THE WORLD'S GUIDE TO COMMERCIAL REMOTE SENSING

Imaging NOTES

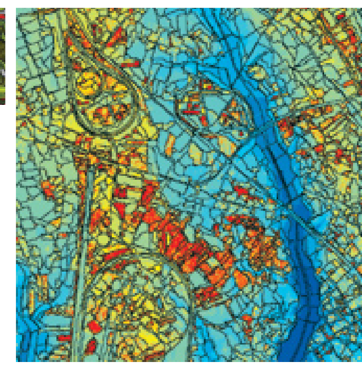
Summer 2004 Vol. 19 No. 3

Renewable energy applications

Industry expects growth

Automating transportation information systems

Tomorrow's technology in satellite image classification. **On hand today!**



eCognition

OBJECT ORIENTED IMAGE ANALYSIS

eCognition is the world's only software for advanced contextual classification of earth observation imagery.

Transforming complex image data into geospatial information: eCognition offers a unique and powerful technology to do it more intelligently, more accurately and more effectively.

eCognition helps users to overcome the challenges and limitations of traditional image classification methods, thus increasing their productivity, reducing the costs involved and improving the efficiency of the operational production of geospatial information.

Now satellite image classification can be as you always thought it should be: **Intelligent, Accurate, and Efficient.**

eCognition PROFESSIONAL

eCognition ELEMENTS

eCognition ENTERPRISE

eCognition FORESTER

Expand beyond pixels!
Download eCognition today. **www.definiens-imaging.com**

DEFINIENS imaging

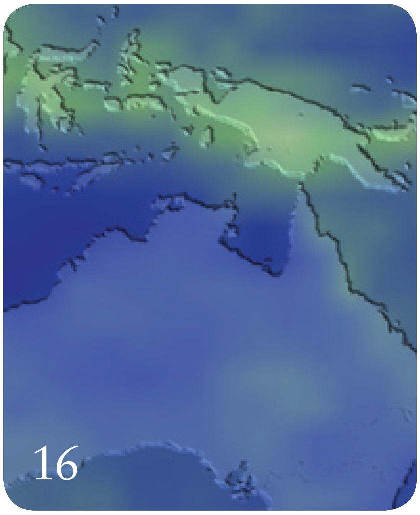
Definiens Imaging • Trappentreustrasse 1 • 80339 München • Germany • eCognition@definiens-imaging.com

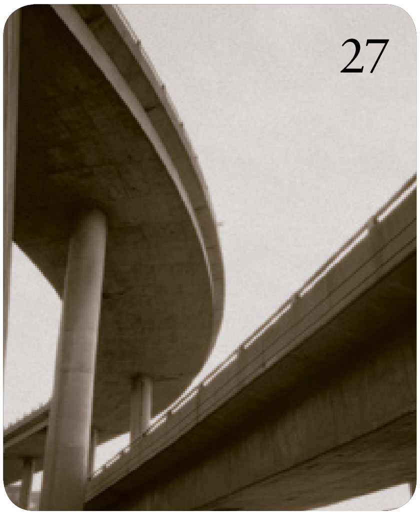
Imaging NOTES

summer 2004

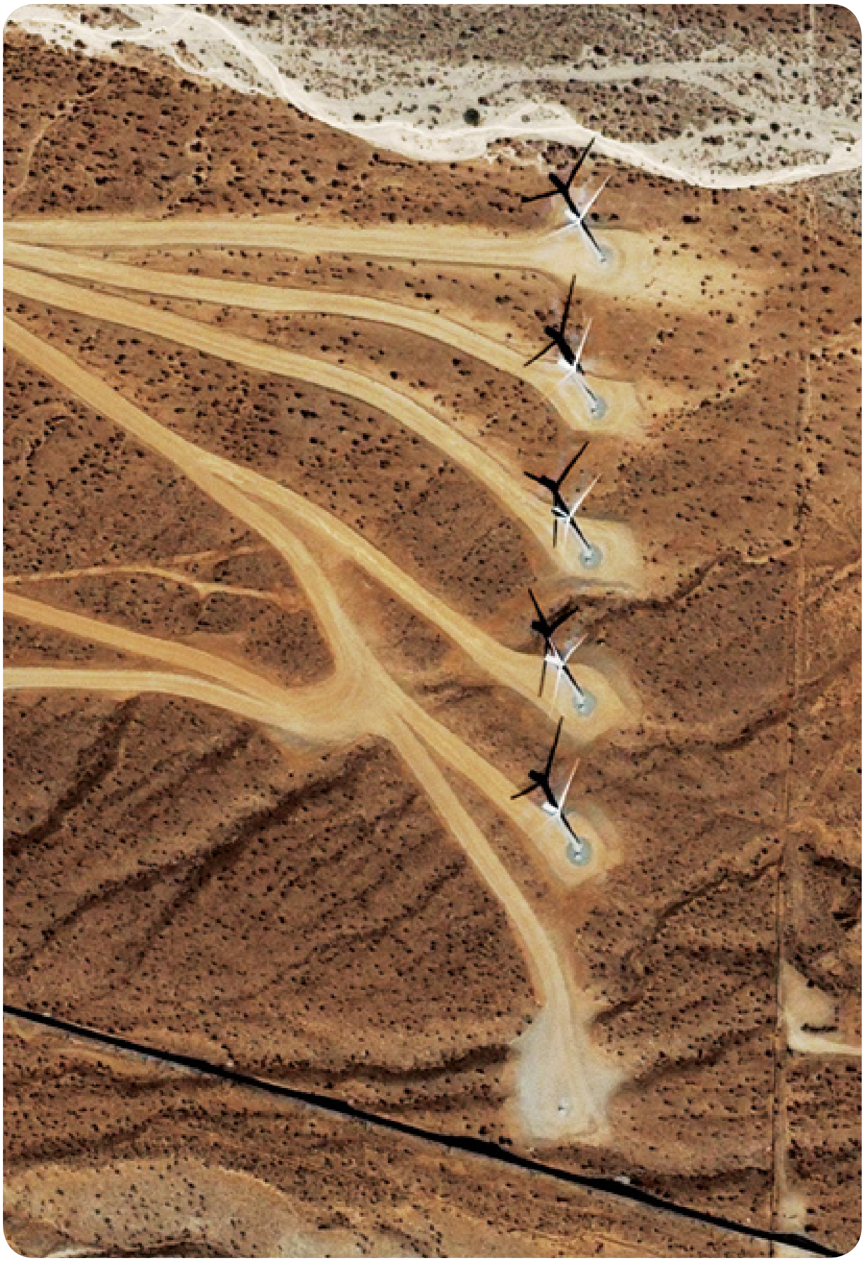
departments


6


16


27

features



The cover image features a near infinite view of wind generators near Palm Springs, Calif., a wind farm which has the potential to supply many southern Californians with a 'clean' supply of electricity, free of the emission of carbon dioxide and sulfur dioxide, which are the result of generating electricity from burning fossil fuels.

The wind-tunnel effect in the San Gorgonio Pass supports the location of these wind farms, providing a high average wind speed during the year and the large areas of land necessary to hold all of the turbines. Wind-energy organizations in the valley sell their electrical power to Southern California Edison or to a growing number of 'green-energy' wholesalers, who then sell the electrical energy to consumers.

The image is a 1-meter multispectral image, and was captured on Sept. 13, 2003.

Imaging Notes

The World's Guide to Commercial Remote Sensing

Summer 2004 / Vol. 19 / No. 3

PUBLISHER
Myrna James Yoo
Publishing Partnerships LLC
myrna@publishingpartnerships.com

ADVERTISING
Teresa Lalley
t_lalley@comcast.net

ART DIRECTOR
Jürgen Mantzke
Enfineitz LLC
jmantzke@earthlink.net
www.enfineitz.com

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

SUBSCRIPTIONS
To subscribe, please go to www.imagingnotes.com, and click on 'subscribe.' Subscriptions are free for those who qualify.
For changes, please submit changes with old and new information to imagingnotes@spaceimaging.com.

Imaging Notes is published quarterly by
Publishing Partnerships LLC
PO Box 11569, Denver CO 80211

Imaging Notes (ISSN 0896-7091)

Imaging Notes is printed on 20% recycled (10% post-consumer waste) paper. All inks used contain a percentage of soy base. Our printer meets or exceeds all federal Resource Conservation Recovery Act (RCRA) Standards.

People

Daticon has new CFO

James A. Bologa has joined Daticon Inc.(Norwich, Conn.) as chief financial officer and executive vice president. Bologa brings over 18 years of financial and operational experience and will oversee all Financial Services and Human Resources functions for the company. Daticon provides litigation support services for law firms, corporations and government agencies involved in complex litigations, mergers or compliance matters.

New Managing Directors for Definiens Imaging

Definiens Imaging (Munich, Germany) has appointed Dr. Ursula Benz and Martin Ehrhardt to the positions of managing directors. Benz joined Definiens Imaging in 2000 from the German Aerospace Centre, initially responsible for SAR development before creating the Definiens Imaging Professional Service Group. Ehrhardt joined in 2003 from Autodesk Germany where he was head of major account sales for Germany, Austria, and Switzerland. Most recently he was vice president of sales and marketing at Definiens Imaging.

GeoVantage Names CEO

GeoVantage (Swampscott, Mass.) announced the appointment of Michael Nappi as president and CEO. Nappi has more than 20 years of experience in the GIS industry. Nappi was a founding member of MapQuest.com where he held the position of Vice President and General Manager.

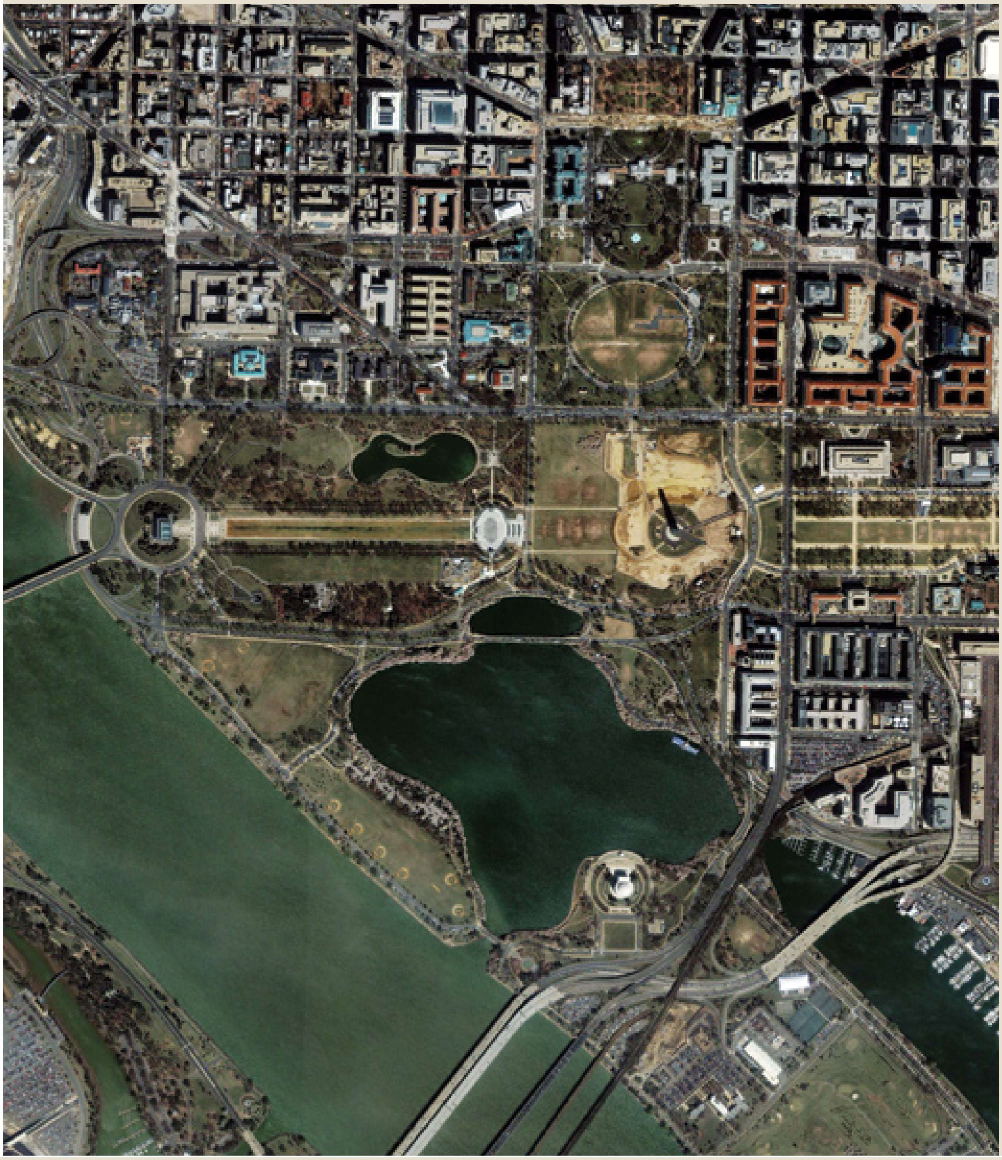
Applications

Red Cross Uses Imagery for Security

American Red Cross used IKONOS satellite imagery for support activities associated with the WWII Memorial dedication in Washington, D.C. over Memorial Day weekend.

Space Imaging provided access to 1-meter imagery of the National Mall area in Washington, D.C., which included the recently completed National WWII Memorial, to the American Red Cross, Geographical Information Systems (GIS) unit. Planning involved two primary components: 1) Contingency planning in the event of a natural or man-made/terrorist event and 2) Support planning for Red Cross activities on the official dedication day.

The color IKONOS imagery, in geo-TIFF format, was used in a desktop GIS platform and served as the base layer of multiple GIS datasets which included building footprint layers provided by the D.C. Office of Emergency Management. Several Red Cross elements such as vehicle locations, support tent locations, bulk water drops, the Red Cross command post and volunteer shuttle routes were added as layers on top of the color IKONOS imagery. Electronic versions of the maps with imagery were used in presentations during planning meetings and management briefings. Small format maps were printed and used in volunteer training materials and supplied to all Red Cross shuttle drivers. Large format maps were used during planning meetings and in the Red Cross mobile command post on the day of the dedication to support on-going decision-making. The color IKONOS imagery greatly enhanced the planning maps and provided improved visualization of the area.



Imaging the Rafah Refugee Camp

Photographs of Palestinians sorting through the rubble of their destroyed homes in Rafah dominated world news in late May of this year. Incursions by the Israeli Defense Force (IDF) into this area of the Gaza Strip near the Egyptian border resulted in the destruction of 298 residential structures housing 710 families in that month alone, according to the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). The IDF has engaged in the demolition of homes in the Gaza Strip since the beginning of the *intifada* in September, 2000.

The IKONOS satellite has imaged Rafah more than 10 times beginning in April, 2000, and pairs of these photographs bracket major IDF operations in time. Space Imaging is limited by law to provide no better than two-meter-resolution imagery of Israel and the occupied territories. Nevertheless, this data is sufficient to document specific damage to features in Rafah and construct a cartography of these IDF operations.

Rafah camp is only two to three square kilometers in size but is today home to over 90,000 refugees from Palestine, according to UNRWA. Nearby features captured in the IKONOS images include the Israeli settlements of Rafah Yam and Shalev, the town of Tel es-Sultan where a number of Palestinians from Rafah camp have settled, Gaza Airport and the border crossing with Egypt (Rafah Terminal). The runway at Gaza Airport was damaged by the Israelis in 2002, as shown in a comparison of two IKONOS images.

Possible explanations and views from different perspectives will be provided in a feature story in the next issue of *Imaging Notes*, combining satellite imagery with ground data and interviews from a forthcoming report by the New York-based NGO Human Rights Watch.
www.hrw.org

Before and After Imagery of Iranian Nuclear Facilities

GlobalSecurity.org is publishing several Space Imaging images of Iranian nuclear facilities in Natanz and Arak from several years ago and this year. The "after" photo shows that the Iranians covered their nuclear facility with earth to protect it from attack. The analysis is by GlobalSecurity.org, a non-profit organization "focused on innovative approaches to the emerging security challenges of the new millennium."
www.spaceimaging.com
www.globalsecurity.org

Companies and Contracts

DAT/EM SYSTEMS INTERNATIONAL (Anchorage, Alaska), a developer of photogrammetric hardware and software products and services, recently signed a Cooperative Research and Development Agreement (CRADA) with the National Geospatial-Intelligence Agency (NGA).

DAT/EM Systems will be expanding the capabilities of its digital stereoplotter, SUMMIT EVOLUTION to perform photogrammetric tasks unique to the government including the ability to read National Imagery Transmission Format (NITF) images and other Mapping, Charting and Geodesy (MC&G) imagery.
www.datem.com

Lockheed Martin Partners with Definiens Imaging

Definiens Imaging (Munich, Germany) has signed a reseller agreement with Lockheed Martin to allow the aerospace and defense company to resell its eCognition image classification software as part of its defense solutions to organizations worldwide. Definiens Imaging is a provider of object-oriented image classification software and associated services. The agreement was signed with Lockheed Martin Missiles and Fire Control in Dallas, Texas.
www.lockheedmartin.com
www.definiens-imaging.com

Spacemetric Forms Partnership with Dutch Defense Project

Spacemetric (Stockholm, Sweden) has entered into an agreement with the National Aerospace Laboratory (NLR), making it a partner in the Netherlands Ministry of Defense Force's Ground Support for Imagery Operations Project, GISMO. Spacemetric will provide a solution for the operational geometric correction of Eros-A and SPOT-4 satellite imagery received by NLR's RAPIDS mobile ground station. NLR is an independent non-profit research institute based in The Netherlands that carries out contract research and provides expert contributions to activities in aerospace and related fields.
www.spacemetric.com
www.rapids.nl

Improving Transportation Security:

A Geospatial Approach

Shortly after the Sept. 11, 2001, attacks on the World Trade Center and the Pentagon, geospatial experts went to work assisting in the response and recovery efforts. Their experiences demonstrated the utility of remote sensing and other geospatial technologies in the battle against terrorism. These technologies, while certainly not a panacea, often provide the critical edge for security planning and rapid response to emergencies.

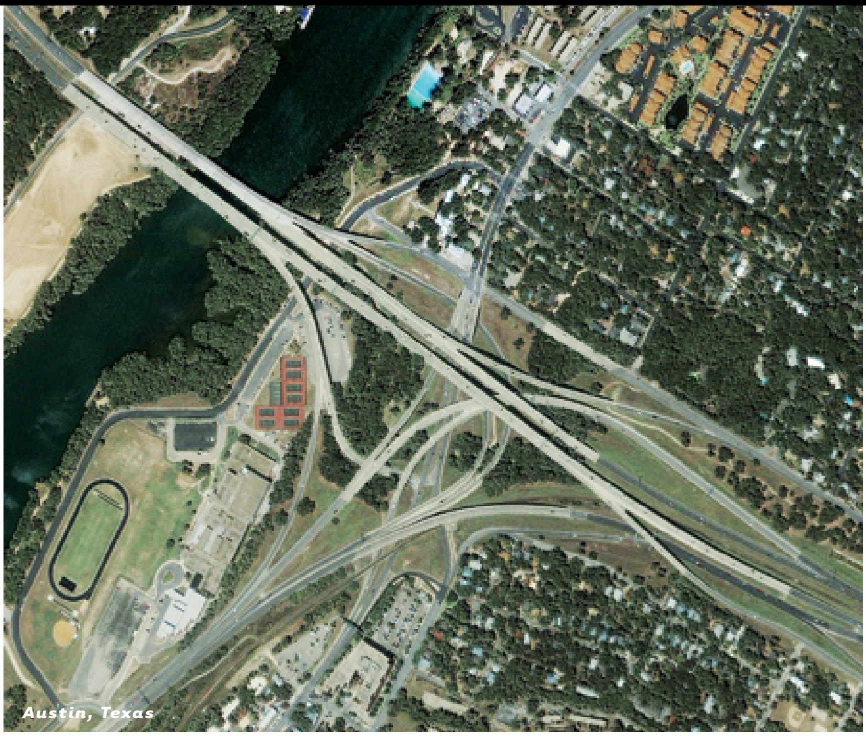
Unfortunately, too few state and local communities yet have the capacity to put these useful tools to work, in large part because too little focused attention has been directed at research, development, and implementation of user-friendly geospatial tools to support security efforts.

Surface transportation security is of highest concern because vulnerabilities throughout elements of the transportation infrastructure render them potential targets of terrorist activity. Intermodal freight transport and the transport of hazardous materials make particularly tempting terrorist targets. Further, the several modes of intermodal transport could be used clandestinely to convey weapons of mass destruction (WMD).

Hazardous materials such as nuclear cargo and waste can be diverted in transit by terrorists and used destructively. Common and widely-transported materials such as gasoline or chlorine can even serve as frightening instruments of destruction. The security of both intermodal and hazardous materials transport is a matter of overwhelming importance for state and local authorities, who bear the responsibility of first response in any emergency.

Remote sensing, geographic information systems (GIS), and position, navigation, and timing (PNT) technologies provide powerful tools for states and local communities to use in dealing with these important security concerns. The National Consortium for Safety, Hazards, and Disaster Assessment of Transportation Lifelines (NCRST-H) has recently issued a report devoted specifically to issues of intermodal freight transport and surface transport of hazardous materials (www.trans-dash.org or www.gwu.edu/~spi). As the report explains, many transportation security applications require new geospatial tools, which necessitate continued R&D, testing and implementation.

America's transportation system, vibrant and complex, yet open and accessible, exhibits numerous vulnerabilities. Further, the interconnectedness of the system increases the potential that an attack on key elements of the system could cascade throughout, causing serious supply disruptions. Some of the most vulnerable modes include the many surface transportation vehicles, including cars, buses, subways, and trains, that ply the nation's streets and rails. Improved protection will require geospatial inventory of the myriad, diverse transportation components,



and continual updating of their condition and security status.

Intermodal freight transport poses a significant challenge to transportation security because freight containers may change transportation mode several times during their long trek from supplier to customer. Some five million containerized freight shipments move through America's ports each year, shifting from ship to truck or rail transport or both to reach their final destination.

The logistical complexities of intermodal transport make this sprawling component of the transportation industry extremely difficult to secure.

Remote sensing and other geospatial information holds the potential for end-to-end tracking and monitoring, which are critical to improving intermodal transportation security and to supporting the U.S. economy.

Moreover, improved information management tools such as databases and statistical analyses, when merged with geospatial technologies, will increase the effectiveness of both tool sets. A suite of tools that includes advanced cargo shipping information, automated manifest interface, advanced profiling, and vulnerability and risk assessment tools is clearly needed. Systems for automated identification of high-risk cargo and automated identification and communication systems are also of deep interest.

Transporting hazardous materials, such as toxic chemicals and nuclear waste and fuel, relates to many of the issues and solutions dealt with in intermodal transport. Nevertheless, because the materials themselves pose particular health and safety hazards, regardless of terrorist concerns, and because they can be used as weapons of terrorism, the transport of hazardous materials also requires detailed attention. The sheer volume of hazardous materials such as gasoline, chlorine, and other chemicals transported every day through towns and cities makes the task of tracking them particularly difficult. Geospatial tools, combined with advanced communications technologies, can ease this burden and provide security officials with better quality information.

Current methods of planning and tracking hazardous materials transport, which often depend on relatively crude, expensive methods, could be significantly improved with the more precise position information and routing details that geospatial technologies can provide. For example, if a shipment is attacked or communication is lost, highly detailed, image-based maps of the route can help authorities answer such questions as: What is the physical environment in the area of last communication? What is the quickest route to reach the area? These and other important questions can be answered quickly and cost-effectively by employing new, sophisticated geospatial tools, such as mobile mapping, which combines the use of GPS, real-time video, and digital photography.

Nevertheless, despite the utility of geospatial technologies to assist the antiterrorist effort, the Department of Homeland Security has been slow to embrace these powerful technologies in its daily operations. Such technologies have also generally not sufficiently penetrated to the state and local authorities that would have to respond in the event of a future terrorist attack.

We can and must make our transportation system less vulnerable. Fortunately, satellite imagery and other geospatial tools make that goal much easier to attain than ever before. And there is a side benefit to putting these tools to work in a serious way. Transportation improvements that reduce vulnerability to attack can also improve transportation safety, and reduce environmental impacts. Despite the progress that the National Consortium on Remote Sensing in Transportation was able to make in the three years it was funded by the Department of Transportation, funding was cut just as some of the geospatial tools under development were nearing the implementation stage.

Improving the nation's transportation security will take more than funding. Needed are supportive policies at federal, state and local levels, and extensive education of the potential user community to the promise and utility of remote sensing and other geospatial technologies.

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-author of the report described in this column.*

Thomas L. Lewis
Director of Global Alliances
Space Imaging
Thornton, Colo.
www.spaceimaging.com

ADVERTORIAL

CARTE

tools to

Satellite imagery is a key tool in gathering intelligence for either a civil or national government entity or for a commercial company. The use of remote sensing — the ability to collect imagery of the earth's surface from a distance — has been a key tool for government and military operations for hundreds of years.

The proliferation of this technology has allowed its cost to be lowered significantly, making this an appealing solution for many civil government agencies and commercial companies around the world. Satellite imagery is a unique form of remotely-sensed data in that it is the most immediate, most current, and most accurate geospatial data available.

Satellite imagery is used by many governments in military and peacekeeping efforts, as well as by commercial organizations both large and small. Typically, imagery is in demand by governments, military entities, researchers, news organizations, meteorologists, oil and gas companies, geospatial firms, environmentalists and farmers, and by users in other fields and disciplines as well.

However, satellite imagery isn't the only form of data. Organizations may have several other types of intelligence that may need to be managed and integrated with the imagery to attain full intelligence solutions. Organizations may have other information layers that they would like to incorporate, such as maps, charts, GPS locational data, natural and cultural features, topographic data, digital terrain models and vector data, to name just a few. »

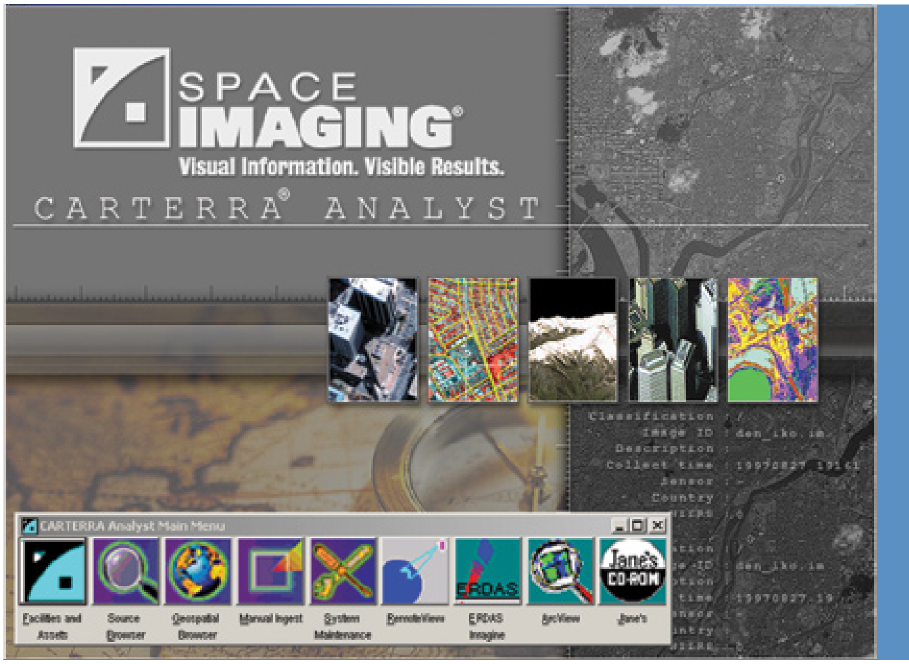


FIG. 1

CARTERRA Analyst Menu shows a wide variety of features

RRA Analyst

manage and live by

Taking advantage of all the data has to offer

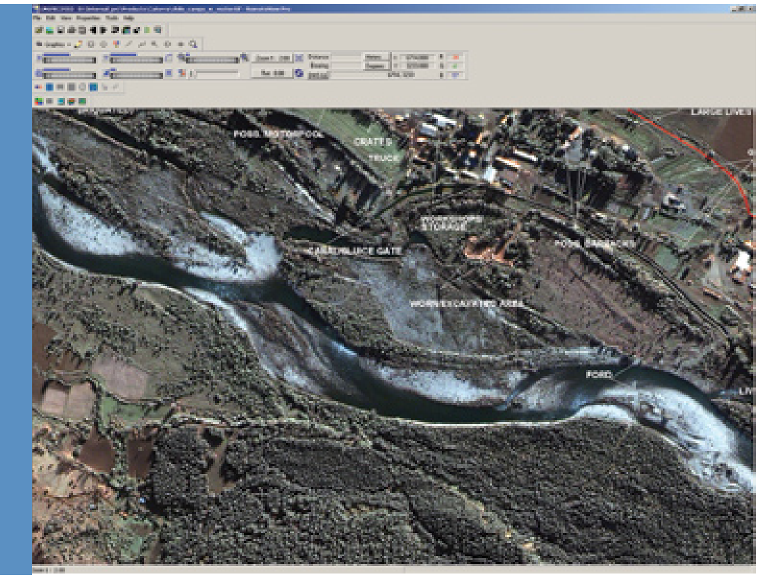


FIG. 2

Example of imagery exploitation capabilitites

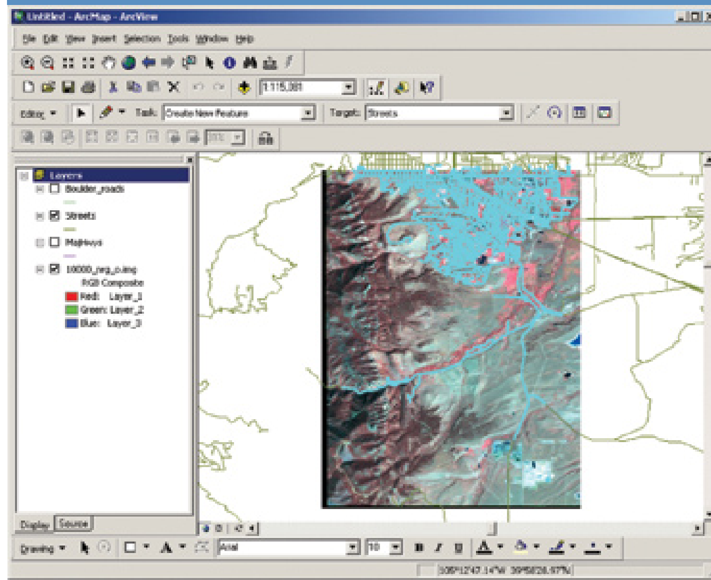


FIG. 3

GIS vector creation, analysis and maps using ESRI ArcView

ADVERTORIAL

Gathering the information is only one piece of the puzzle. The ability to manage this data across many organizations, to achieve true data sharing, and to integrate it with other information sources turns disparate pieces of information into useful, practical intelligence for your organization. This is the key to unleashing the data's true power.

Information needs will vary from organization to organization, but the core tools needed to plan, manage, exploit and process the data are very similar. Effectively meeting these goals to help users overcome the challenges often associated with image processing and data management requires a scalable system that increases productivity, reduces costs and adds value across the organization.

Satellite imagery and other forms of data are critical to the information analysis process, and they allow for a complete picture to be formulated. Having disjointed systems with data posted to stove-piped databases and hoping that miraculously, through human intervention, it will all work together in times of critical need is simply a thing of the past. Today's systems must be agile and responsive. As information is gathered, integrated and analyzed, it can be used by key decision-makers to make critical and strategic situational assessments.

Accessing and retrieving all pertinent information in a timely manner can mean the difference between clearly understanding a situation and assessing the options, or being relinquished to putting together post-event charts on what happened and how it can be avoided next time. Being a former imagery analyst, I can attest to the fact that having the ability to use and retrieve the information quickly and effectively, while combining, displaying, analyzing and corroborating information to develop and share a common operating picture, is the key to information dominance, whether the organization is a government entity or a commercial company.

In the past, imagery analysis has required someone to assemble a series of tools, each accomplishing a specific task. CARTERRA Analyst, a geospatial analysis and production tool set, can help efficiently and effectively manage, process, exploit and analyze remotely-sensed imagery data. The ability to seamlessly integrate the commercial applications provides an end-to-end workflow solution for the analysis and management of imagery and intelligence products.

This paradigm represents a departure from the current ways of doing business, by incorporating all the tools necessary for retrieving and interpreting images in one complete system utilizing a sophisticated software framework that integrates and enhances the included commercial off-the-shelf (COTS) technology. This system incorporates tools to handle tasks ranging from ingesting and cataloging to analyzing and reporting functions. CARTERRA Analyst provides a solution for those who desire either to set up or to augment a remote sensing capability, whether as a stand-alone shop or as an adjunct to a GIS or cartographic organization.

This product is a family of information analysis solutions that offers users a scalable approach to storing, retrieving, analyzing, and disseminating digital spatial information. The system recognizes a variety of data formats including documents, photographs, maps, videos, and audio recordings.

The single interface of CARTERRA Analyst is exceptionally easy to use and supports numerous workflow tasks, from locating and retrieving data to generating a final product. Analysts can take advantage of a fully digital environment and a variety of analytic techniques, including data fusion, change detection, terrain analysis, and multispectral analysis. To help ensure seamless integration, data flow is designed for typical image exploitation and GIS products. This system is designed in an open architecture environment and can be integrated with satellite access system facilities or function as a stand-alone system. The system also supports multiple language requirements and addresses multiple user level requirements and associated security issues.

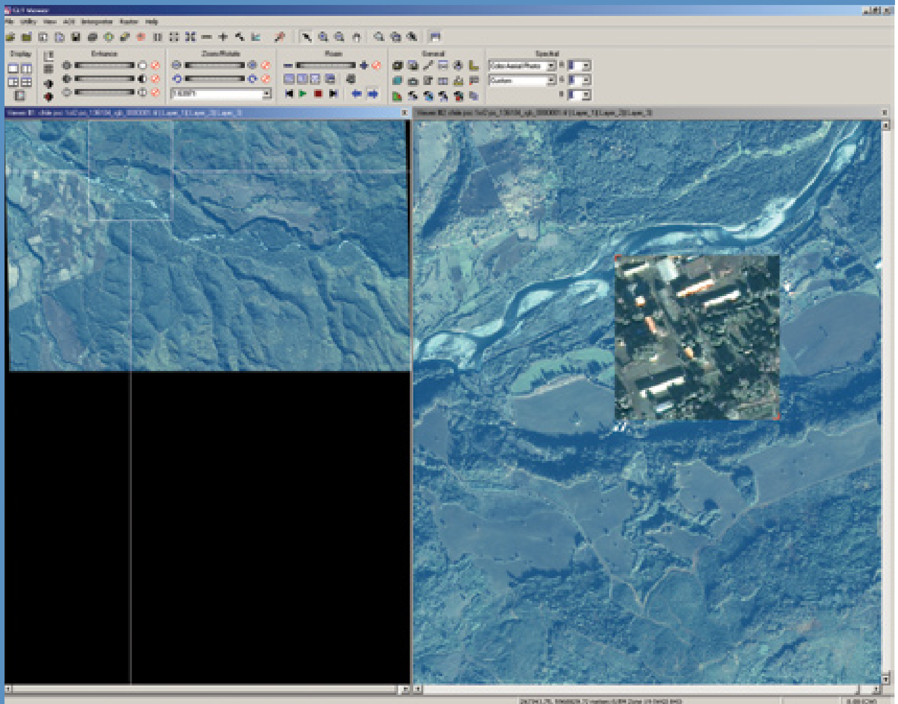


FIG. 4

Topographic analysis/image processing capabilities example

CARTERRA Analyst meets geospatial data management, processing, and distribution needs by including the following capabilities under one user interface:

- » **A geographic information system that stores complex graphics and text attribute information in a geographically referenced system.**
- » **An electronic light table that manipulates and exploits images quickly and accurately without sacrificing quality.**
- » **Image processing tools that permit advanced image analysis, data access, manipulation, and management.**
- » **Desktop reporting that allows the creation of graphically enhanced, professional quality reports.**
- » **Intelligence database tools that provide the ability to manage data by correlating geographic location information with facility installations and asset information.**
- » **Cartographic tools that provide highly interactive, cartographic-quality map production tools. (Custom functionality, which is available tailored to meet specific end-user requirements, may be ordered.)**
- » **Integration software that enables embedded applications to share data, delegate tasks, disseminate results and monitor a productive workflow environment.**

CARTERRA Analyst is ideal for customers who regularly work with orthorectified imagery and use it to create and update Geographic Information Systems. The electronic light table capability permits full manipulation of an image, such as contrast enhancement, roaming, panning, zooming, and rotating. Further, the vector information already stored in existing shape files can be overlaid on the image to aid in searching for a particular item. Since imagery is both orthorectified and geo-referenced, specific coordinates can be found to the accuracy of the image, measurements can be taken and vector information in the GIS can be updated.

This tool set provides a fully digital work environment, including a variety of functions for target monitoring, change detection, feature extraction, terrain analysis, data fusion, and advanced visualization and multispectral analysis. The product also provides electronic access to various industry image archives for updating a customer's own geospatial archives with the most up-to-date imagery.

The CARTERRA Analyst cataloging capability stores information about imagery already on hand and permits a full geospatial search capability. As customers accumulate imagery, each image's metadata and a thumbnail image are stored in the computer's hard drive for search and retrieval, with comprehensive and easy-to-use tools including Windows-based menus and directory schemas/trees.

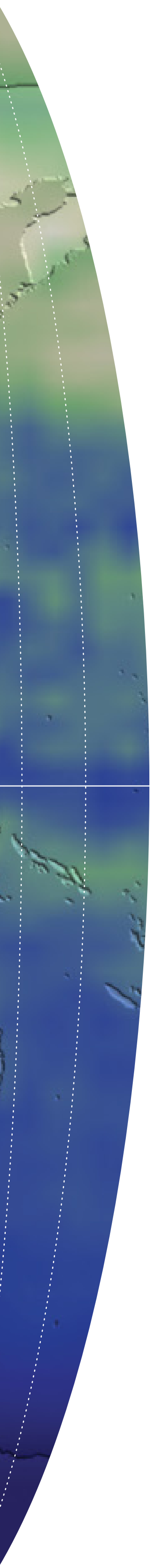
Space Imaging has combined the best names in the industry to offer a cost-effective integrated tool that lets users view, analyze, store and retrieve geospatial information from the convenience of their desktop environments. To address evolving user needs, the offering can be configured on various levels and for various platforms. Today, it is seen as an intuitive, end-to-end solution for all tasks associated in the information analysis and dissemination phases of the remote sensing data cycle.

High-volume production tools are also available to produce agency-quality mapping products for topographic and national mapping, forestry, natural resource, property mapping, and nautical charting. Currently, these tools are being used in a number of national, state, and local mapping agencies and commercial mapping companies around the world, supporting government and international mapping agencies in producing and maintaining a broad range of products.

CARTERRA Analyst provides the tools to manage, process, analyze and produce various sources of data in an environment that is capable of supporting photogrammetric and cartographic production. Integrating leading commercial remote sensing and GIS software products into one convenient solution provides a one-system solution that combines the strengths and capabilities of existing, fielded commercially-available products. These proven tools complement one another and ultimately bring out the power of the information, helping to manage data and intelligence products. Making the most of imagery and data allows the analyst to turn information into knowledge — discovering new ways to make the data "speak" to the user and reveal its true information content.

Remote sensing applied to developing renewable energy

fig. 1



Energy. It is the fundamental essence of our universe. Even matter, energy's cosmic complement, can be reduced to quantities of energy via Einstein's famous equation $E=mc^2$. It is the energy of the sun that allowed for the evolution of life on this planet and sustains life today. The increasing ability to exploit energy resources has defined the progress of human civilization. Indeed, energy is a universal factor within economies and across societies, and thus much of modern governmental policy revolves around securing and controlling energy resources.

Several problems plague the ways that humans currently collect energy resources and use them. The U.S. Department of Energy predicts that as world population approaches 10 billion around 2030, global energy demand will surpass supply by 20 percent. Moreover, the negative externalities of current fossil-based energy sources range from health and environmental consequences to those of international politics and security. For these reasons, there is a consistent motivation toward the use of alternative energy sources. The power of light from the sun, currents of wind, and heat from the earth's interior have been used in traditional, non-industrial capacities around the world for millennia. Further development of these renewable sources of energy for modern industrial society is one important way of mitigating the problems of decreasing global energy supply and increasing energy demand, and of the negative external effects that accompany generation from fossil fuels.

Satellite-based remote sensing can aid in realizing the potential of renewables. While not directly involved in the generation of energy, application of this complementary technology is in the supply of information for determining the optimal location of generating facilities, as well as for operational decisions of generating facilities and electric power grid management. Increased investment into the research and development of environmental satellites by government is essential in the interest of sound and sustainable policies, both for energy and for space. Three promising forms of renewable energy — solar, wind and geothermal power — can benefit from on-orbit remote sensing.

Avery Sen
MA, International Science and Technology Policy
Researcher, Space Policy Institute
The George Washington University
Washington, D.C. www.gwu.edu/~spi/

Figure 1: ***"Pacific SeaWinds" is part of an image from the SeaWinds instrument on NASA's QuikScat satellite, collected from the College of Oceanic and Atmospheric Sciences, Oregon State University website.***

SOLAR IRRADIANCE

Much experimental work has been done over the past decade both in Europe and in the United States to use satellite-based imaging technology as a tool in resource assessment for solar energy. Inaccuracy of solar irradiance (sunlight intensity) information can lead to the selection of less than optimal site choices, system sizes, and performance reliability. Government-owned hardware already exists to provide data as a public good for a number of meteorological and environmental applications, among them determining solar irradiance at the surface of the earth. Satellite techniques offer a relatively inexpensive method of assessing solar irradiance over large areas. Even low-resolution data using moderate-level technology could provide a useful starting point for subsequent ground-based measurements, saving both time and money. ***See Figure 3, page 19.***

Currently, NASA has several experimental satellites yielding data applicable to surface solar irradiance assessment, including Terra, Aqua, and the Tropical Rainfall Measurement Mission (TRMM). These satellites employ instruments such as the Cloud and Earth Radiant Energy System (CERES) and the Moderate Resolution Imaging Spectroradiometer (MODIS).

The most advanced use of satellite data for solar resource assessment has come with the European Commission's HELIOSAT-3 project, conducted under the Energy, Environment and Sustainable Development program. This project aims to address several problems identified by the solar energy industry concerning solar irradiance data. Specifically, the uncertainty of solar irradiance estimates is too high, the spatial and temporal resolutions are too low, and many variables such as angular and spectral distribution are undetectable even with ground-based equipment. Objectives for HELIOSAT-3 are to supply irradiance data by angular and spectral distribution, to double spatial and temporal resolution, and to reduce errors to less than 5 percent, 10 percent and 20 percent RMSE (Root Mean Squared Error) on a monthly, daily and hourly basis, respectively.

Until now, the accuracy of solar irradiance assessment using satellite data has been limited by a lack of information about the state of the atmosphere (e.g. clouds and aerosols). To improve accuracy, HELIOSAT-3 exploits data from the European Space Agency's new METEOSAT Second Generation (MSG) satellites. As opposed to the first generation of imagers offering only three wide frequency bands measuring data with 8-bit coding, MSG imagers collect light in 12 narrow bands with 10-bit coding. This improvement translates to an increase in spectral and radiometric resolution, which will allow for the identification of atmospheric parameters with much greater detail, and thus will lead to a better estimation of the true conditions on the ground. MSG also improves accuracy in time and space from pictures of 2.5-km resolution every 30 minutes to 1-km resolution every 15 minutes (Heinemann 1999).

The performance of HELIOSAT-3 will be demonstrated for applications not only in the sighting of solar power generation facilities, but in the performance monitoring of existing grid-connected facilities, in the planning and operation of solar thermal generation, and in the optimization of daylight in buildings. In addition, a key component of this project is to make all data available via an internet-based geographical information system (GIS) so that users in the public sector and in industry can fully utilize the results.

To determine future potential economic value, inexpensive and reliable methods are necessary to compare actual power production with expected power production. Actual values are easily obtained through standard metering, but expected values must be obtained though computer simulation. A key input for these models will be timely, site-specific data, such as that from the PVSAT (photovoltaic satellite) project, an experimental performance checking system, which is funded by the European Commission's "Energy, Environment and Sustainable Development" program. It uses hourly METEOSAT irradiance data as a cost-effective alternative to installing irradiance sensors and intelligent monitoring devices (Hammer et al. 2000). The experimenters are comfortable with the quality of the satellite data and believe that this gap can soon be filled with progress in the modeling process (Beyer et al. 2001). The next generation of this system, PVSAT-2, is expected to yield 5 percent reductions in costs of system maintenance and power production (www.pvsat.com/rahmen.html).

OFFSHORE WIND VECTORS

Offshore wind speed is greater and more consistent than wind speed on land. This is the result of the sea breeze effect; convection currents in the air above the shore rise in the morning and in the evening when there is a significant difference between the temperature of the land and that of the sea.

Satellites can be of great utility in yielding information on wind power potential. The importance of accurate wind information is a result of the facts that this power source is uncontrollable, is intermittent and is relatively unpredictable. It is crucial to determine not only the minimum, maximum and average wind power potentials for a given area, but also the variability over different time scales — from the very short-term (hours and days) to the long-term (seasons and years). Areas with variation in wind power potential above 10 percent are not suitable for stable electricity generation.

Satellite-based remote sensing technology with applications for wind energy resource assessment is an idea that has developed only recently. Just as with solar power, there are definite cost-savings advantages to large area measurement of wind speed and direction (wind vectors) rather than the installation, operation and up-keep of extensive site-specific instrumentation.

Because the wind energy resources available over the sea can be greater than those over land, it is in measuring sea winds where satellites can be of substantial benefit to wind energy assessment. Comprehensive, accurate offshore wind vector measurements are essential for the development of generation facilities because energy potential is proportional to the third power of wind speed (Hasanger 2002). Thus, even a small error in measuring speed can translate to a large error in energy potential estimation. Conversely, small amounts of additional speed can translate into additional energy proportional to the third power.

The remote sensing technologies used for determining sea wind vectors are different from those used for solar irradiance, which are all passive; they sim-

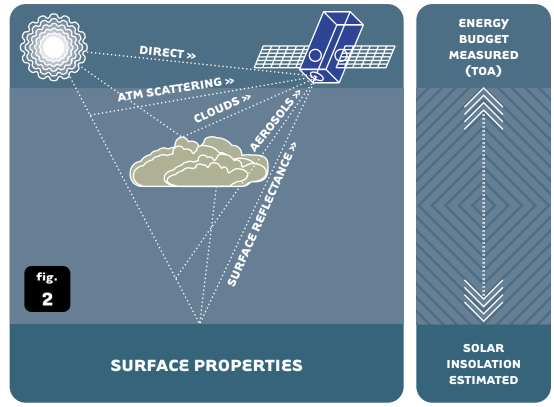


Figure 2: ***Sources of light for satellite imagers (Stackhouse 1999)***

Solar irradiance imagers

Satellites can measure solar irradiance because imagers take pictures essentially like a digital camera, but they differ from the standard digital camera in their sensitivity to the intensity and frequency of the light that they can capture. In addition to visible light, satellite imagers can "see" frequencies of the electromagnetic (EM) spectrum such as infrared, ultraviolet and microwave. This is important because different materials absorb, emit and reflect different frequencies of EM radiation. Water, for instance, is transparent in the visible spectrum but absorbs microwave radiation. By imaging in different frequency bands, we can determine what materials and chemicals are in a picture.

Physical positions, frequencies and intensities of radiation are measurable at a very fine scale. These characteristics are known as spatial resolution, spectral resolution and radiometric resolution, respectively. Imagers are designed to measure specific frequency bands with fixed measures of sharpness, or resolutions. Several different kinds of imagers are placed on a satellite depending on its mission. Satellite imagers collect EM radiation incident upon them; humans, aided by computer models, interpret the data, given the frequency bands and the resolving power of instrumentation.

Assessing solar irradiance at a location on the surface of the earth begins with a picture of that location from one or more orbiting satellites. The light collected by imagers is a sum of radiation from many different sources *(see Figure 2)*. Some of this light comes directly from the sun or may be reflected by clouds. It comes from the scattering of sunlight by chemicals in the atmosphere (aerosols) and the atmosphere itself. It also comes from solar radiation reflected from the surface of the earth. Data from imagers designed to measure each of these components, along with information on the absorptive, reflective and emissive properties of the materials involved, must be considered to estimate the intensity of sunlight at a given location.

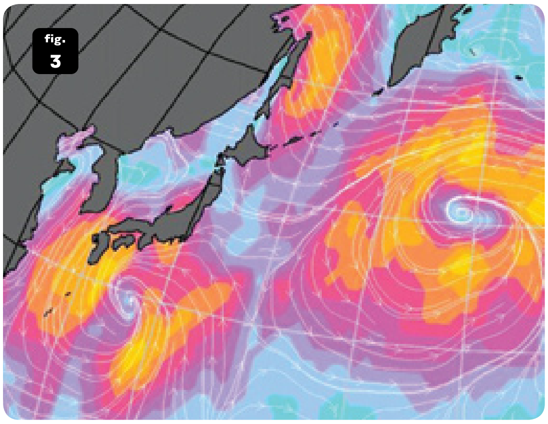


***Figure 3:* Reflected solar energy image from NASA.**

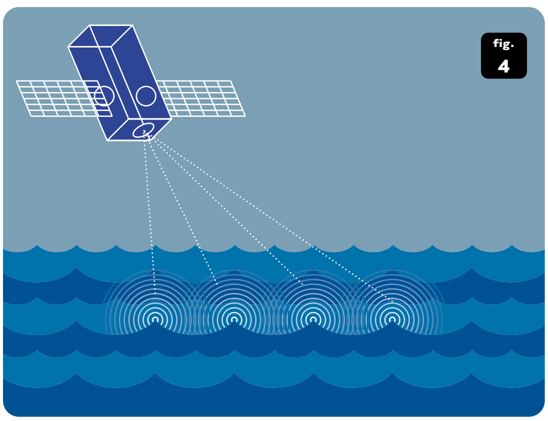


***Figure 4:* Scatterometry measures sea winds indirectly through surface roughness (Kelly 2003)**

ply collect the light that is available. In contrast, determining sea winds involves the use of radar, an active system that emits microwaves and measures their reflection, in a technique known as scatterometry. The foundation of this technique rests in the principle that sea surface winds create small, centimeter-sized waves on the surface of the water and these waves respond quickly to changes in wind speed. Sea surface roughness at this scale is thus dependent on instantaneous wind speed.

Scatterometers do not measure sea surface wind speeds directly, but indirectly through the roughness of the water. A transmitter emits radio waves at an angle relative to the sea surface and a receiver measures the backscattered radio waves ***(see Figure 4)***. A rough surface will scatter these radio waves such that some will be directed back to the satellite, but a flat surface would reflect the radio waves in a different direction. Backscatter brightness will indicate wind speed, while multiple, simultaneous measurements of the same spot from different angles will indicate direction, thus giving the complete wind vector. Because this is a radar system, it is not dependent on sunlight and not hindered by cloud cover, so measurements can be made day or night, during nearly any weather conditions. The challenges to improving this technology lie in the mathematical and statistical methods used to convert scatterometry data into precise wind vectors and in the calibration of measurements with true ground conditions.

The European ERS-2 satellite can perform scatterometry to determine wind vectors using its Active Microwave Instrument; however it can do so only when in "wind mode" and so cannot provide continuous wind data. NASA's QuickScat satellite, on the other hand, is dedicated to measuring only wind vectors. Like ERS-2 and the Aqua, Terra and TRMM satellites mentioned previously, QuickScat is in a low-altitude orbit, but can scan 90 percent of the Earth's surface every day. On board QuickScat is the SeaWinds scatterometer — the same instrument that had been carried on the ADEOS II — which is capable of a 25-km spatial resolution and can measure winds between 3 and 20 m/s to within 2 m/s and 20-degree accuracy ***(see Figure 1, page 16)***. Data are available within three hours for weather forecasts and within two weeks for scientific research.

Investigations into the value of using satellite radar for wind mapping have been performed in Denmark in anticipation of the construction of a large number of offshore wind farms in the near future. Denmark is home to the first offshore wind farm in Vindeby and the worlds' largest offshore wind farm in Middelgrunden, consisting of 20 two-MW turbines. The Danish government plans to have 4,000 MW of offshore wind capacity available by 2030. One Danish study found that ground-based measurements of wind speed on even a relatively small and flat island in the Danish sea did not represent true conditions on the open water. Using ERS-2 scatterometry data did not yield estimates that were much better; the absolute accuracy of scatterometry-derived wind speeds were an order of magnitude less than what is necessary for wind speed predictions. However, the study concluded that the relative accuracy of this new technology could make it useful and that the results are promising.

As with solar irradiance, further research into satellite-facilitated wind energy assessment is being funded by the European Commission's Energy, Environment and Sustainable Development program. The goal of the WEMSAR (Wind Energy Mapping Using Synthetic Aperture Radar) project is to demonstrate the abilities of satellite-based radar systems in mapping offshore energy resources, and the project will take advantage of the fact that spatial and temporal resolution of radar systems are constantly improving. Utilizing data from ERS-2, ENVISAT, and the Canadian RADARSAT, WEMSAR should be able to attain wind speed estimates at spatial resolutions of 400 meters (http://www.nersc.no/~wemsar/).

Currently, satellite information is expected only to supplement surface-based data, but this technology is still in the developmental stage. Spatial and temporal resolution of radar instruments will improve, as will the statistical software that converts raw data into useful information.

With respect to investment potential, wind is the fastest-growing source of renewable energy, with generating prices now similar to those of coal-fired plants. However, it is challenging for power grid management authorities to schedule wind power because of its intermittency. In addition, a 1 percent error in the wind speed on the site can lead to almost a 2 percent error in energy forecast, according to Garrad Hassan & Partners, wind energy consultants. Electricity from wind can be more reliable and more profitable with better forecasts of wind speed and direction, which in turn would benefit from more and better satellite data. Advanced modeling techniques for wind enabled traders in the United Kingdom to increase earnings on the Short-Term Power Exchange by 5.8 - 7.5 percent.

Utilities are also trying to gain better wind information to maximize profits. An analysis of the value of wind forecasting to Southern California Edison (SCE) found that the eWind modeling system produced by TrueWind Solutions could reduce power output forecast error by 33 - 50 percent over the course of a year. This means that SCE can avoid many of the imbalances of costs that result from differences in the amount of electricity it predicted to sell and the actual amount it was able to sell, potentially saving $2 million per month, according to the Final Report to the Public Interest Energy Research Program of the California Energy Commission, January 2003. eWind relies on a regular flow of meteorological data from the U.S. National Oceanographic and Atmospheric Administration (NOAA) via electronic file transfer.

> "The future global energy situation looks increasingly bleak, especially as demand from developing countries increases."

In an effort to improve its product, TrueWind Solutions is looking to use additional atmospheric data, especially over the "data sparse" Pacific Ocean, and is considering the possibility of using satellites to collect three-dimensional, multi-spectral measurements of temperature, moisture and radiance. This will be particularly relevant for offshore generation sites. Remote sensing instrumentation that measures ocean wind speed, such as the SeaWinds scatterometer, will yield very useful information for developing and operating these facilities.

GEOTHERMAL ACTIVITY

As with solar and wind power, remote sensing can play a key role in the exploration phase of geothermal resource development. These resources are in the form of underground water reservoirs that have been heated because of their proximity to magma close to the earth's crust. Estimation of the potential from these reservoirs involves information not only on their location, but also on their depth, temperature, pressure and size. In performing nation-wide surveys of potential sites for geothermal power plants, analyses are conducted at different scales.

Japan's New Energy and Industrial Technology Development Organization (NEDO), for example, breaks the task down into three phases. Survey A is conducted at scales of 100 - 300 km^2, Survey B utilizes the data from Survey A but at 50 - 70 km^2 detail, and finally Survey C is used to study sites at the 5 - 10 km^2 scale ("Present Status of Geothermal Energy Development"). Currently, Survey A is performed using temperature-sensing equipment on aircraft, but data from satellite-based remote sensing could be cheaper and more consistent in quality, and could offer more than one method of inferring geothermal activity.

The most intuitive method of exploring for subterranean geothermal reservoirs is to look for areas on the surface that are warm. Measurements of land surface temperature can be performed by high resolution, multi-spectral imagers operating in the thermal infrared region of the spectrum. Many remote sensing satellites have this capability. Infrared channels on LANDSAT 7, for instance, have been used to detect hydrothermal discharge in remote areas of New Mexico and British Columbia (Schulze-Makuch).

NASA's Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on board NASA's Terra satellite is the most advanced imager for this function. Japan's Institute of Advanced Industrial Science and Technology utilized this high spectral resolution imager in a project to develop geothermal energy on remote islands in the eastern part of Indonesia. Nighttime ASTER images were combined with Synthetic Aperture Radar (SAR) images from the Japanese Aerospace Exploration Agency's JERS-1 satellite, which provided a digital elevation model of the area and thus a topographical base map. The SAR-derived digital elevation model was also very useful in identifying volcanic surface features. These volcanic features gave researchers an additional set of clues as to the nature and location of potential sites for geothermal wells (Muraoka 2003).

Besides SAR, there are other non-thermal/infrared methods of identifying hidden geothermal resources with remote sensing imagers. For instance, hydrothermal discharges can alter the mineral content of the surrounding land surface. Therefore, the presence of certain types of minerals could offer indirect clues as to the location and characteristics of potential geothermal sites. LANDSAT images have been used by the U.S. Geological Survey to produce mineral classification maps of the Great Basin area in the southwestern U.S. Certain kinds of iron-oxides observed with the LANDSAT data were found to correlate with geothermal systems (Taranik et al. 2004).

Hyperspectral imagers on more modern remote sensing satellites could be even more discriminating among the spectral signatures of different minerals. In addition to the observable chemical changes in the land surface that hydrothermal systems can produce, changes in vegetation can also be observed. Some kinds of chemicals that are associated with hydrothermal discharges are toxic to plants and thus can cause them stress. Symptoms of this stress can include dwarfism and gigantism, both of which are relatively easy to identify in field studies. Other manifestations, however, such as a condition called chlorosis, occur at the cellular level and are difficult to see with the naked eye, but can be detected with high-spectral resolution equipment. Common spectral changes include shifts in the red absorption lines for chlorophyll as well as increases in overall albedo. Researchers at the Energy & Geoscience Institute at the University of Utah and the Geographic Resources Center at the University of Missouri have offered so-called vegetation anomaly mapping techniques as a low-cost method for geothermal exploration (Nash and Hernandez 2001).

As with remote sensing of offshore wind vectors, the utilization of hyperspectral and SAR imaging for geothermal activity is still in its infancy. However, sensor technology has continuously improved and novel techniques for using available data have been created.

The potential economic value of remote sensing of geothermal energy has not yet become a target of study. Right now remote sensing is used for the scanning of large areas, in preparation for narrower, ground-based studies to be conducted at a more detailed level. Satellites can perform Earth observation tasks repeatedly, with greater consistency in data quality, and with lower overall cost than airplane surveys. Satellites also are usually equipped with multiple imaging systems to simultaneously detect many different parameters (thermal, geochemical, botanical, etc.) in concert. Furthermore, satellite-based remote sensing is a successful evolutionary technology, meaning that the expertise of individuals and institutions in creating imaging systems is largely focused on satellite platforms because this is an area of technology that is advancing in general. Improvements in the spatial, temporal, spectral, and radiometric resolution of satellite imagers should be expected to benefit geothermal resource exploration, in addition to solar irradiance and offshore wind vectors.

CONCLUSIONS

NASA is currently demonstrating the value of remote sensing data for renewable energy needs in the U.S. NASA's Earth Science Enterprise Project called Prediction of World Energy Resources (POWER) has been proposed to coordinate with other government agencies, energy industry associations and individual companies to make better use of NASA meteorology and solar radiation data. The Earth Science Enterprise makes several interesting predictions as to the benefit that POWER services could provide to the United States economy.

Using energy demand and cost estimates from the Department of Energy and assuming a growth rate of 25 percent for solar and wind power, ESE calculates the yearly POWER benefits to this part of the renewable energy industry to be $1.5 billion by 2010 and $7.13 billion by 2017 (Whitlock and Stackhouse 2002). This prediction is preliminary and optimistic, but if true, it would represent a spectacular value to industry.

The future global energy situation looks increasingly bleak, especially as demand from developing countries increases. Thus renewable energy sources such as solar, wind and geothermal will be very important components in assuring that energy supply can keep up with energy demand. The satellite imaging techniques described here can be useful tools in realizing the full potential of sustainable energy sources.

The largest strides toward developing renewable energy sources are being made in Europe, including the use of remote sensing technologies. In accordance with the Kyoto Protocol, the European Commission has pledged that 22 percent of Europe's energy will come from renewable sources by 2010. It is therefore not surprising that the European Space Agency announced its plans to fund an international program to use Earth observation services to assist in the development and management of solar, wind and hydroelectric sources (according to the European Space Agency Website, http://www.esa.int/export/esaSA/SEMORAYO4HD_earth_0.html). We have already seen similar efforts from the European Commission with projects such as HELIOSAT and PVSAT.

Other space-faring nations with high demand for energy may therefore wish to explore the possibility of cooperation with Europe in the research and applications of remote sensing technologies to this end. The United States and Japan fall into this category, but emerging space powers such as China and India — having even faster growing energy requirements — certainly do as well.

From rising energy prices to global climate change, the consequences of continued dependence on fossil fuels as a primary energy source will not be borne by one nation alone. Technologies to mitigate these effects should, therefore, be developed through the collaborative efforts of nations with capable space programs.

References

Stackhouse, P.
"Satellites and Sensors: Satellite Missions Impacting the Estimation of Solar Irradiance." National Renewable Energy Laboratory, 1999. www.nrel.gov/ncpv/documents/26563/26563TOC.html

Heinemann, D. and H.G. Beyer
"Current and Future Data Streams from METEOSAT Geostationary Satellites for Solar Energy Applications." National Renewable Energy Laboratory, 1999. www.nrel.gov/ncpv/documents/26563/26563TOC.html

Hammer, A. et al.
"Surveillance of Photovoltaic Solar Energy Systems Using METEOSAT Derived Irradiances." EUMETSAT Meteorological Satellite Data Users' Conference, Bologna, 2000, www.pvsat.com/rahmen.html

Beyer, H.G. et al.
"Accuracy of the Estimation of Monthly Performance Figures of Grid-Connected PV Systems Based On Remote Data Sources." 17th European Photovoltaic Solar Energy Conference, München, Germany, October 22—26, 2001. www.pvsat.com/rahmen.html

Hasanger, F. et al.
"On Offshore Wind Energy Mapping Using Satellite SAR." Canadian Journal of Remote Sensing, Vol. 28, No. 1, 2002, p. 82.

Kelly, P.
"Remote Sensing for Wind Power Generation." Geo Information Science, Department of Geology, Salem State College. www.dgl.salemstate.edu/Profs/Young/RS-final/Wind/wind%20scatter.htm

Schulze-Makuch, D.
"Exploration of Geothermal Discharge Areas Using Remote Sensing and Hydrological Methods." University of Texas at El Paso. http://mured.nasaprs.com/report/rt_reports/2001/FAR_UT-ElPaso_SchulzeMakuch_Rpt.pdf

Muraoka, H.
"Exploration of Geothermal Resources for Remote Islands of Indonesia." Institute for Geo-Resources and Environment, AIST Today, No. 7, Winter 2003.

Taranik, J. et al.
"Regional Assessment of Exploration Potential for Geothermal Systems in the Great Basin using a Geographic Information System." Great Basin Center for Geothermal Energy. www.unr.edu/geothermal/docs/GeothermalGISProp_Coolbaugh.pdf

Nash, G.D. and M.W. Hernandez
"Cost-Effective Vegetation Anomaly Mapping for Geothermal Exploration." Proceedings of the 26th Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, 29-30 January 2001.

Whitlock, C.H. and Stackhouse, P.W. Jr.
"An Estimate of NASA/ESE/POWER Program Benefits to the U.S. from 2002 through 2017." June 3, 2002. Obtained through Jackson D. Collier, Outreach and Applications, NASA's Earth Science Applications Division.

Remote sensing industry expects growth

A Summary of the ASPRS 10-Year Industry Forecast

Mr. Charles Mondello
Sr. VP Corporate Development
Pictometry International
Rochester, N. Y.
www.pictometry.com

Dr. George F. Hepner
Professor and Director
Southwest Center for Environmental Research and Policy
Department of Geography
University of Utah
Salt Lake City, Utah
www.geog.utah.edu/faculty/

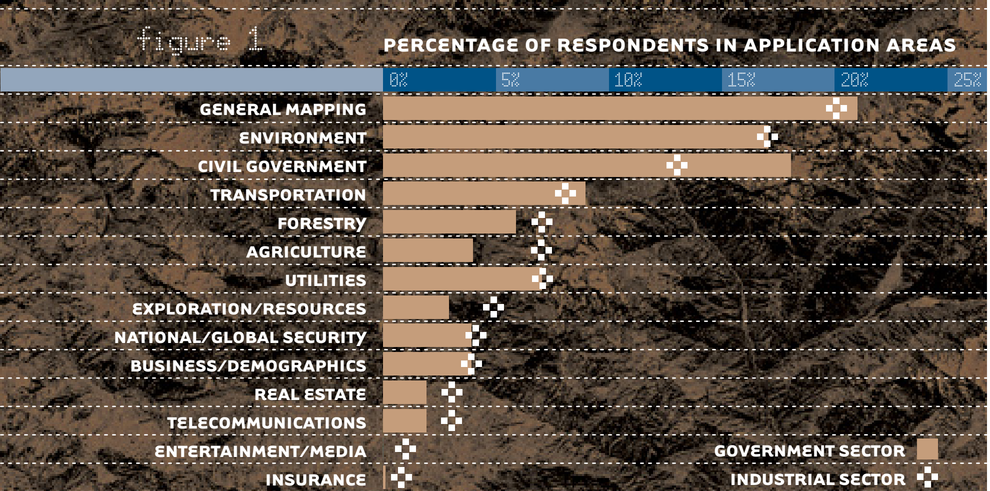
Dr. Ray A. Williamson
Research Professor
Space Policy Institute of The George Washington University
Washington, D.C.
www.gwu.edu/~spi

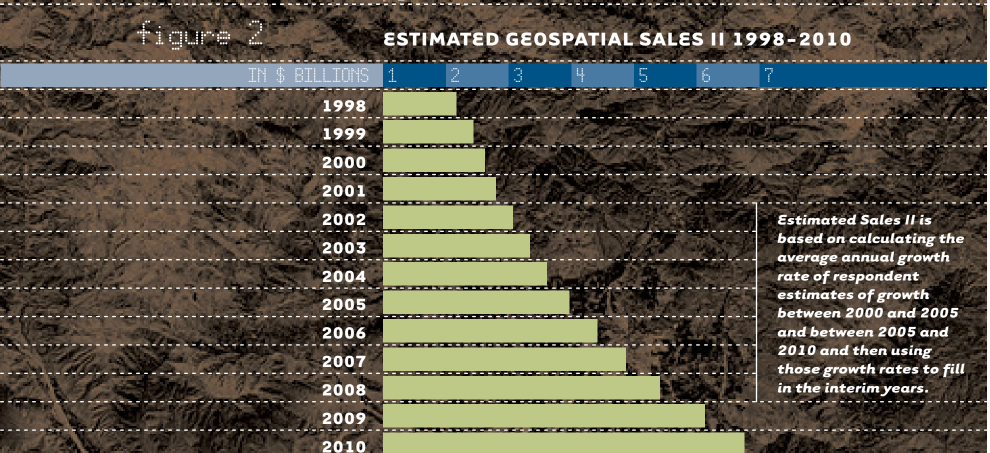
In August of 1999, the National Aeronautics and Space Administration (NASA) and The American Society for Photogrammetry and Remote Sensing (ASPRS) agreed to undertake a comprehensive study of the remote sensing and geospatial information industry in the United States. Their ultimate goal was to develop a continuing forecast of the remote sensing industry. In 2002, the National Oceanic and Atmospheric Administration (NOAA) formally joined NASA and ASPRS to support the documentation and analysis of the forecast and to provide further information to the private sector and government agencies.

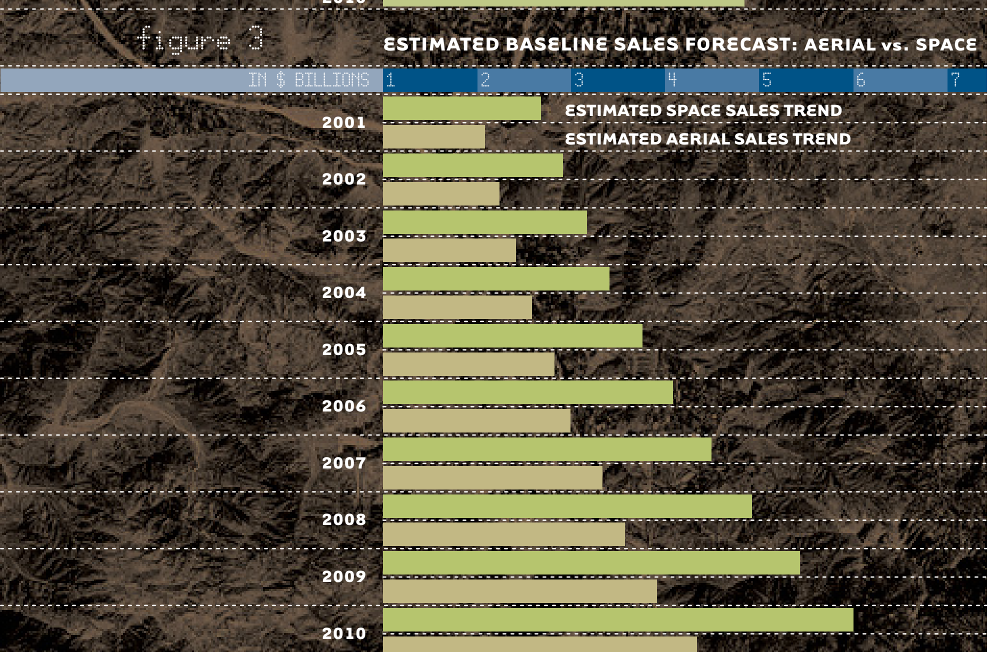
An estimated 175,000 people are employed in the rapidly growing U.S. remote sensing and geospatial information segment of the much larger information industry.

Prior to this study, few comprehensive data about the industry, and no reliable, unbiased assessments of the industry's future existed. This study is an attempt to remedy these limitations by combining the experience of the talented volunteers of the membership of ASPRS with the knowledge, experience and resources of NASA, NOAA and the U.S. Geological Survey (USGS) in a continuing forecast of the industry and the key factors that affect it.

The forecast is composed of three phases to date. Phase I, which was completed in December 2000, characterized the industry and developed a financial and activity baseline and an initial forecast. Phase II, completed in 2002, centered on the identification and assessment of the end users of remote sensing and geospatial information products. Phase III focused on validating the results of Phase I and II and delivering an updated technology and market assessment, especially given the potential impacts on the industry following the events of September 11, 2001. Post-Phase III (Phases IV and on) activities will center on developing a revised market forecast and standardizing methods for continuing the rolling forecast. ***Figure 1 shows response rates by industry.***







SUMMARY

Industry members hold an optimistic view of future industry growth, estimating that it will increase by 9 percent to 14 percent per year.

The industry is undergoing rapid change as technology improves, and potential clients realize the benefits of using geospatial data and analytical technologies for their information needs. In 2001, the industry gained estimated revenues totaling $2.4 billion, not including sales of satellite systems and aircraft platforms. Based on the 2000 and 2001 surveys of gross revenue, the industry currently appears to be growing at rates of between 9 percent and 14 percent per annum. Phase III of the forecast assessed the effects of September 11, 2001, on industry growth. Consistent with the contraction of the U.S. economy since 2001, study respondents reduced their growth projections in Phase II to nine percent over the next few years (from 14 percent in Phase I). ***See Figure 2.***

Survey responses revealed that most firms in the industry are relatively small (fewer than 100 employees) and are focused on providing specific, narrowly defined services or data. By contrast, the few large firms (greater than 500 employees) generally provide a wide range of services. Most of the civilian remote-sensing industry involves the provision of mapping and engineering applications needed by governments at all levels. The many smaller firms that undergird the industry are less inclined to support internal research and development (R&D) and workforce development, are more affected by governmental competition with their services, and are less able to meet foreign competition forcefully.

AERIAL IMAGERY: COMPETITIVE OR COMPLEMENTARY?

Contrary to the expectations of some analysts, the introduction to the market of high-resolution satellite imagery has enhanced, rather than undercut, sales of data acquired from aerial platforms. Both segments have experienced growth and tend to complement each other. ***See Figure 3.***

Over the past decade, the commercial remote-sensing industry has experienced significant technological change and improved market penetration. New sensor technologies, both in aerial and space systems, offer a myriad of new information capabilities.

The development of high-resolution commercial satellites (1-meter black and white and 2.5-meter multispectral or better) has opened new data and new collection methodologies to the ultimate information customer. In response, in part, to competition from satellite remote sensing, the aerial industry has also developed new methods of capturing geospatial data in computer-friendly digital form. Initially, some analysts believed that satellites would usurp aerial's market share, but this survey shows that both segments are growing and augmenting each other. In several cases, satellite and aerial data producers have formed strategic partnerships to enhance each other's market opportunities.

> "Inconsistency in governmental policy has introduced extra uncertainty and risk for the industry."

POLICY CHALLENGES

More than in most other businesses, growth opportunities for private firms and academia are tightly coupled with the information needs at all levels of government.

Federal, state, and local governments participate in the remote sensing marketplace by purchasing data and services and by providing R&D funding. Government agencies constitute the largest single class of customers for data and services. They also hire analysts with skills in RS/GIS. Industry interactions occur primarily business-to-business and business to government, with minimal direct interaction with citizen consumers. As a result, the private sector is heavily influenced by governmental involvement in the marketplace.

Much of the civilian R&D for both government and private sector takes place in academic institutions. The future workforce for the industry depends on the viability and responsiveness of the academic community to the rapidly changing technological developments and skill needs of the industry.

Federal government policies, developed and refined over the years, have had a major influence over the development of the market for remote sensing data, new technologies and other applications within the geospatial industry. Conversely, inconsistency in governmental policy has introduced extra uncertainty and risk for the industry.

Federal funding has developed the basic technologies for all forms of satellite remote sensing and contributed markedly to the development of advanced airborne instruments, such as light detection and ranging (LiDAR), interferometric synthetic aperture radar (IFSAR, INSAR), and hyperspectral digital sensors. For stated reasons of national security, the federal government has limited the development of high-resolution civilian satellite sensors and maintained sharp boundaries between the technologies developed for national security and for civilian uses.

In the early 1990s, more liberal federal policies began to promote the use of satellite data for a wide variety of uses. As government at all levels is the primary purchaser of data, the price and licensing of data are key issues evolving in the private sector, especially in the satellite domain. Inconsistent, or highly variable, governmental policies are particularly worrisome because they introduce an extra element of risk for industry, especially for satellite data firms. In order to stay in business, these firms need supportive governmental policies that allow them to recoup the massive investments they have made in modern satellite technology. By comparison to the satellite segment of the industry, the aerial market is very large and has a profitable, more assured business model.

On April 25, 2003, the White House issued a new commercial remote-sensing policy that further eased previous restrictions on the commercial collection and sale of satellite remotely-sensed data. Among other things, the new policy provides guidance for establishing a "long-term, sustainable relationship between the United States Government and the U.S. commercial remote sensing space industry."

Phase III results regarding the real and potential effects of the attacks of September 11, 2001, on governmental policy indicate that increased restrictions on the public availability of geospatial information have had a negative effect on organizations producing geospatial data and information, especially in data export, airspace restrictions and data purveyance to the public. The user community, primarily civilian government and private sector, cited little change in 2002 and anticipated minimal impacts in the future.

Many industry decisionmakers recognize that keeping data prices low and eliminating data-use restrictions for government-supplied low- and moderate-resolution satellite data have helped to stimulate the commercial market while providing a public geospatial infrastructure meeting many data needs. The prices charged for commercial satellite data products must recover the costs of developing, building, and operating the satellite system, just as they must for aerial data services.

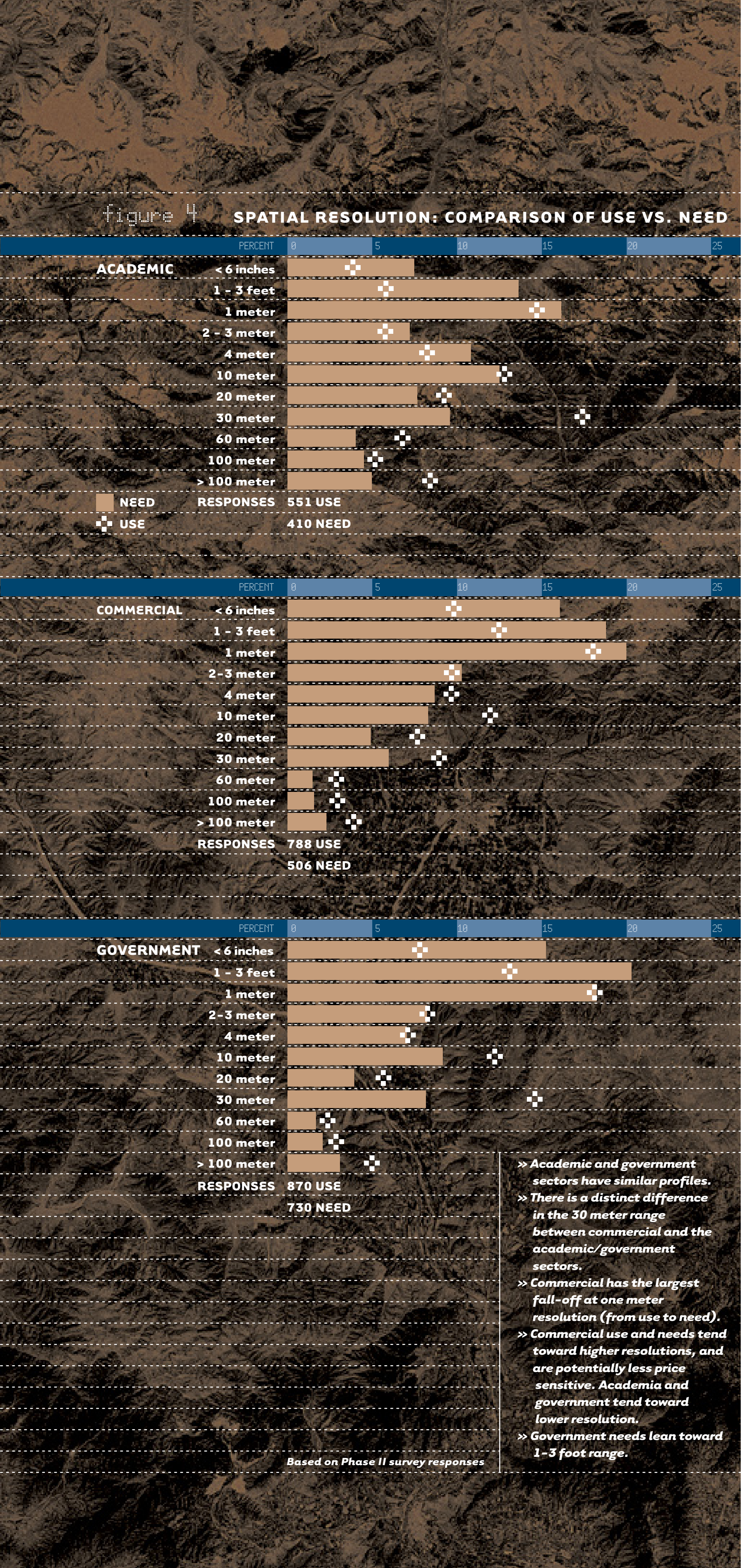
Many educators have expressed considerable anxiety about future access to data, not only with respect to funds to acquire data, but also the right to use and share new, advanced data with few restrictions. The federal government could assist the academic community to improve its research capacity and the development of more efficient ways to apply improved data by underwriting more of the data costs for research and education.

In some disciplines, government agencies may compete with commercial entities in the provision of data and services. Some commercial suppliers of data and value-added services voiced strong concern about perceived government competition with these suppliers.

WORKFORCE ISSUES

The development of a capable workforce is of major concern for continued industry growth. Graduates are not entering the workforce in sufficient numbers or with sufficient training in the latest technologies and techniques. Lack of retention of entry level workers is hampering the long-term health of the industry.

Governmental and private sector leaders declared a strong need for properly educated and trained entry-level employees. This need has become more pronounced as market growth has increased, and much of



the workload has shifted from the government to the private sector.

Most RS/GIS programs in the U.S. are offered in departments or colleges of geography, natural resource management, forestry, and civil engineering. Other disciplines offer individual courses in RS/GIS, but these four disciplines provide most instructional programs of multiple, integrated courses. These academic programs are small and cannot adjust rapidly to new advancements taking place in the industry. Further, the smaller firms generally have limited resources for additional on-the-job training to compensate for any educational deficiencies in new staff.

Certificate programs (non-degree supplemental programs) are gaining increased acceptance in the educational community. These programs provide a means for disciplinary specialists to retool their knowledge and skills.

The study also revealed concerns over the retention of qualified employees. Phase II showed that the age structure of workers in the industry follows a bi-modal distribution, with most either older, experienced workers or younger employees, new to the industry. These data suggest that many younger employees are leaving the industry, potentially creating a shortage of mid-level personnel. The reasons for this trend are not clear.

MARKET OPPORTUNITIES

The development of new analytic methods and new geospatial technologies will lead to future growth and new applications, especially in market segments that are currently underserved. Data customers especially desire higher resolution and improved positional accuracy.

Phase I of the study revealed ample opportunities for growth in diverse market segments. Although mapping, civil government, national defense and global security applications of geospatial data/information currently dominate the market, the needs of local and state government for homeland security, environmental assessment, and infrastructure applications are substantial and are likely to increase.

Smaller firms are attempting to provide specialized value-added services on both satellite and aerial products to meet customer needs. Further, the use of both aerial and satellite data is increasing. Hence, the industry appears to have opportunities both for a greater number of firms and continued growth among diverse markets. For example, industry gains only a small portion of revenues from certain business activities with strong geospatial requirements, such as real estate and insurance. These businesses could bring future market opportunities if geospatial information can be tailored to their special needs and potential customers are educated in using such information effectively.

In aerial remote sensing, the transition to digital sensor technologies, some capable of direct geo-registration and elevation collection, has opened new markets for urban mapping and infrastructure inventory and analysis. In general, sensor technologies have increased in diversity and improved in capability during the past two decades. Digital aerial cameras coupled with inertial measurement and onboard GPS enable the low-cost acquisition of geo-positioned information, which will assist in opening new markets, especially where pricing has limited acceptance of remotely sensed information.

Data users are evaluating the replacement of multispectral data with hyperspectral data. Growth will be seen in the key areas of hyperspectral, SAR (IFSAR), and LiDAR for aircraft, especially as sensor systems evolve that provide low-cost, broad-area coverage. Hyperspectral sensor systems in development will offer automated feature detection, identification and classification. Markets as diverse as defense, precision agriculture and forestry all benefit from change detection technology. The elevation component of remote sensing from IFSAR and LiDAR sensors also provides high growth potential. These systems can provide data to create highly accurate digital elevation models (DEMs) to markets in need of superior geopositioning and terrain information.

Further, issues of high data cost, delays in acquisition, and licensing of data sales may inhibit adoption of these data by users. Continued industry growth will occur only with the implementation of improved technology and government policies that support geospatial research and development in a number of disciplines.

Phase II evaluated the customer's data needs by undertaking a detailed requirements analysis of "use versus need" as a function of multiple user types. Data characteristics included ground sample distance (GSD), geopositional accuracy, data layers, elevation accuracy and data timeliness. While all are important to the remote-sensing industry, small GSD and high geopositional accuracy are critical. Neither the needs of the academic data customers nor those of governmental data customers are being met at sufficiently high levels of accuracy.

Forecast data imply that data users desire resolutions smaller than three feet (0.9 m). ***See Figure 4.*** Data sets may be used to assess urban infrastructure or for high-accuracy mapping. Further, they can be used to delineate details in the environmental, forestry and agriculture segments. High-resolution imagery over broad areas requires high levels of data storage, which will require improvements in computer storage capacity and access speed. Geospatial data and information users desire improved geopositional accuracy, signifying market opportunities for firms interested in achieving more stringent geo-positioning. Direct geo-registration techniques have increased data collection firms' ability to achieve improved positioning, but additional R&D will be required to reduce costs and improve market penetration of high-accuracy techniques.

The remote sensing industry is growing, though supportive government policies will be needed to foster continuing growth. There is a tight linkage among commerce, government and academia in this highly fragmented industry. New technologies, data and sensors from air and space are fostering growth. However, limited workforce availability, as well as inconsistent federal policy on data holdings, technical restrictions and exports, limits industry growth.

Acknowledgements:

The authors are deeply indebted to all of the ASPRS volunteers, Ronald Rabin and his staff at Stennis Space Center, Tim Stryker and Katy Vincent at NOAA, and to James Plasker and his staff at the ASPRS in Bethesda, Maryland.

The complete forecast report is available from ASPRS at 301-493-0290 x101. Information is available at www.asprs.org.

Allen Ibaugh
Urban and Regional Solutions Manager
Space Imaging
Orlando, Fla.
www.spaceimaging.com

Dawn Tuten
ETDM Manager
Florida Department of Transportation
Orlando, Fla.
www.myflorida.com

streamlining transportation information systems

Several initiatives to automate many internal business functions have been undertaken by the Florida Department of Transportation (FDOT) District Five in Orlando, Fla. These functions include the development of regional impact review, mitigation, work program development and review, and level of service analysis.

Recognizing the booming information technology market, the district has initiated programs with the underlying objective of automating transportation planning and policy procedures to reach a goal of a more efficient and effective planning process. Information technology tools, such as geographic information systems (ArcGIS and ArcIMS), relational database management systems, and Web-based delivery mechanisms, are either currently being utilized in the automation effort or will be in the near future. This article reviews these current initiatives and discusses their foreseen outcomes as well as future potential information technology prospects.

This streamlining of many processes and tasks by developing a data integration system has materialized over the past year and has saved time and money while significantly increasing the quality of work.

The origin of this system began many years ago as a mainframe data comparison system. At that time, data describing financial information about roadway facility and program projects, which was stored on the mainframe, was compared with spreadsheets that were maintained in the district planning office. This comparison was very helpful for various planning analysis tasks.

If comparing a few datasets is good, comparing hundreds of datasets could be even better, if done correctly. Over the years more and more information has been made available through advances in technology and improvements in communications throughout the department. Very recently, several technology tools have been developed that allow the information to be shown in graphic rather than tabular form.

The resulting project is TAIMS, or the Transportation Automated Information Management System. The core datasets in TAIMS are:

A. Work Program Project Databases
B. Roadway Characteristics Inventory (RCI)
C. Florida Geographic Data Library (FGDL)

RCI and FGDL provide the geographic base complete with monthly updates from Tallahassee's FDOT Central Office statistics unit for specific roadway segment data. This information is stored on a data server and viewed within an interface that also provides access to many datasets maintained in the district's planning office in Orlando. »

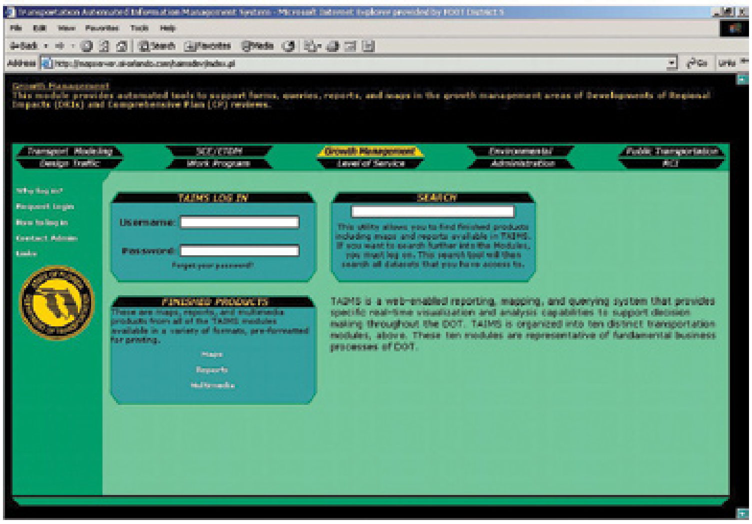


Figure 1: TAIMS log-in page

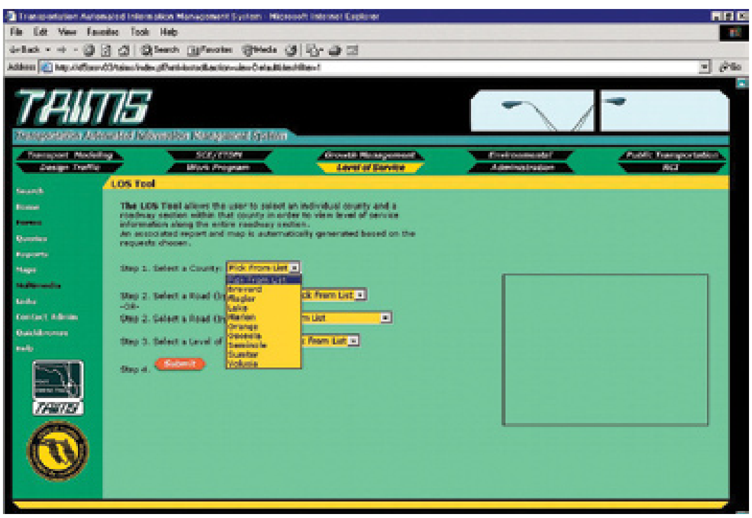


Figure 2: LOS tool functionality

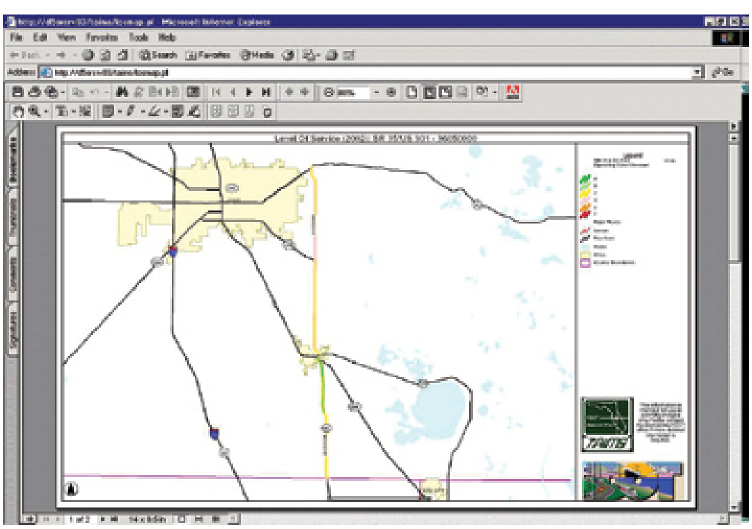


Figure 3: Level of service example 1

TAIMS is organized by functional groups within the planning office. Each section of TAIMS includes forms, queries, reports, maps, and links. Forms allow easy input into databases. Queries allow specific information to be extracted. Reports organize and display data in various formats, sometimes matching documents and spreadsheets traditionally used over the years, and sometimes showing those created for a specific purpose. Three levels of mapping graphically depict datasets. Links send the users to other sites within the FDOT intranet or to external sites. ***(See Figure 1.)***

TAIMS users generally fall into two categories: database users or map users. The following will describe database efforts and mapping efforts within TAIMS.

The development of TAIMS has already provided a significant savings in time and an increase in quality of work product. One example of this can be found in the development of District Five's LOS_all, a database of congestion levels on each section of state roadway throughout the central Florida area. In past years this information has been stored in a spreadsheet and updated by manually checking roadway characteristics data for every roadway segment in the district. This year, the characteristics stored in LOS_all were mapped and compared with the characteristics updated monthly by the Tallahassee statistics office. The resulting product is a database that can be represented in a table or on a map. Because it has been cross-referenced with the statewide RCI database, the quality of the product has been improved even though the level of effort has been reduced. The following graphics highlight the LOS tool functionality within TAIMS. ***(See Figures 2, 3, and 4.)***

The next phase of development in TAIMS will showcase another database effort in D5 planning that has already saved the department a significant amount of money and time. District Five Planning Technical Applications Group has created an Archive Design Traffic Database to keep track of completed ESAL (Equivalent Single Axle Loading) and PD&E (Project Development and Environment) Final Traffic reports. These reports are initiated in planning but used by other sections throughout the district.

Previously the final planning documents have been stored but rarely used other than for the initial purpose, partly because the hard copies of the documents have not been easy to access. Planning office staff realized that the information in these documents could be used for many other tasks if it were made accessible.

In the process of developing the database, staff included several factors from the completed reports to allow interested parties to retrieve this current information for new construction and resurfacing projects. As a result the database has saved in excess of $35,000 over a period of about three months in requests for new traffic reports by obtaining valid information from the Archived Design Traffic Database.

The actual paper document is still stored in the same manner as before, but the data is stored in an Access database. The ESAL document is assumed to be valid for a period of two years. The archive database retains ESAL documents for a period of three years and automatically purges the old documents. Additional information will be retrieved from the traffic reports and forwarded to the statistics group for their use. Technical applications staff is in discussions with the statistics unit to try to find some common needs and tasks to be undertaken jointly rather than separately by various consultants. This may result in further cost savings and increased product value. The Design Traffic Database will soon be available for access in TAIMS for any party with interest in this information.

The planning office works with outside agencies frequently to receive and provide information. One group within planning works with Metropolitan Planning Organizations (MPOs) and rural counties to assist in the development of a Transportation Improvement Program (TIP), which is made up in part by information from the department's adopted five-year work program. The department provides a copy of its work program, which the local agency sorts through in order to retrieve relevant information. Last year, the planning office provided many of these local agencies with TAIMS reports instead of the traditional paper copy of the work program.

The TAIMS report used raw work program data from the mainframe and formatted it according to the specific agency's TIP format. The result was time savings both to department staff and the local agency's staff. This year, any TIP reports produced last year can be used with the new data, and the task is already complete. The planning office intends to finish developing reports for any local agencies that did not receive this type of report last year. In future years, when it is time to send the TIP report, all the work will be done and the entire task will be accomplished with a simple email. The following graphics highlight the TIP tool in TAIMS: ***(See Figures 5, 6.)***

There are several other ongoing database efforts within the district. Each of them share a commonality, which is that data can be entered or maintained within a form, pulled out specifically within a query, or produced for final output through a report. Many of the datasets also have a mapping component, which can be generated in ArcGIS or ArcIMS, or displayed through a series of jpg files containing pre-made maps.

Geographic information system (GIS) technology is rapidly emerging as the one of the easiest ways to quickly interpret transportation data. TAIMS utilizes GIS through ESRI products for three different user levels.

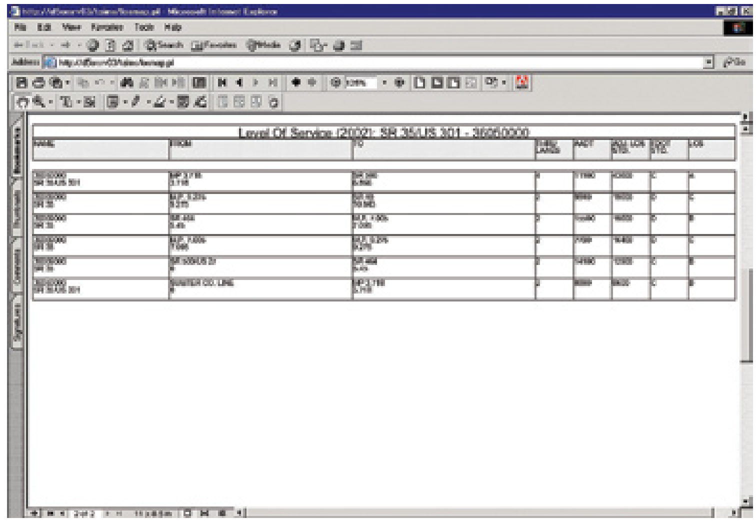


Figure 4: Level of service example 2

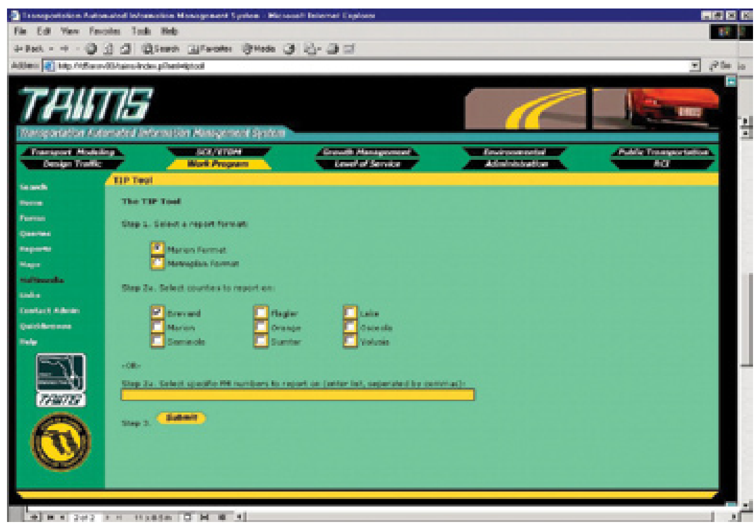


Figure 5: TIP tool

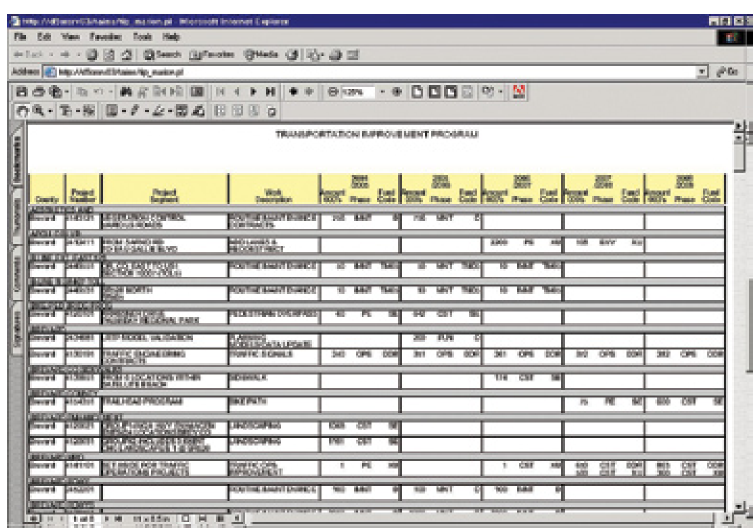


Figure 6: TIP report

The most basic level of mapping contained within the system consists of a set of approximately 30 graphics for each of nine counties within the district. Each of these graphic files shows a basemap with a specific data layer or layers added. Currently, these maps are generated in Arcview and exported to jpg. This process results in what is referred to within the office as "TAIMS for Dummies." This level of mapping has been created for those users who just wish to look at a final product map that is produced on a regular schedule. The technical applications group has begun producing these maps on a schedule, with some datasets being updated yearly and others monthly or even more frequently.

The maps fall into three categories: the District Needs Assessment series, which includes general information about the district, such as roadway projects, congestion levels, and land use information; the RCI series, which is specific information about each roadway segment in the district such as median width or number of lanes; and the environmental series, which contains information about features such as wetlands, basins, and floodplains.

The next level of mapping within TAIMS pulls data layers created from database and spreadsheet programs, text files or Word documents. Some of the data is input through Web forms built within TAIMS. This information is then sent to dbf files, and event themes are created on the statewide roadway basemap. The resulting layers are divided into related subjects and put into various ArcIMS views. Intermediate users can turn layers off and on, zoom, measure, and query within ArcIMS. Future plans for this level include an expansion of customized views for each planning section and the creation of pushbutton simple automation of repetitive transportation analysis tasks now performed manually.

The most advanced level of mapping within the system is traditional GIS. Any layers utilized in the ArcIMS version can also be accessed in ArcGIS or ArcView 3.3. This is the level at which a user is able to edit geographic information. Since TAIMS is accessed only through user name and password, the data is protected from unauthorized changes.

The next step in TAIMS development is to conduct a business process analysis to determine informational needs that can be met by the system. This process is now underway. After the analysis is complete, district management will evaluate and prioritize the needs and weigh them with available funding to determine how the system will be improved. It is anticipated that cost savings already realized by utilization of TAIMS will more than fund many of the enhancements that will be considered.

november

7 – 10
URISA 42nd Annual Conference
Reno Hilton
Reno, Nev.
www.urisa.org/annual.htm

december

6 – 9
I/ITSEC Conference
Orange County Convention Center
Orlando, Fla.
www.iitsec.org/confinfo.cfm

St. Louis

august

7 – 10
ESRI Education User Conference
Marriott Hotel and Marina
San Diego, Calif.
www.esri.com/events/educ/index.html

9 – 13
ESRI International User Conference
San Diego Convention Center
San Diego, Calif.
www.esri.com/events/uc/index.html

29 – September 1
URISA's 6th GIS in Addressing Conference
Hyatt Regency
St. Louis, Mo.
www.urisa.org/address.htm

30 – September 3
1st International Workshop on Geographic Information Management (GIM 04)
Zaragoza, Spain
http://gim04.unizar.es/

september

13 – 14
Commercial Remote Sensing Industry Conference
Embassy Suites
Denver, Colo.
www.srinstitute.com/cg117

20 – 24
IGARSS 2004
Egan Convention Center
Anchorage, Alaska
www.igarss04.org/

26 – 29
SpatialTech 2004
Walt Disney World Dolphin & Swan Resort
Orlando, Fla.
www.ntpshow.com/spatialtech/

october

6 – 8
GIS in the Rockies
Plaza at the Mart
Denver, Colo.
www.gisintherockies.org/index.htm

12 – 14
GEOINT 2004 Symposium
Sheraton New Orleans
New Orleans, La.
www.usgif.org/symposium/index.html

18 – 22
RADAR 2004
Toulouse, France
www.radar2004.org/

New Orleans

Imaging NOTES
12076 Grant Street
Thornton, CO 80241 USA