Connect the Coastal Dots

Both on the ground and in the air, mapping the Florida Keys proves difficult. But gathering aerial images in strip form rather than frames helps establish control and improves GIS layers.

By Mary Jo Wagner

If the employees of the engineering and geospatial consulting firm Woolpert, Inc. could design a T-shirt to mark their recent completion of an orthophoto mapping project over the Florida Keys, it might read: "The Florida Keys—Heavenly to Visit, Devilish to Survey." It would be a fitting tribute, for though you can't dispute the beauty of the region's lush vegetation, vibrant colors, and dotted coastline, the very coastal nature of the region presents a considerable challenge to surveyors in accurately mapping it.

"The geography and geometry of the Florida Keys, with its little dots of islands stretched out over 100 miles, makes it really difficult to find sufficient locations to set control," says Woolpert's Andria Shaman, an aerial data acquisition manager with the Dayton, Ohio-based company. "There is also no adequate way to conduct an aerial survey with a typical frame camera—digital or film—because once you have a frame full of water, you lose all your orientation and your ability to accurately tie individual frames, or areas of land, together."

These are the same challenges that have dogged local geospatial professionals in Monroe County, home to the Florida Keys, every time they attempted to acquire higher resolution and more precise imagery over the region. "The orientation of the islands has made it very difficult to obtain adequate control to create a uniform, detailed base map upon which to build other essential data layers such as an accurate parcel layer," explains Kim Rohrs, a senior GIS planner with the

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Monroe County Growth Management Division (GMD). Without a solid anchor point, our data layers were kind of 'floating' in the GIS."

Here is where the county's story might have ended yet again had it not been for one piece of advanced airborne technology. Unlike in past upgrade attempts, this time Woolpert had a Leica Geosystems ADS40 Airborne Digital Sensor, which collects dual-band (color/panchromatic) data in long strips rather than individual frames.

The "push-broom" nature of the ADS40, says Rick Hudson, Woolpert's project manager, finally provided them with the means to connect the Florida Keys' dots. "With a film or digital frame camera, you have to be able to tie the individual image frames together by aerial triangulation. That cannot be done with a series of frames that are entirely over water—a real dilemma for the Florida Keys. The fact that the Leica ADS40 imagery is produced in strips eliminates the need to tie together any image along the flight line; you only need to tie strips of imagery together. Without using ADS40 imagery, I don't think it would have been possible to have contiguous coverage of the Keys at the level of accuracy Monroe County required."

Armed with this advanced airborne technology, Woolpert provided a new, highly detailed set of orthophotography over the region that not only enables users to ground their floating data layers, but helped re-energize the GMD, a department stagnated by the murky waters of inaccurate maps.

A String of Dots

A necklace of about 822 islands that begins just south of Miami, the Florida Keys are connected by the Overseas Highway (US 1) with its 43 bridges over the Atlantic Ocean and Gulf of Mexico. Some 46 Keys divide into five regions, including Key Largo, Islamorada, Marathon, Big Pine and the Lower Keys, and Key West, all dominated by emerald-green lagoons, deep-blue seas, olive-green mangroves, and a distinctly laid-back atmosphere.

Key West, the southernmost point in the United States

That beauty and tranquility is indeed attractive, as thousands of visitors transition to full-time residents each year. And that keeps county departments such as the Monroe County Property Appraiser and Rohr's Growth Management Division very busy as they try to maintain present property data and plan for future growth. Both tasks, however, have been difficult to manage effectively, says Rohrs, because of geospatial data inconsistencies and inaccuracy. "We have been using USGS DOQQs as our predominant base layer. The overriding problem we have had with our geospatial data was that the farther we moved from US 1, the less accurate our data became. And the horizontal accuracy was variable. It would be off more in the upper Keys than in the lower Keys.

"We, like many other agencies such as utilities and the Florida Keys Aqueduct Authority, rely on the parcel data supplied by the property appraiser," she continues. "If you have a floating parcel layer with variable accuracy, it's very difficult to build additional data on top of that for our business tasks. That lack of consistent accuracy was really hindering our ability to effectively plan for urban expansion. We really needed a high quality aerial survey that would provide us with a uniform, regional dataset at consistent horizontal accuracy."

Adding to the data disconnect was the fact that aerial survey programs were being run independently by different state and local agencies such as the Florida Department of Transportation (FDOT) and Florida Department of Revenue, all using their own resources and acquiring orthophotography for their

own purposes. That created pockets of "good" datasets dotted around the state, but they were held in isolation.

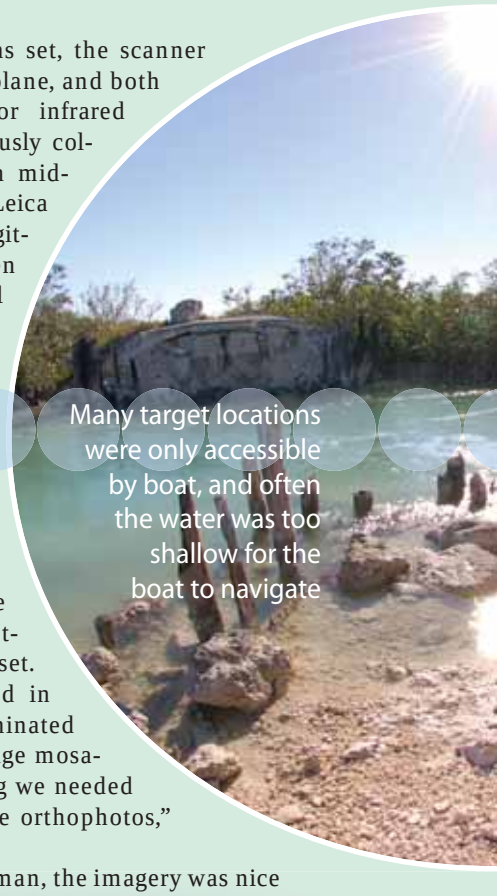
However, that began to change in late 2005, when first, independent agencies realized that if they could pool resources together, they could acquire a much better spatial product with which to build a homogenous and seamless base map for users. And second, with Woolpert's help, they learned that the imaging capabilities of the Leica ADS40 could provide them with the dataset they wanted and at a higher accuracy than they have ever achieved before. With that, the FDOT District VI and Monroe County launched a joint aerial mapping program and commissioned Woolpert to produce true color and color infrared, half-foot-resolution orthophotos of the Florida Keys area.

Using the county's 1:24,000 topographic maps and ancillary images, Woolpert personnel planned their flight lines over the 843 square miles of interest and sent field crews to the scene in February 2006. Soon after arriving, they readily began to appreciate the survey challenges the area presents. "The Florida Keys offers very limited area for ground control," illustrates Hudson. "Apart from having only one principal road, many of the target locations were only accessible by boat, and often the water was too shallow for the boat to navigate. In addition, sometimes what looked like a small island on the topo map or other imagery turned out to be just a cluster of trees rooted in the water, which was insufficient for placing a control target. So we had to revise our control points many times."

Despite the ground control "musical chairs," field crews had all control targets set and surveyed using GPS in less than two weeks—relatively quick field operations, says Hudson, due in large part to the scanner technology. "Because the ADS40 collects imagery in strips rather than frames and it uses inertial measuring, it lessens the need for control."

Ready to Fly

With ground operations set, the scanner sensor was loaded into a plane, and both true-color and false-color infrared imagery were simultaneously collected over the area from mid-February to early March. Leica GPro software and a digital terrain model were then used to process the digital imagery into a seamless mosaic of half-foot resolution orthophotos with a horizontal accuracy of 1"=100'. Although the mosaicking process is typically time-consuming with a frame camera, the strip approach of the scanner enabled image analysts to more efficiently create a seamless dataset. "Having imagery collected in strips versus frames eliminated over 50 percent of the image mosaicking and tonal balancing we needed to perform to produce the orthophotos," says Hudson.



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Not only that, says Shaman, the imagery was nice on the eyes too. "My first impression of the imagery collected was that it was particularly gorgeous. You could see different kinds of sand formations and varied features into the water. It was really stunning." In September 2006, Woolpert

The Overseas Highway connects the Florida Keys with 43 bridges over the Atlantic Ocean and Gulf of Mexico

began delivering the orthorectified imagery to the county, and the final datasets were delivered last February.

Since obtaining the new imagery, Rohrs agrees that it is indeed esthetically beautiful, but more importantly, the orthophotos are "beautifully accurate. With the DOQQs as our common base dataset, we were always uncertain if we were looking at the most accurate representation because base layers were constantly being updated. With this new orthophoto dataset, we know precisely what the horizontal accuracy is for any given point. That is invaluable."

By design, the imagery has integrated seamlessly with the county's ESRI ArcGIS and FDOT's Microstation and ESRI ArcMap information systems. Now that they have complete, contiguous coverage of the Keys, Rohrs and colleagues have wasted no time in using the dataset for quality control to help them build a common, precise base map of the region. Users have already identified scores of inaccuracies in previous data stores, but now they can rectify them with confidence. Most importantly, says Rohrs, they now have the geospatial core they need to begin living up to the "growth management" part of the division's mission. "Because we didn't have a good base map to work from, we were relatively stagnant in our development and planning. We were just maintaining the status quo. The imagery has completely re-energized the department and allowed us to begin a number of new planning initiatives."

That energy has not been confined to urban planners. Other users who have historically relied on parcel and other GIS-related data, such as the electric companies, are also integrating the orthophotos into their databases to improve their business operations. Another recent recipient of the imagery, The Nature Conservancy, plans to use the data for a number of natural resource planning and management applications such as mapping vegetation communities, modeling sea-level rise, planning fire management, and developing control strategies for invasive exotic plants.

"One of the most significant benefits of this joint mapping project is that we can now provide a uniform base map to all of the GIS users in Monroe County," concludes Rohrs. "We really needed that platform to build and develop our own data and allow us to better integrate and share data with other agencies." Although the orthoimagery is presently being disseminated to other agencies by request, the overall goal is to develop a central GIS repository for other agencies to access, complete with the orthophoto base map.

Rohrs readily admits that it was quite a feat for Woolpert to triumph over the naturally challenging geography of the Florida Keys to produce such high quality and precise orthoimagery. Hudson adds, "Prior to collecting these strips of imagery, we would have had to collect frames. With the large expanses of water in the Florida Keys, that would have meant flying much higher than we did and resulted in a larger pixel resolution and lesser degree of horizontal accuracy of the orthophoto imagery."

Indeed, Monroe County offers solid proof that island communities can be surveyed and mapped to a high degree with the right technology. As that word spreads, other coastal regions may soon beckon. And that may mean more T-shirts for Woolpert employees to design.

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