The Point-and-Click Future of GIS

A Report from Geospatial Solutions

Since its 2001 acquisition of LH Systems and ERDAS, Leica Geosystems GIS & Mapping Division has mobilized to integrate its product offerings in airborne data acquisition, geographic imaging, GPS/GIS, and Land Information Systems. As it begins to optimize the interoperability of these complementary technologies, Leica Geosystems aims to transform the way we capture, analyze, and use spatial data.

Wouldn't it be nice if populating your GIS database was as simple as using a digital camera? With consumer-level software for digital cameras, one can shoot a series of photos in a panorama and the software finds the matches and mosaics the individual scenes into a single large image.

Perhaps in the not-too-distant future, GIS professionals will acquire spatial data in a similar manner. After all, it is already quite commonplace for individuals to acquire images located with GPS. And many systems now allow GPS field data to be fed directly into a GIS. With the combination of GPS, inertial navigation systems, and digital imaging, it is already possible to create accurate orthomaps with little or no ground control.

As the software supporting these solutions continues to advance, the technological complexities will become increasingly invisible. Much as a GPS user needs to know little about complex mathematics and satellite signal processing, the user who wishes to extract features from imagery will soon need only minimal knowledge about the underlying photogrammetry to reap its benefits. Soon, software will be able to transparently assemble a collection of images, automatically determine tie points, solve the orientation, extract elevation information from the overlaps, generate orthophotos, and create a single large mosaic – with no need for human intervention. From the orthophotos and the elevation information, one could then enter a virtual world and visit the site of the imagery. Because all the imagery and orthophotos would be geographically aware, they could all be used to create photorealistic worlds, which could be accurately measured. This 3D world could be used to verify existing 3D GIS databases or build new ones. Software could then recognize and identify features in the images such as roads, ground cover, buildings, and so forth. The 3D world could also be shared among office and field workers, with wireless communications enabling two-way data flow. Field crews could send data to the office, while office staff could wirelessly transmit database updates to workers' image-enabled systems, all in real time.

Is this a utopian vision of 3D GIS data capture – some wild dream that can never be realized? Hardly. After all, the convergence of spatial technologies has been proceeding at full steam for several years.

Convergence. Once disparate tools used by distinct disciplines, GIS, GPS, and imaging technologies are becoming increasingly integrated. Add to that the increased power of handheld computing and the proliferation of wireless communications capabilities and such an ideal seems quite real and very near.

Such is the long-term vision of Leica Geosystems' GIS & Mapping Division. And it was just this type of farsighted thinking that led the Division last year to integrate the geographic imaging expertise of ERDAS and the aerial imaging and photogrammetry know-how of LH Systems with its own GPS/GIS prowess.

"Combining these resources allows us to address the growing requirements for acquisition, processing, and visualization of 3D imagery to populate GIS and CAD databases," said Bob Morris, President of Leica Geosystems' GIS & Mapping Division. "It creates a tremendous opportunity to leverage the strengths of each group in developing world-class solutions for producing intelligent 3D maps and databases."

And Leica Geosystems has a lot of strength to build on.

A firm foundation

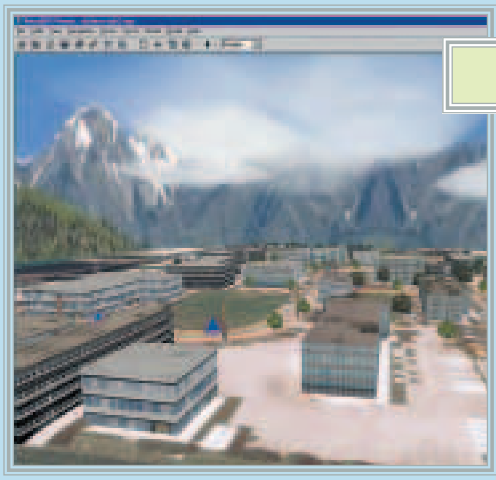
The company already has extensive expertise in each of the markets and technologies it aims to coalesce. Its RC30 aerial film camera, for instance, is well established in its marketplace and has recently been complemented by the ADS40, an Airborne Digital Sensor, and the ALS40, an Airborne Laser Scanner. Each of these products is well positioned to serve customers whose focus is on airborne operations.

The Division's photogrammetric solutions include options for the professional photogrammetrist and the GIS analyst. The longstanding SOCET SET® software suite, with ORIMA for triangulation and PRO600 software for data extraction and editing, is complemented by the DSW500 film scanner to meet the increased editing and speed demands of the professional photogrammetrist.

The ERDAS flagship product suite, ERDAS IMAGINE®, with its numerous specialty tools for image processing, remote sensing, and photogrammetric processing and analysis, enhances the workflow requirements of the Division's diverse customer base. Its IMAGINE OrthoBASE® and OrthoBASE Pro™ have also made a quick impact on the photogrammetric marketplace since their recent introductions to the GIS analyst. And, as a tool for visualizing imagery and data, IMAGINE VirtualGIS™ has a significant future in a variety of applications that could benefit from image-enabled data acquisition tools.

With its roots in surveying and GPS technologies, Leica Geosystems was already a top contender in GPS/GIS data acquisition. Its GS50, and now GS50+, coupled with its GIS DataPRO™ office software, and the brand-new GS20 (see page 17) enable users to collect spatial data and store them in a GIS-ready format. Add the soon-to-be-released Land Information Systems products to the equation and you have top-notch management solutions that bring survey-quality measurements into the GIS world. These products include a unique innovation to provide survey tools that extend the functionality of ESRI's ArcGIS, providing a new route from survey measurements to the GIS database with integral quality management tools (ESRI's Survey Analyst); a powerful package that manages surveying, mapping, and database operations for cadastral purposes (ArcCadastre); and a tool for field data collection and update using the ESRI Geodatabase format (FieldGIS).

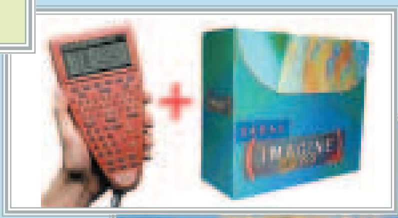
Indeed, each of the previously distinct organizations that make up the Leica Geosystems GIS & Mapping Division already boasted an impressive product lineup and supported a well-established customer base in disparate application areas (see "Customer Snapshot" sidebar on page 24). But building on the synergies among the products and people is really where the Division's future lies. The coalescing of talents and products from these well-established technology leaders may just be the key to realizing the vision of point-and-click GIS.



IMAGINE VirtualGIS will be central to image-enabled data acquisition tools.

Coalescing technologies

Today, Leica Geosystems' GIS & Mapping Division provides customers with integrated mapping solutions across four previously distinct areas – airborne data acquisition, geographic imaging, GPS/GIS, and Land Information Systems. The company's sensors, field data collectors, workstations, and software enable users to create and update GIS databases quickly and accurately. Such capabilities enable Leica Geosystems to offer products and support for data acquisition ranging from space-



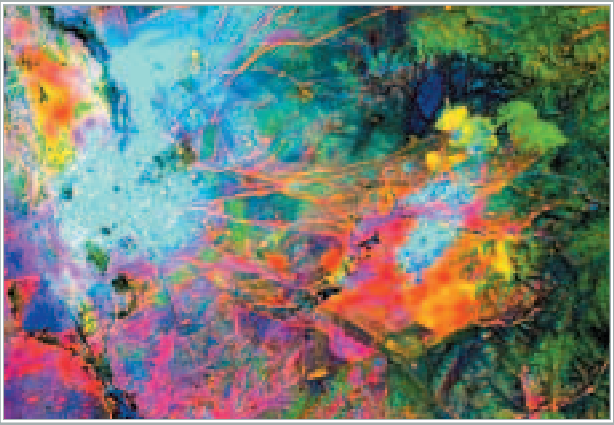
The company's product lines are increasingly bundled and integrated. Customers who purchase a GS50 or GS50+ data collector through March 2003, for instance, will receive a free copy of IMAGINE Essentials software to organize, edit, and present their data.

borne (satellite remote sensing) to airborne (aerial photogrammetry) to handheld, with precise GPS/GIS and land information management. And, cross-pollination among the Division's more than 300 employees – plus 2,100 more innovators that drive Leica's other five divisions (Consumer Products, Industrial Measurement, New Businesses, Special Products, and Surveying & Engineering) – promises to yield technological advances that cut across the company's entire product line. "Leveraging the scope, experience, and tremendous expertise of our employees, along with the

Customer Snapshot

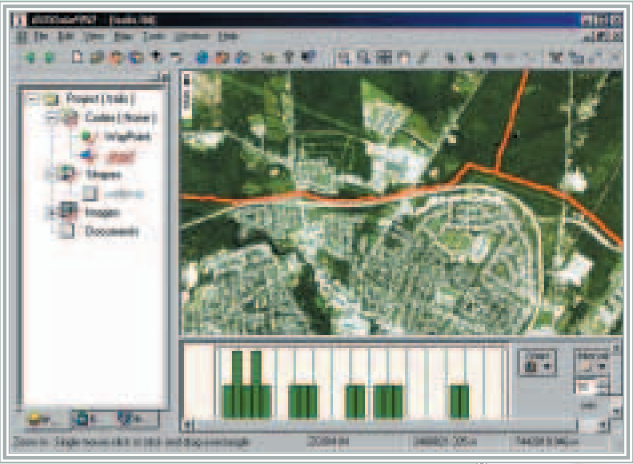
Versatility in mapping. In New Brunswick, Canada, the City of Fredericton uses Leica Geosystems' GS50 handheld GPS/GIS data collectors to map snowmobile trails in the winter and storm sewers and manholes when the snow recedes. And the mapping work isn't just done by surveyors. According to GIS Supervisor Rob Lunn, the GS50's simple interface means end users can complete their own mapping tasks according to their own schedules and in accordance with their specific needs.

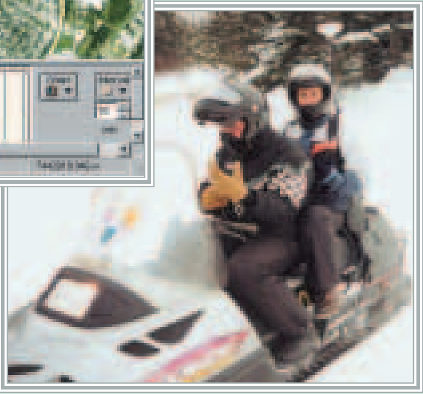
Indiana DOQQs. In 2002, Kosciusko County, Indiana, tasked mapping and design firm Woolpert LLP (www.woolpert.com) with acquiring aerial photography, ground control, and LIDAR data and producing digital orthophotos.



The Chinese Ministry of Agriculture is using ERDAS IMAGINE to estimate grass areas for the entire country.

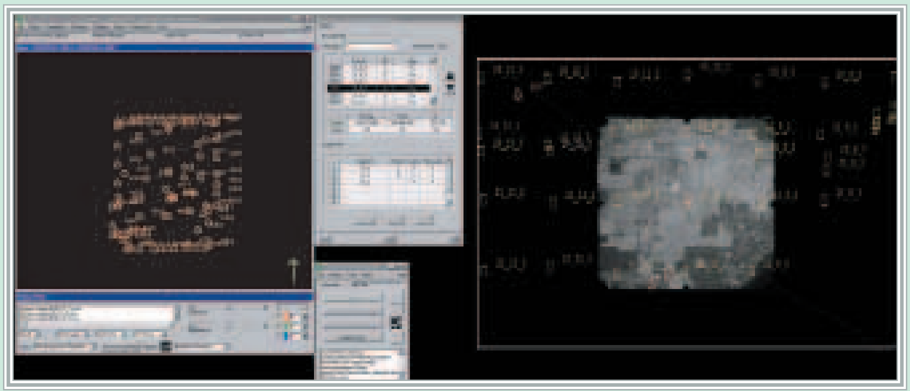
Woolpert used SOCET SET, ORIMA, and GPS support software supplied by Leica Geosystems to perform the aerial triangulation. According to Woolpert, using SOCET SET and ORIMA decreased production time 75 percent compared with using conventional aerial triangulation methods.





City of Fredericton staff use the GS50 to map snowmobile trails in the winter (above and right) and city infrastructure in the summer.

Woolpert chose SOCET SET, ORIMA, and GPS for aerial triangulation (below).



Monitoring grasslands. In China, where grasslands compose 40 percent of the entire country, monitoring the structure, function, and dynamic change of this important land resource is critical, especially given the growing population and threats from natural disasters and development. To manage grasslands, the Ministry of Agriculture (MOA) is building a unified information system for monitoring grass bio-logy. It is using SPOT (www.spot. com) images to acquire the most current information about the grasslands, ERDAS IMAGINE to estimate the grass areas from these images, and ESRI's (www.esri.com) ArcGIS to conduct analysis. The MOA will integrate historical information, statistical data, and the considerable experience of its staff with spatial monitoring of grassland conditions (including the transition from grassland to desert or marshland) and productivity. From the information gathered, the MOA will develop a prediction and protection report to provide to government decision makers.

pure economies of scale, will allow us to provide unparalleled service to our customers," said Morris.

Already, the GIS & Mapping Division has announced significant developments that demonstrate the evolving technology cohesion.

Digital data processing.

In May, for instance, the Division introduced the Leica Terrain Productivity Bundle, a software package that combines the workflow functionality of IMAGINE OrthoBASE Pro with the terrain editing capabilities and speed of SOCET SET. Comprising ERDAS IMAGINE, IMAGINE OrthoBASE PRO geographic imaging software, and SOCET SET's CORE, STEREO, and ITE modules, the bundle enables customers to more effectively process, edit, analyze, and visualize such data as automatically generated digital terrain models.

"We are developing logical interaction across our extensive product lines to make our systems even more intuitive and responsive to customer needs," said Morris. "This bundle is especially designed for GIS and mapping professionals whose technical requirements demand greater terrain editing flexibility than is available with IMAGINE, but do not call for the full functionality of SOCET SET's advanced photogrammetry system." (For more about uses of SOCET SET, see "Mapping the Hoover Dam Bypass" sidebar. Read more about image processing with ERDAS IMAGINE in the "Calculating Open Land" sidebar on this page)

Image cleanup. For image dodging and balancing, Leica Geosystems' GIS & Mapping Division recently introduced the ImageEqualizer. Tailored for photogrammetrists, the product is a standalone application for correcting such image variations as hot spots, unequal lighting, atmospheric and temporal effects, or color cast in single and multiple images simultaneously. Once the user selects the images to be corrected, the product sections imagery into tiles and collects statistical information about brightness and contrast. It then uses this information to create a correction function that compensates for disproportionate variation for each image.

Image-enabling. Among the most lofty product integration goals still in development is that of image-enabling many of the company's data acquisition products to make them even more intuitive and easy to use. The ERDAS IMAGINE product line will serve as a core development environment for this task.

"The power and versatility of IMAGINE VirtualGIS for visualizing imagery and data is remarkable and will have a significant future in a variety of applications," said Morris.

This particular development avenue truly highlights the ongoing trend toward coalescing spatial technologies.

"These small examples demonstrate our commitment to product integration," said Morris, "but soon we plan to introduce even more integrated service offerings covering the spectrum from hardware service through software support to education and training."

Meanwhile, the company continues to innovate in each of its business and technology areas.

Mapping the Hoover Dam Bypass

When contractors for the Federal Highway Administration began to weigh their options for the $198 million Hoover Dam Bypass, they required aerial imagery to help them evaluate the environmental, historic, cultural, and aesthetic impact of multiple proposed roadway and bridge concepts. The bypass project aims to relieve major traffic congestion on U.S. Highway 93. A major commercial corridor between Arizona, Nevada, and Utah, the highway passes along the top of the Hoover Dam National Monument.

Kenney Aerial Mapping used SOCET SET digital photogrammetric software to create color digital orthophotos of Hoover Dam.

In July 2001, the prime contractor, HDR Engineering (www.hdrinc.com), tasked Kenney Aerial Mapping (KAM, www.kam-az.com) with the aerial mapping. Once ground control was established, KAM flew nine flight lines at 1,800 feet over the project area, acquiring photography at a scale of 1:3,600 with 80-percent overlap. They captured additional stereo coverage at 1:12,000 and 1:24,000 to support future mapping efforts. Design mapping was completed covering an area 4.3 miles long and 500 feet along either side of the proposed alignment. Next, using SOCET SET's digital photogrammetric software from Leica Geosystems, KAM created color digital orthophotography with a 0.3-foot ground sample distance.

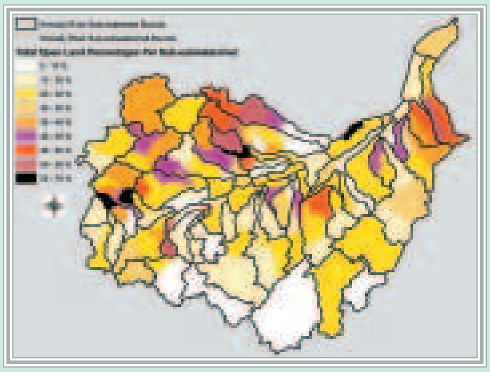
The mapping project extended up the cliff faces. KAM digitized a 3D model where vertical stereo imagery was inadequate. Surveyors scaled the cliffs to establish control for these areas. Ground-based LIDAR helped capture 3D data of the cliff faces, resulting in an integrated 3D surface model for the entire project.

"Compilation of the irregular terrain created a challenge," said KAM's John Cahoon. "It required numerous breaklines to depict rock outcrops and rough swales accurately, and that's not to mention processing the massive and complex electrical facilities of Hoover Dam." Despite the challenging work environment and schedule, though, the imagery was acquired, processed, and delivered in only six weeks.

Calculating Open Land

Human alteration to the landscape of the Nemadji River watershed — which covers 275,000 acres in northeastern Minnesota and northwestern Wisconsin — has accel-erated erosion of the area's glacial till and red clay soils. Consequently, extensive sediment is being deposited into Wisconsin's Superior Bay. To analyze and address the problem, the Nemadji River Basin Project set out to identify the subwatersheds in which the amount of open land — land that is either in agricultural production or timber that has been harvested in the past 15 years — was 40 percent or greater.

To identify open land within the watershed, the project called on Community GIS Services (www.commgis.org), a nonprofit organization serving the needs of government entities. Community GIS used 16 years of Landsat 5 and Landsat 7 imagery to develop 0–15-year timber age class GIS coverage using ERDAS IMAGINE Professional software for image rectification and change detection.



To delineate open land and conduct change detection, Community GIS processed Landsat data using ERDAS IMAGINE.

"ERDAS [IMAGINE] performed astoundingly well while rectifying 16 scenes of Landsat imagery," said John Kubiak of Community GIS. "Our next step was to analyze changes in the land cover by comparing the rectified Landsat scenes on a year-to-year basis. We used ERDAS (IMAGINE) change detection to give us a good idea on where to look, but continued to review them manually throughout the analysis."

Local governments will use the information to work on a voluntary basis with public and private landowners to coordinate timber harvesting and tree planting along riparian corridors in subwatersheds that are approaching the 40-percent open land threshold.

Digital sensing. In the airborne data acquisition realm, the GIS & Mapping Division recently debuted the ADS40 to American customers. Offering the coverage performance of an aerial film camera, the ADS40 provides multispectral data, something normally acquired from a spaceborne platform. The digital sensor – which captures 3 panchromatic channels (forward, nadir, and backward) and 4 multispectral bands (red, green, blue, and near-infrared) simultaneously – can be used for crop and land-use analysis, environmental planning, and all photogrammetric applications. "The convenience of the all-digital workflow means an up-to-date, efficient production environment for our customers," said Ludger Ullrich, Vice-President of Airborne Data Acquisition, Analog/Digital Sensors.

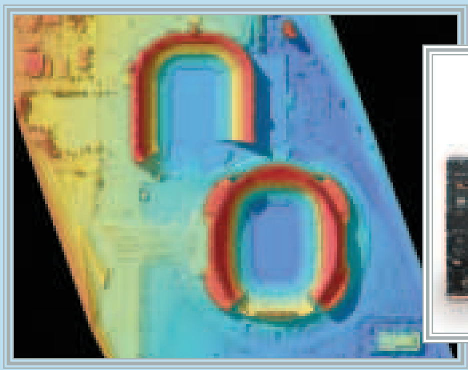
LIDAR. Moving well beyond traditional digital sensors, Leica Geosystems' integration of LH Systems also introduced LIDAR (light detection and ranging) to the mix. Its ALS40 reportedly offers the widest field of view (75 degrees) and highest altitude capability (6,100 meters above ground) of any LIDAR system available. Further, range and intensity can be altered midflight, on a flightline-by-flightline basis.

"The ALS40's flexibility to switch modes midflight can save users a tremendous amount of storage and processing costs by collecting exactly the level of detail necessary for each flightline," said Doug Flint, Director, LIDAR, Leica Geosystems GIS & Mapping.

Centimeter-level GPS. To enable centimeter-level GPS/GIS data collection, the division recently unveiled its GS50+ with a real-time kinematic, 24-channel, dual-frequency receiver GPS engine. For GIS data acquisition with GPS position, the GS50+ stores ESRI shapefiles in its GIS DataPRO post processing software. (For more about use of the GS50 and DataPRO software, see "Building a Bus Route GIS" sidebar on page 27.) The shapefiles can be automatically transferred to any software capable of reading shapefiles – including ERDAS IMAGINE – to visualize, manipulate, analyze, measure, and integrate geographic imagery into two- and three-dimensional environments.

The unit features full expandability, offering scalable architecture in

The ADS40 simultaneously captures data from three panchromatic and four multispectral bands, as seen in this imagery of Adria, Italy - no difficult choice to make between panchromatic, color and false color film.



Merrick and Company used the ALS40 to acquire LIDAR data and render the above image of football stadiums in Aurora, Colorado.

which users can switch from GIS to survey functionality or add GIS capabilities to an existing survey receiver. It also boasts a real-time accuracy monitor, graphical navigation display, area/ perimeter calculation, and one-step transformation and coordinate geometry that allows users to conform to any coordinate system in the field and on-the-fly. For transferring data, the unit supports data radios and also enables users to transmit via digital modems or cell phones. By plugging the modem into the product box, users can control it from their handheld terminal.

Just point and click

So what does the future hold for Leica Geosystems' GIS & Mapping Division? "Very simple," said Morris.

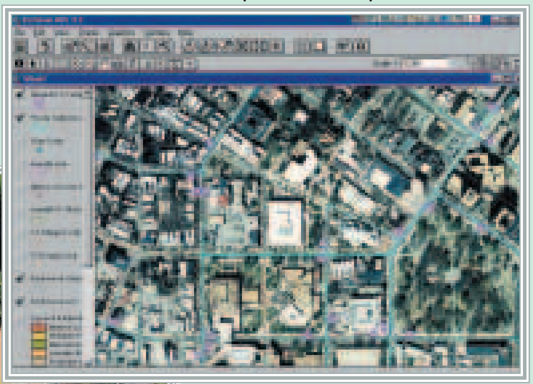
"We aspire to be the leading player in offering 3D solutions in data acquisition, processing, quality control, update, and visualization for GIS databases. 3D GIS is at the very center of our development efforts."

Combine this with effective workflows and wireless data transfer, and Leica Geosystems may just make point-and-click simplicity a part of your GIS world.

Building a Bus Route GIS

The GRTC Transit System operates more than 180 buses and serves about 2,800 county bus stops. In the past, it ran this extensive network without an in-house spatial database. As the primary provider of bus and other transport-ation services to the fastest-growing metro-politan area in central Virginia, GRTC Transit needed to remedy this situation, and quickly, especially with urban growth demanding that new bus routes be added regularly. So, in early 2001, it acquired a GS50 data collection system and set out to build a GIS.

GIS Coordinator Jake Helmboldt first built a base layer using centerline, roadway, and sidewalk files, along with orthophotos and parcel data obtained from the City of Richmond and Henrico County. To develop the bus stop layer, he hit the streets with the GS50 and recorded the GPS locations of all existing bus stops. While at each stop, he also recorded curb lengths. He obtained positions on each end of the curb when necessary and recorded such impediments as intersecting driveways or business entrances. He further documented the positions of trash cans, benches, shelters, and ramps and noted existing conditions and maintenance needs.



Using the GS50, Jake Helmboldt mapped the location and attributes of 2,800 central Virginia bus stops en route to building a transit system GIS.

Using a codelist he specifically developed for the project, Helmboldt recorded attributes of each feature, including length, bus stop number, sign type, and bus stop-facing direction.

He used the GS50 to note which bus stop signs needed to be replaced or repaired, and to indicate which signs had already been replaced. From a project management standpoint, Helmboldt said the sign replacement data had been especially valuable. Back at headquarters, Helmboldt downloaded the data into Leica's GIS DataPRO for post processing.

"This was really easy with DataPRO," Helmboldt said. "Not much post processing was necessary. It was mainly a matter of matching up our data to verify our bus stop identification numbers and eliminate duplication in our database."

To accomplish this, he simply cross-referenced bus stop identification numbers with bus routes. Then, he converted the data to ESRI shapefiles and used them to create an entire route network.

Using this GIS database, he's already conducted some proximity analysis to assess holes in coverage areas and done some buffering to analyze walking distances for prospective riders. In addition, some of the attributes Helmboldt collected have helped the transit company to determine whether stops are Americans with Disabilities Act–accessible and decide where additional amenities are needed. And, as soon as they get their hands on ESRI's Network Analyst, GRTC Transit will start to conduct routing analysis.