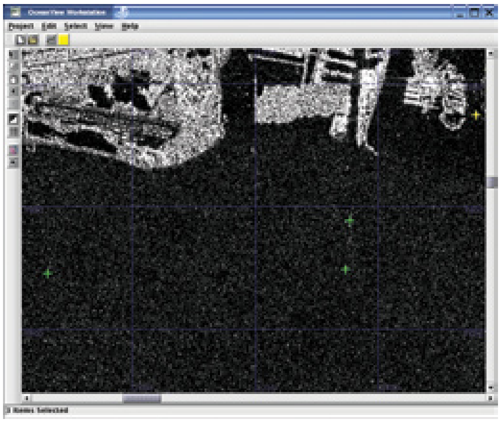

Figure 4 *OceanView-processed image showing detected vessels (indicated by color crosshairs) in waters off Florida Keys.*

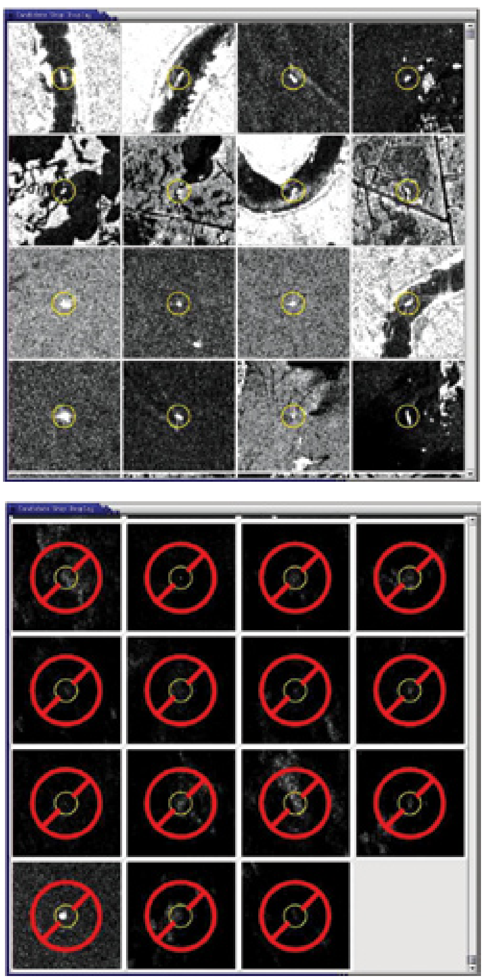

Figure 5 *Detected objects displayed in OceanView in order of probability. Objects in the top window have been flagged as potential vessels while the objects in the bottom window have been identified as unlikely to be vessels and will not be exported as ships to the Gold Report.*

ability score based on the value of parameters calculated for the detected object that include: length, width, heading, cross-section (integrated brightness), position (line pixel or latitude/longitude), brightness, and ratio of object brightness to mean neighborhood brightness.

Additionally, the system can estimate vessel speed and course through the detection and measurement of ship wakes and can provide ship analysis through image sharpening techniques.

Image analysts control the acquisition of imagery and maritime targets to discern whether detected objects require a closer look by the human eye. They may also interactively adjust the parameter values used to discern ship probability. The entire process can be operated onsite or the data can be quickly moved to a remote location for analysis. Once the results have been reviewed, the analyst may then generate and distribute reports in the NATO standard OTH-GOLD format and in the form of a web page with imagery available worldwide from an encrypted web site.

Because the operations occur in real-time, land and sea forces can be immediately mobilized to intercept suspect vessels. The ability of a satellite to perform electronic intelligence while being completely unobserved by suspect vessels, with real-time streaming of data to other assets, allows maritime law enforcement the element of surprise and reduces the number of manned aircraft placed in harm's way, particularly in a war zone. An additional and significant advantage is the ability to monitor maritime activities at night and in bad weather when movement of clandestine vessels may be most likely.

SEEING IS BELIEVING

In mid-2004, Vexcel and CSTARS demonstrated the OceanView ocean surveillance system installed and operational at the CSTARS ground station facility in South Miami to representatives of the U.S. Navy, Coast Guard, Homeland Security, and the office of the Secretary of Defense.

RADARSAT-1, operated by Radarsat International, was used to provide a real-time, real-world test of the system, structured to prove the suitability of the project for U.S. Homeland Security and coastal surveillance. Within minutes, a detailed picture of the nearby ocean ranging from the Caribbean Sea to the Gulf of Mexico near the panhandle of Florida—a pass of about 4600 km—was captured and available for processing. See ***Figure 4***.

As the satellite made its pass, the SAR data was downlinked and archived at the CSTARS facility. Under the careful observation of the distinguished guests, the data were then processed and the ships were automatically detected by the system in real-time.

The representatives looked on as quality control was performed on the automatic ship detection and displayed on one of the facility's large computer monitors. The entire exercise from downlink to ship detection, including verification by experienced imagery analysts, occurred within 60 minutes. The exercise demonstrated the existence of a readily available, low-cost, proven solution to detect and classify ships within a probability range of 95 to 98 percent—an alternative to the traditional methods of ship detection involving aircraft and high resolution government satellites, allowing an unprecedented broad surveillance range through inexpensive, medium-resolution commercial satellites.

CONCLUSION

Maritime crime today is much more complex and sophisticated than in earlier centuries when legendary pirates terrorized the high seas, and presents serious security and law enforcement concerns for coastal nations. Order at sea must be secured to permit the free flow of sea-borne trade and to ensure the preservation and protection of marine environments. To step up actions to counter this growing menace, maritime law enforcement agencies must now look to innovative technology solutions for effective ocean surveillance.

Satellite maritime surveillance systems such as OceanView offer a new approach to tracking objects in the oceans and is based on technology already proven for other SAR and EO applications such as coastline monitoring, oil-slick detection, ground motion detection, coherent change detection, and coherent target monitoring. This new application allows cost-effective, broad-range ocean monitoring capabilities through readily available commercial satellite imagery. In doing so, solutions like OceanView allow coastal nations to respond to maritime crime in a proactive and coordinated manner, and to give no quarter to today's pirate vessels.


Munich

february

1-3
ESRI Federal User Group
Washington D.C.
www.esri.com

5-7
Kuwait First International Conference on GIS
Kuwait City, Kuwait
www.gulfgis.com

8-10
INTELCON
Arlington, Va.
www.intelcon.us

13-16
GeoTec Event
Vancouver, B.C., Canada
www.geoplace.com

15-18
URISA 9th Annual Integrating GIS and CAMA Conference
Savannah, Ga.
www.urisa.org/cama

22-23
AFCEA Homeland Security Conference
Washington D.C.
www.afcea.org

march

1-3
Homeland and Global Security Summit
Washington, D.C.
www.globalsecurity.bz

6-9
AAAE Airport GIS Conference
Dallas, Texas
www.aaae.org

6-9
GITA's Annual Conference 28
Denver, Colo.
www.gita.org/events/annual/28

7-11
ASPRS 2005 Annual Conference
Baltimore, Md.
www.asprs.org/baltimore2005

8-10
Munich Satellite Navigation Summit
Munich, Germany
www.munich-satellite-navigation-summit.org

16-18
CalGIS 2005
Bakersfield, Calif.
www.calgis.org

18-23
ACSM Conference and Technology Exhibition
Las Vegas, Nev.
www.acsm.net

21-23
International Symposium on Geo-Information for Disaster Management
Delft, Netherlands
www.gdmc.nl/gi4dm

april

5-9
AAG Annual Meeting
Denver, Colo.
www.aag.org

6-8
Royal Institute of Navigation 2005
Reading, England
www.rin.org.uk

11-15
Joint Navigation Conference
Orlando, Fla.
www.jointnavigation.org

16-21
GSDI Conference
Cairo, Egypt
www.fig.net/cairo

21-22
Thai Real Estate Appraisal Symposium
Bangkok, Thailand
www.trebs.ac.th

25-26
ILMF 2005
New Orleans, La.
www.lidarmap.org

26-28
GeoSpatial World 2005
San Francisco, Calif.
www.geospatialworld.com


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