

# the digital perspective

## Filling in the Gaps with Complementary Technologies

Contributed by Ron Roth and Don Marsh, Leica Geosystems Geospatial Imaging and Geoff Jacobs, Leica Geosystems HDS

■ Airborne laser profiling is seeing increased use in a variety of surveying and mapping applications, and performance of airborne systems has increased dramatically over the past several years. However, there are still applications in which an airborne survey will not provide adequate results, despite current high performance levels. The history and convergence of airborne and ground-based LIDAR technologies offers insight into what could be perceived as overlap in the two technologies. The technologies might best be employed in a complementary fashion, fusing airborne and ground-acquired LIDAR data.

### Market perspective and system design

Airborne LIDAR systems have existed commercially for approximately ten years. There are now over one hundred airborne LIDAR systems worldwide and virtually all of them are still in service. The pioneering systems integrated primarily by institutional organizations (i.e., government agencies, military and universities) have given way to a mature merchant-supplied market.

Similarly, the installed base of ground-based LIDAR systems has grown, from initial systems delivered in 1998 to a current installed base of nearly 700 systems world-wide.

Both airborne and ground-based LIDAR are served by products aligned along an array of applications. Airborne LIDAR systems generally fall into two categories: flexible, general-purpose mapping systems and low-altitude systems designed for corridor mapping applications.

General-purpose mapping systems mounted in fixed-wing aircraft form the bulk of the airborne LIDAR fleet. General-purpose mapping requires systems that can cover vast amounts of terrain from high altitudes, while retaining the ability to deliver tight post spacing (< 1 m) even from fixed-wing aircraft, all with accuracy of better than 10-15 cm root mean square error (RMSE). Maximum flying height for these systems is typically 3000 m above ground level (AGL) or higher, though the bulk of general-purpose mapping is performed at somewhat less strenuous altitudes.

Low-altitude systems, typically flown on helicopter platforms, are part of a growing specialty market segment. These systems can economize in the mission planning area by flying low enough for the pilot to navigate by merely looking down to confirm that the intended target (power line, pipeline, roadway, etc.) is at nadir. Systems serving this market segment commonly fly as little as 50 m above ground, resulting in impressive accuracy and post spacing, while entering the market at prices significantly lower than that of general-purpose airborne LIDAR.

Most general-purpose airborne LIDAR systems are capable of providing data as accurate and as dense as specialized corridor-mapping systems when used at similar altitudes and aircraft speeds. The increased

flexibility of general-purpose systems does, of course, result in higher prices for these systems. Interestingly, the data production process is virtually identical for both general-purpose and corridor-mapping LIDAR systems.

Ground-based LIDAR systems tend to fall into three major categories: systems for

engineering applications requiring fine (2-3 cm) post spacing and high (~6 mm) accuracy; systems for stand-off (100-1000 m range) data capture where medium (2-3 cm) accuracy is needed; and systems with ultra high measurement rates for very high point density at very short (typically < 20 m) distances.

### Development history of airborne LIDAR

As both airborne and ground-based systems approach the ten-year mark in terms of time-in-market, performance, by most technical metrics, has increased steadily.

In the case of airborne systems, the maximum pulse rate of airborne LIDAR systems has increased twenty-fold. The maximum pulse rate of airborne LIDAR systems has doubled every 2.1 years. This increase means greater productivity during raw data collection. It also paves the way for increased point density or conversely tighter post spacing from the airborne system.

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In parallel with the increases in maximum pulse rate, airborne LIDAR systems have shown an increase in maximum flying height. Initial systems, introduced with maximum flying heights of only 1000 or so meters AGL, have given way to systems regularly operating at up to 4000 m AGL, and specialized versions have flown at up to 10 km AGL, providing slant range data for terrain up to 15 km from the scanner. Though not as radical as the growth in pulse rate, the growth in maximum altitude has provided increased flexibility to the user, allowing for single-altitude flight plans even over areas of great vertical relief.

Finally, airborne systems have steadily increased in accuracy, particularly when operating at lower altitudes where GPS errors are minimized. Early systems provided data with accuracies on the order of 20+ cm, even at their lowest flying heights. Today's systems take advantage of more developed rangefinder and DGPS technology to allow accuracy as fine as 5 cm when used at low altitudes with short GPS baseline and optimal GPS planning.

For the users of airborne LIDAR systems, that has meant a steady increase in both productivity and the accuracy of the delivered product, allowing airborne systems to be used in applications that may have demanded field surveys only a few years ago.

*There are certain applications that will forever remain the domain of ground-based LIDAR systems.*

## Development history of ground-based LIDAR

Ground-based LIDAR systems, like their airborne counterparts, have also experienced a steady level of performance improvement, though their history is somewhat shorter. Early systems featured pulse rates of around 1000 Hz while attaining engineering-level performance. Recently, systems with pulse rates of 1500 Hz have become available.

The other performance metric that has seen greater improvement is the maximum range at which the needed 6 mm resolution can be obtained. This has doubled since 1998, from maximum useable ranges of 50 meters initially to approximately 100 meters today.

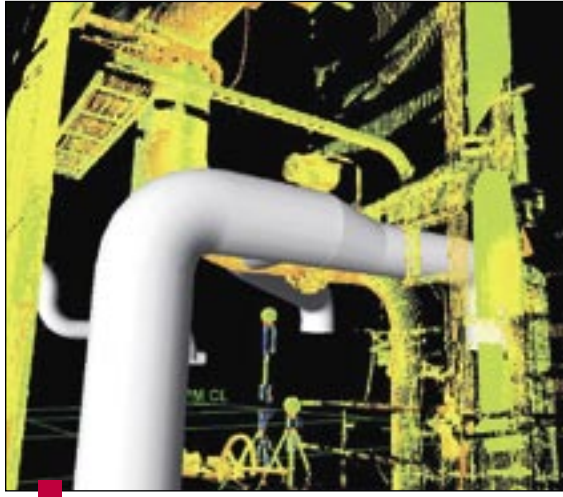
One aspect of ground-based LIDAR performance that has improved substantially is field of regard. Initial systems were introduced with field of regard of 40 x 40 degrees. Very quickly, the industry began to introduce systems capable of greater coverage, until today's systems, which may offer coverage areas in excess of one hemisphere. Therefore, although increases in pulse rate have provided only modest increases in data collection productivity, the ability to "set-and-forget" (setting up the system and then letting the system autonomously collect data over a large coverage area) allows operators to perform other duties while the system continues to collect data.

## Points of convergence

What are the obvious points of convergence for these technologies, if any, and is it possible that airborne data acquisition could replace ground-based LIDAR?

The two most obvious points of convergence involve technical performance:

- Data density, particularly from low-altitude

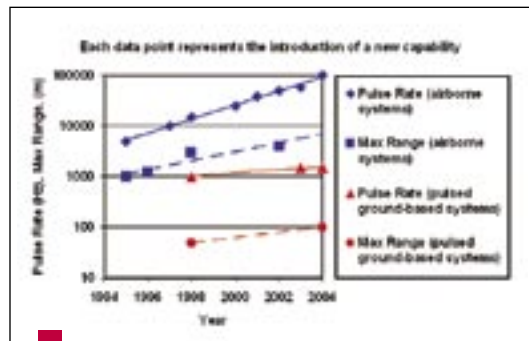


Typical level of detail for ground-based LIDAR systems.

platforms (i.e., will airborne systems be able to deliver engineering-level data densities (i.e., 2-3 cm post spacing)?)

- Accuracy (i.e., will the accuracy of airborne systems ever be adequate for engineering work?)

In terms of data density, as high-performance airborne LIDAR systems acquire data at faster and faster rates, the potential exists to decrease post spacing. This is especially true if the aircraft is allowed to fly at low altitude (or otherwise cover a narrower swath). This is further enhanced if the system is mounted in a platform with a very slow forward speed, such as a helicopter. In an effort to provide a legitimate comparison, the average post spacing of various airborne LIDAR systems over time has been calculated assuming a 40-degree swath (similar to initial ground-based systems) and



Summary of LIDAR technology advancements.

system mounting in a helicopter with 30 knot forward speed. The results are compared to the typical post spacing of ground-based LIDAR systems (i.e., 2-3 cm posting).

The results provide an interesting picture. Does this mean that the two technologies are converging? Perhaps they are in some way. What is the time horizon? Today's airborne LIDAR systems could perhaps achieve 0.090 m average posting versus 0.025 m for ground-based systems in a full-scene scan. This is a factor of 3.6 in post spacing, so the two technologies are not as close together as they seem. Furthermore, reducing post spacing in both the X and Y directions captured by the airborne system would require a factor of  $3.6^2 = 13$  higher pulse rate.

As for data accuracy, low-altitude LIDAR systems are being advertised at levels as precise as 5 cm in XYZ. This is clearly not acceptable for typical engineering applications, where 6 mm accuracy is needed. Even survey-grade kinematic DGPS can only deliver accuracy

in the area of 2 cm, so it would seem that this alone could be a limiting factor. In addition, the IMU used to determine the orientation of the airborne LIDAR with respect to the earth below introduces error in determining the location of a point in the scene. Though it is a small error at low altitudes, it is present nonetheless.

## Complementary versus competing

So why not use airborne LIDAR for everything? Which technology is better?

There are certain applications that will forever remain the domain of ground-based LIDAR systems. Even current ground-based systems are capable of delivering point densities higher than that regularly achieved by high-resolution aerial photography, much less airborne LIDAR. Furthermore, obtaining spatial data under overhangs remains a virtual impossibility for airborne LIDAR. There are also several factors that will drive manufacturers down different development paths for these two technologies:

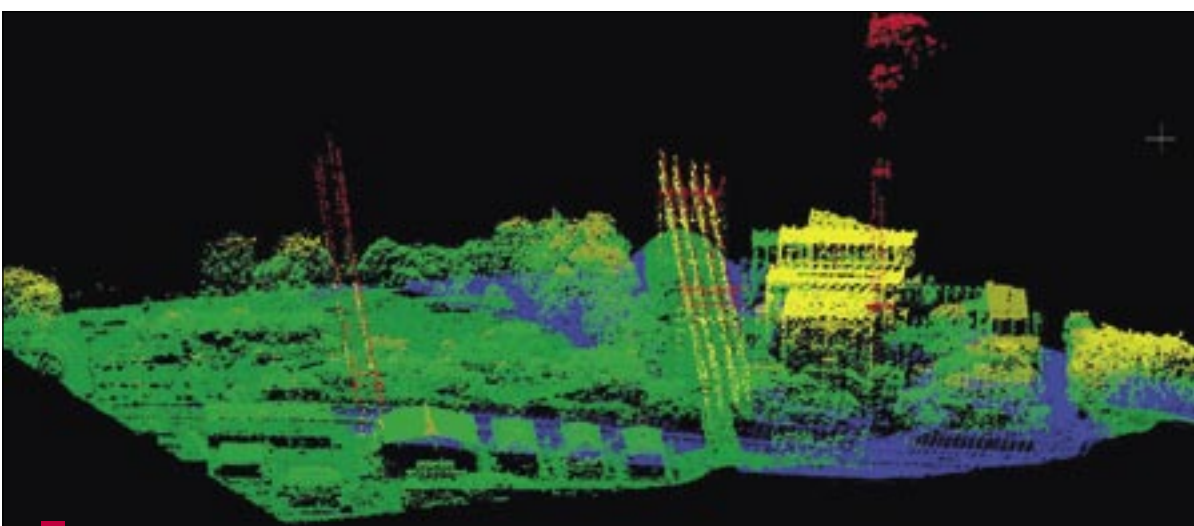
- Accuracy - Georeferencing airborne data is inherently more challenging than providing accurate data from a stationary platform.
- Mobility - Airborne LIDAR will allow the user to "drop in" on remote or inaccessible survey areas.
- Maximum Range - Airborne LIDAR is not generally constrained to human-portable, battery-pack operation. This allows the use of more powerful laser devices and larger collecting apertures.
- Eye Safety - Ground-based systems must essentially be limited in terms of maximum laser output to energy levels not unlike that of a typical laser pointer, thus maximizing safety for persons in the immediate vicinity of the system while airborne systems need only be eye safe for a person on the ground when the aircraft flies overhead.

It seems that the two technologies only appear to converge. Airborne systems are good at mapping infrastructure in between nodes in the infrastructure system (e.g., pipelines/power lines), while ground-based systems are good at mapping the nodes themselves (e.g., refineries/power plants). These two technologies are then, for the most part, complementary.

## Conclusions and predictions for the future

It appears that airborne and ground-based systems both have a healthy future. They will continue to fill the niches they fill today. As the performance of airborne systems increases, there may be some small overlap with demands currently met using ground-based techniques, but it is even more likely that we will see both types of data acquired at the same location for differing purposes. Consider also these possibilities and parting thoughts, and what they might mean to LIDAR users in the future:

- Pulse rates of both airborne and ground-based LIDAR will continue to increase.
- Airborne LIDAR will continue to take advantage of GPS technology, and this will push Airborne LIDAR accuracies closer to that of today's ground-based LIDAR systems. However, GPS is simply one error source that ground-based LIDAR systems do not have to contend with.
- Airborne and ground-based LIDAR data will see increased use in fused data sets. The LIDAR industry must increase the speed with which:
  - Ground-based data can be georeferenced.
  - Large data sets from airborne systems can be ingested.
  - Ground-based and airborne-acquired data can be displayed and handled, especially in conjunction with auxiliary sensors.
- Planning and processing software will continue to be enhanced for both airborne and ground-based systems. Processing takes a large portion of the overall job budget and is the most obvious "point of pain" for practitioners.



Typical level of detail for ground-based LIDAR systems.

# Growing Usage of Geospatial Data in State and Local Government Decision Making

State and local government agencies are increasingly using geospatial data for many purposes. The areas of engineering/public works, tax assessment and planning/development, are the segments that most frequently utilize GIS data, software and hardware for decision making and planning purposes.

Government entities rely on GIS data for urban change detection when doing tax assessment. Local public works and engineering departments utilize geospatial information for assessment and planning of various infrastructure needs. For example, in Atlanta, Georgia, U.S., the city's water department is using GIS data gathered by the Georgia Institute of Technology (Georgia Tech) Center for GIS to determine how to improve the city's sewer systems. ("The City of Atlanta, Georgia Meets 21st Century Water/Wastewater Demands with GIS" [the link](#), Q2 2005.) Through the use of this valuable information, city officials were able to make projections on new sewer infrastructure needs and also develop a fee model for charging property owners based on their water, sewer and storm water runoff usage.

**Local government users account for approximately 70% of all imagery related revenues in the geospatial market.**

- *World Commercial Remote Sensing Imagery GIS Software Data and Value-added Services Markets (Frost & Sullivan)*

The largest costs and expenditures among users in the local government market are dedicated to GIS construction and maintenance. This includes obtaining the data required to 'feed' the GIS and designing the 'system' that would enable different users within the local government to use the data for their specific applications. According to the Frost & Sullivan report, *World Commercial Remote Sensing Imagery GIS Software Data and Value-added Services Markets*, local government users account for approximately 70% of all imagery related revenues in the geospatial market. High resolution imagery such as Leica ADS40 Airborne Digital Sensor imagery is increasingly being used for highly detailed infrastructure and utility construction and assessment in densely-populated urban areas.

Up to date geospatial imagery is being used to help identify new and extended residential and commercial building structures. This information is cross-referenced with other business intelligence located within the enterprise such as filed building permits in order to determine violations. The use of imagery minimizes the need to conduct building to building inspections which are known to take several years in larger urban landscapes. Imagery plays a critical role in helping local authorities manage developments within urban cities while maintaining a sustainable development plan.

Geospatial imagery is also a valuable source for automatically identifying and monitoring 'green space' within growing urban environments. Images obtained from different time periods can be used to monitor the change in 'green space' while providing policy makers the information they need to protect the environment.

### Significant Challenges

While they are relying more and more on imagery, these government entities face a number of challenges to effective use. For government agencies already facing resource challenges, the prospect of having both human and technological resources dedicated to gathering, managing and maintaining GIS information is not a viable option.

Even though the use of such information has become a critical part of their decision making process, the reality is that incorporating a system for processing such data can be a time intensive and costly endeavor.

In the past, remote sensing GIS applications were able to scan in a single frame or work directly with hardcopy imagery. This required only a server and a few disks to store the digital data and a couple of networked workstations for feature collection. The advent of the "complete digital workflow" has dramatically altered the landscape.

Digital data now comes from a variety of sources. Satellites, aerial photography from conventional methods, and now more than ever in the military arena, unmanned aerial vehicles (UAVs) collect digital imagery. The typical image file from these sources can range from 100MB to 500GB and larger. IT infrastructure is no longer a complementary asset to a GIS business; a robust infrastructure is a requirement to become as productive as competitors in the market place.

The enhanced capabilities of GIS applications require enhanced data management solutions to be able to handle the wide variety of data types and formats in which GIS information is now available. One such solution from Leica Geosystems is GeoVault, a one of a kind, cost effective and comprehensive solution designed to address the IT, data management, and security issues that organizations must confront when implementing a GIS project. An enterprise data manager, GeoVault is an automated client-server system that keeps digital data easily accessible while also protecting it.

### An Opportunity to Provide Solutions

Given the challenges that are faced by these government organizations, there is a trend in the industry toward providing services to address those challenges. This void creates a new opportunity in the marketplace for organizations that are already in the geospatial imaging business.

With the Integrated Solutions Group (ISG,) Leica Geosystems is providing customized solutions for these agencies or working with data provider customers to service end-users. Using an array of technology and customized toolsets, ISG provides tailor-made solutions that can help organizations access and process the vital information they require in an efficient and effective way.

According to Richard McKay, Vice President Commercial Solutions for Leica Geosystems Geospatial Imaging, the ISG initiative was designed to address the needs of those organizations that rely on geospatial data but do not have the in-house resources to manage the complexities of getting the specific information that they demand.

"We assess how the organization is utilizing geospatial information and then design a workflow that helps it efficiently process and generate the information it needs," said McKay. "Through our industry leading product offerings and vast expertise in all areas of the geospatial imaging process, we can provide integrated solutions that empower our customers to fulfill their unique requirements."

The ISG team develops solutions that assist customers in defining an effective workflow, developing specialized applications and customizing training courses to help achieve the goals of their geographic imaging, aerial survey or GPS projects. By integrating the Leica Geosystems family of products into, or as a support for, the customer's existing workflow process, ISG enables them to better utilize the resources it has available.

Through industry-specific, custom developed software packages, such as the Intelligence Production System (IPS) designed to meet the unique needs of intelligence related organizations, ISG helps these entities to save time and money. In providing this value-added service, ISG implements systems that fulfill the agency's specific data processing needs for imagery exploitation, targeting, terrain analysis, map production, and visualization.

The defense intelligence community, in particular, requires quick production of orthorectified imagery products. ISG addresses this need with a customized solution called Geospatial Engine. Geospatial Engine consists of a server-based application for rapid



This 15 cm color orthophoto of Rutherford County, Tennessee, USA, was acquired by EarthData. Image courtesy of Rutherford County Government.

processing of geospatial imagery directly from airborne and space borne sensors using ERDAS IMAGINE® and Leica Photogrammetry Suite (LPS) as the core. Geospatial Engine minimizes the user interaction necessary to perform processing steps to ingest raw imagery, rectify, orthorectify, mosaic and create image outputs.

### LIDAR – A Valuable Tool

The ways in which geospatial imagery data is being used is also demanding more detailed imagery. There is a growing trend to use LIDAR imagery because of the level of detail it provides.

Next to aerial imagery, terrain elevation data is the top revenue generating geospatial data product in the geospatial market today (Frost & Sullivan, *World Commercial*). This is largely due to the wide acceptance of LIDAR as a source for creating accurate and detailed terrain datasets in a timely fashion. In the report *North American Remote Sensing Vertical Market Analysis*,

Frost & Sullivan note that terrain data derived from LIDAR is increasingly being used in the federal civilian, defense, local/state government, hydrology and environmental markets.

Across all market segments, terrain datasets derived from LIDAR are valuable inputs for infrastructure planning and management. This is especially true for applications involving utilities and telecommunications

where other approaches for collecting terrain data are more time and cost prohibitive such as land surveying and aerial photogrammetry.

The high density of surficial terrain data derived from LIDAR techniques are also very useful for extracting buildings, trees and infrastructure such as utility lines, pipelines and antennas. Intelligent feature extraction techniques are now available which automatically produce clean digital terrain data products and digital surface models.

### On the Horizon

As imagery becomes more affordable and available in higher resolution, people are finding more uses for geospatial imagery, which in turn creates more opportunities and demands for it in the marketplace. The state and local government sector is growing with new agencies and departments being created to address the growing infrastructure of the United States. Given this trend, there is an increasing need to obtain and customize detailed GIS information for various initiatives. And with this growing demand, there will continue to be a need for the data and the services to support the requirements of the organizations that use it. Leica Geosystems is meeting these needs through its comprehensive offering of image data acquisition and processing applications and by providing the value-added services to help organizations utilize this data in an efficient and effective way.

# Flight Planning and Evaluation Software (FPES) – New from Leica Geosystems

Leica Geosystems will soon be releasing new software to serve as the first step in powering geospatial imaging. Designed for integration with the company's existing sensors and photogrammetric software offerings, Leica Flight Planning and Evaluation Software (FPES) will augment the company's sensor product workflow to provide an integral part in a complete geospatial imaging solution.

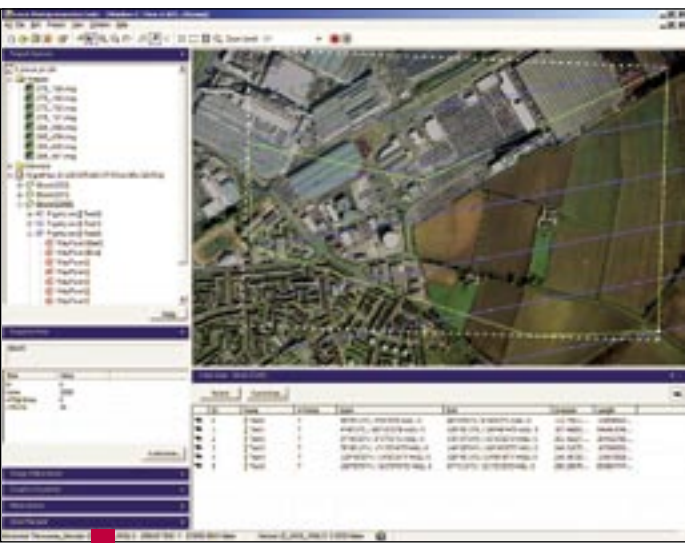
FPES replaces the office modules of its predecessor, Leica Aerial Survey Control Tool (ASCOT). The new program offers increased functionality and compatibility with the overall Leica Geosystems workflow, featuring an easy to learn graphical user interface that is similar to that of Leica Photogrammetry Suite (LPS). The software also includes coordinate transformation libraries like those in both LPS and ERDAS IMAGINE®. In addition to the coordinate input methods already available in the ASCOT flight planning modules, FPES performs flight planning based on digital raster maps and images.

"Flight planning is the first step in the geospatial imaging workflow," said Wendy Watson, Vice President of Product Management and Marketing for Leica Geosystems Geospatial Imaging. "We wanted to develop a functional and easy to use tool that would be an integral part of that process and an added value to the existing Leica Geosystems workflow."

This flexible and efficient survey flight planning tool enables efficient handling of small to large projects to be flown with the Leica RC30 Aerial Camera, ADS40 Airborne Digital Sensor, and ALS50 Airborne Laser Scanner, as well as other frame, line or ON/OFF sensors. With an easy upgrade path from ASCOT and the ability to import data from existing ASCOT flight plans, FPES is a cost and time efficient tool for flight planning, proposals, flight reporting and providing data for invoicing.

FPES equips users with powerful tools for editing and modifying flight plans, and enables easy optimization for area coverage and comparison of different flight line layouts. FPES outputs flight plans for flight execution with ASCOT and FCMS. Through a customizable and flexible workspace, layered data organization, and user defined property and data panels, FPES enables easy work and a seamless data flow from flight planning to photogrammetry.

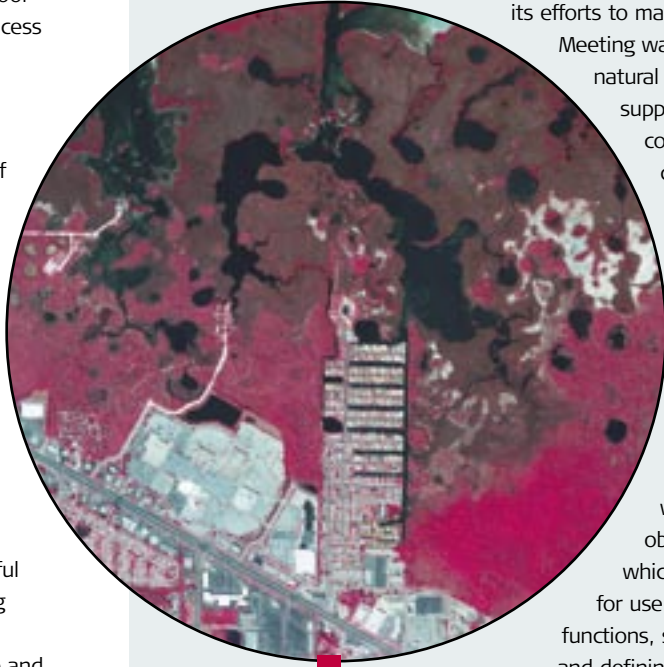
FPES is scheduled to enter the marketplace in summer 2005.



FPES performs flight planning based on digital raster maps and images.

# Southwest Florida Water Management District ADS40 Imagery

The featured image for this issue was captured by EarthData with a Leica ADS40 Airborne Digital Sensor on behalf of the Southwest Florida Water Management District (SWFWMD) and the U.S. Geological Survey. This color infrared image depicts the west coast of Florida near Port Richey, and is part of a larger set of imagery utilized by SWFWMD in its efforts to manage water-related resources.



The featured image for this issue was captured by EarthData with a Leica ADS40 Airborne Digital Sensor on behalf of the Southwest Florida Water Management District (SWFWMD) and the U.S. Geological Survey. This infrared image depicts the west coast of Florida near Port Richey.

Meeting water needs while protecting the natural systems that provide its water supply, the agency oversees flood control, regulatory programs, water conservation, education, and supportive data collection and analysis efforts.

SWFWMD has acquired from EarthData one-meter digital ortho quarter quadrangles (DOQQs) to update land use and land cover classification models of five-year trends. It has additionally contracted with 3001 Inc. and Woolpert to obtain one-foot ADS40 imagery, which it plans to update annually for use in regulation and permitting functions, such as investigating violations and defining agriculture classification. The use of digital orthophotos provides a cost effective, accurate means of updating land use, permit locations and transportation networks.

The District's GIS database was developed to support many of its planning, environmental and regulatory activities. The SWFWMD Comprehensive Watershed Management Decision Support System has

integrated GIS capabilities with other District data, both spatial and tabular, incorporating District data, satellite imagery, digital photographs and scanned documents. As a result, it includes a considerable amount of information that is potentially of value to federal, state, regional and local government agencies, as well as to private businesses and citizens.

General maps and specialized geographic and hydrologic data, including 1999/2000 USGS color infrared DOQQs are available online via the SWFWMD web site. A map-viewer interface displays general map information online. Users may access the District's specialized database of mapping layers and imagery available for download. Hydrologic data is provided in various file formats, and user-customized queries display tabular and plotted reports on a wide array of water resource topics, including rainfall, water levels and more.

To learn more about how the Southwest Florida Water Management District is employing imagery for resource management, please visit the SWFWMD Web site at <http://www.swfwmd.state.fl.us/>.

## Show off your imagery!

Do you have outstanding images acquired with a Leica Geosystems Geospatial Imaging airborne sensor, scanner or camera? We are looking for striking imagery to showcase.

Submit your images, along with an overview of the project and your entry could be the featured imagery in an upcoming issue of **the link**. You've done great work – share it with your colleagues!

To enter your images or for more information, please contact Lisa Young at +1 770 776 3400 or [lisa.young@gi.leica-geosystems.com](mailto:lisa.young@gi.leica-geosystems.com).

**SEND IN YOUR IMAGES TODAY!**

## Calendar of Events

Date	Event	Location
<b>July</b>		
23–26	ESRI 2005 Educational Users Conference <a href="http://www.esri.com">www.esri.com</a>	San Diego, CA USA
25–29	ESRI International 2005 User Conference <a href="http://www.esri.com">www.esri.com</a>	San Diego, CA USA
<b>August</b>		
17–20	GISBrasil <a href="http://www.gisbrasil.com.br/english/home.asp">www.gisbrasil.com.br/english/home.asp</a>	Sao Paulo, Brazil
22–25	Map Asia <a href="http://www.mapasia.org">www.mapasia.org</a>	Jakarta, Indonesia
<b>September</b>		
5–9	50th PHOWO - Photogrammetric Week <a href="http://www.ifp.uni-stuttgart.de/phowo/index.en.html">www.ifp.uni-stuttgart.de/phowo/index.en.html</a>	Stuttgart, Germany
6–9	RSPSoc Annual Conference: Measuring, Mapping & Managing a Hazardous World <a href="http://www.rspsoc.org/calendar/calendarMain.htm">www.rspsoc.org/calendar/calendarMain.htm</a>	Portsmouth, UK
12–14	ISPRS WG III/3, III/4, V/3 Workshop on "Laserscanning 2005" <a href="http://www.isprs.org">www.isprs.org</a>	Enschede, Netherlands
25–30	NSGIC 2005 <a href="http://www.nsgic.org">www.nsgic.org</a>	Rochester, NY USA
13–16	DSEi - Defence Systems & Equipment International <a href="http://www.dsei.co.uk">www.dsei.co.uk</a>	London, UK
15–16	OZRI 2005	Gold Coast City, Queensland Australia
22–24	Leica/ESRI Latin American User Conference <a href="http://www.img.com.br/lauc2005">www.img.com.br/lauc2005</a>	Rio de Janeiro, Brazil
<b>October</b>		
4–6	INTERGEO 2005 <a href="http://www.intergeo.de">www.intergeo.de</a>	Düsseldorf, Germany
18–22	Australian RS & Photogrammetry Conference	Fremantle, Australia
23–27	16th Pecora Remote Sensing Symposium <a href="http://www.asprs.org">www.asprs.org</a>	Sioux Falls, SD USA
31–Nov. 2	GEOINT 2005 Symposium (Defense)	San Antonio, TX USA
<b>November</b>		
22–26	Asian Conference on Remote Sensing (ACRS)	Kathmandu, Nepal

## Contact Us

For more information about Leica Geosystems Geospatial Imaging and its products, please call +1 770 776 3400 or +1 877 463 7327, email [info@gi.leica-geosystems.com](mailto:info@gi.leica-geosystems.com) or visit [gi.leica-geosystems.com](http://gi.leica-geosystems.com).

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