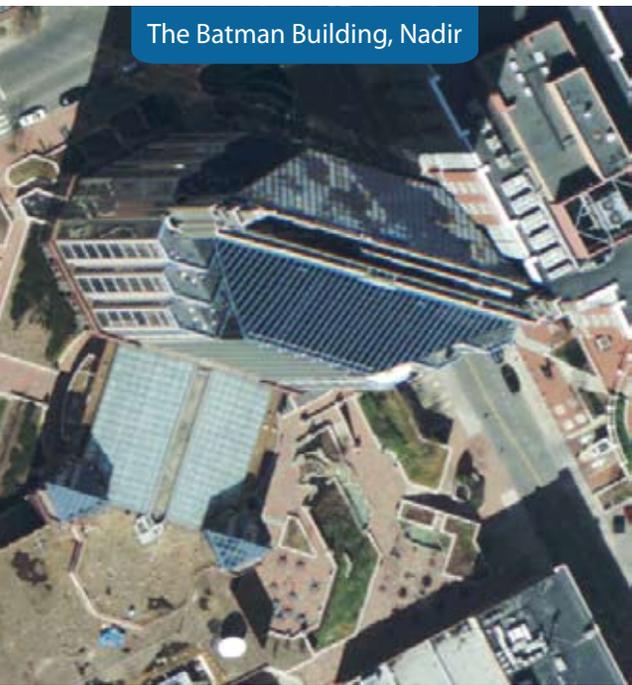


Photography That's Music to Your Eyes



The Batman Building, Nadir



The Batman Building, North

From the nadir view, you can't tell why the AT&T (formerly Bell South) building in downtown Nashville, Tennessee has been nicknamed "The Batman Building." Once you see the oblique view of the north side, however, it becomes obvious. The unmasking comes courtesy of Woolpert's new SmartView process and Wehrli/Geosystem's 3-OC-1 pushbroom style oblique camera.

south, east, and west) so the user sees continuous coverage of the entire project area from any given angle.

During the first week of March 2008, Woolpert flew 5,000 feet above the 96-square-mile project area to capture the half-foot pixel resolution imagery. The project required 47 GPS/IMU controlled flight lines in total, with 22 lines in the north to south direction and 25 lines oriented east to west. Additionally, 16 shorter, cross-flight lines were

Known as Music City USA, Nashville, Tennessee has long been recognized as a hub for innovation and creativity. This year, it became the site of a unique aerial imagery project displaying a breakthrough process in the photogrammetry industry dubbed SmartView.

SmartView supplies oblique aerial view imagery that supplements traditional overhead orthoimagery by providing multiple, angled views of ground features. The imagery is captured using the Wehrli/Geosystem 3-OC Digital Oblique Camera, the first pushbroom-style oblique camera.

Dennis Pedersen, director of GIS services for the state's Office of Information Resources, wanted to explore supplementing the Tennessee Base Mapping Program with oblique imagery. Several months of discussion led to a relationship between Woolpert and the state's GIS contractor, Tennessee Geographic Information. The densely complex urban area of downtown Nashville was chosen for a pilot project, providing a true and real test of the camera and the concept.

"We had gotten a lot of inquiries from local governments on the possibility of using oblique imagery in public safety and property appraisal," Pedersen said. "There is a lot of interest in expanding the mapping we've already developed to include an oblique view. When we found out that Woolpert had the technology, that set the stage for the project."

SmartView combines all the lessons Woolpert has learned about aerial photography, camera formats, and imagery to create a new oblique photography process and a product customers have not been accustomed to until now. The oblique imagery is captured at consistent angles then orthorectified, seam lined, and mosaicked for all five views (nadir, north,

used to enhance the image quality of the high-rise district. A Wehrli/Geosystem technician was part of the Woolpert aerial acquisition team. The image acquisition phase was completed in three flights between March 1 and 5. Before any flying began, a Woolpert survey team acquired 20 photo identifiable ground control locations distributed throughout the project area.

Woolpert converted the three-view flight lines from raw to processed images using a combination of commercial and proprietary software. Each flight strip was triangulated, tied to the ground control data, and ortho-corrected to the client-supplied digital elevation model. A seamless mosaic was prepared using manual crop lines along each flight strip. The project specification required that standard GEOTIFF files be delivered matching the client tiling scheme for each of the five views. Additionally, a comprehensive MrSID compressed file was required for each of the views.

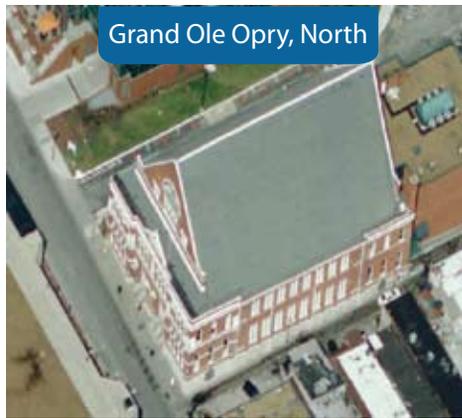
The project was delivered in early August for the client's review. The result is a beautifully accurate portrait of Music City from five perspectives.

Inventing a New Kind of Camera

Traditionally, aerial photography captured for mapping purposes is vertical or straight down. Oblique photography is imagery captured at an angle other than straight down, but oblique images have not been useful for measurements. With the nadir view rectified into orthoimagery, clients such as county property appraisers can draw property lines, map roads, measure distances and more. However, they cannot tell how tall a building is, where its doors are or whether that new square at the back of a house is a covered porch or an additional room.



Grand Ole Opry, Nadir



Grand Ole Opry, North

The Ryman Auditorium still shines in downtown Nashville as the original home of the Grand Ole Opry. From a traditional nadir orthophoto, the roof is visible. With the southern oblique view, you can see the steps where greats such as Johnny Cash and Loretta Lynn made their entrances. Wehrli/Geosystems's 3-OC-1 pushbroom style oblique camera and Woolpert's SmartView process have produced a picture that's worth a thousand lyrics.

Vertical orthoimages are taken from an unfamiliar point of view. Woolpert's Tennessee client wanted users to know they were looking at the Ryman Auditorium (traditional home of the famed Grand Ole Opry) by seeing it in a familiar context with an accurate perspective. Woolpert found a way to give them familiarity without losing accuracy.

The typical problem with oblique photography is the camera being used. Traditional frame cameras distort the images they capture. Woolpert has used pushbroom cameras for traditional orthoimagery since 2004. Using a pushbroom for oblique imagery capture was a natural next step. Satellite imagery, that uses both frame and pushbroom technology, sparked the idea. If a satellite can look down at the world from an angle and capture perspectives of features not visible from directly above, then why can't an aircraft? The problem was that such a camera did not exist.

Wehrli/Geosystem was able to design and deliver a variant of its 3-DAS-1 digital aerial camera within 10 months. The system really is three self-contained, individual cameras all bundled in a single housing. The nadir camera is looking straight down and uses an 80mm focal distance lens. The forward and backward cameras are viewing the ground at 45-degree angles via prisms directing their 100mm focal distance lenses.

A separate objective lens is used for each view and each camera has a Kodak tri-linear CCD sensor array providing true color imagery. The sensor arrays have 8,023 pixel elements with a physical pixel size of nine by nine micrometers. The 3-OC captures pixels in a row, one row after another. The key is every pixel is the same size.

With a frame camera, there will be omni-directional radial distortion, and the oblique view magnifies this effect. The foreground of the frame camera photo will have a different ground sample distance than the background, making accurate measurements difficult. With the pushbroom, there's no forward- or along-track distortion, and operators can minimize and even remove any across-track distortion simply by increasing the side lap of the flight lines.

Flight lines are drawn both from north to south and from east to west, enabling Woolpert crews to capture five unique views in a single mission. The 3-OC is equipped with a GPS antenna, inertial measurement unit system, and stabilizing platform. All temperature sensitive camera elements are mounted in invar steel to guarantee long-term stability of the camera's high accuracy.

The 3-OC system operates with Windows XP or Vista and is fully upgradeable to accommodate technical developments and future requirements. The transfer of image data from the sensor electronics to the computer is by the camera link standard, at 14 bits, to a PCI-X 64-bit line grabber. The camera link also provides a control channel and the downloading of new firmware.

Woolpert's workflow includes ground control, analytical triangulation, and rectifying the imagery using a digital elevation model. The rectified nadir and oblique imagery provide seamless mosaics showing vertical, north, south, east, and west views. The imagery then has broader applications than imagery captured with traditional frame cameras. Chief among



Wehrli/Geosystems's 3-OC-1 pushbroom style oblique camera is actually three cameras in one and is equipped with a GPS antenna, inertial measurement unit system, and stabilizing platform.

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those applications is the ability to overlay existing mapping data onto the oblique imagery, stretching local government investments.

While frame cameras limit the application of the resulting imagery, the SmartView workflow is a true photogrammetric process. Woolpert will take a “photo,” but do the “grammetry” part too. The result is the ability to overlay clients’ data with confidence.

Since the oblique imagery has been georeferenced, mosaicked, and rectified it can be considered mapping, and National Map Accuracy and other standards can be applied. The oblique imagery is delivered in conventional industry formats; therefore, it is compatible with existing GIS, CADD, ImageServer, and web mapserver systems. The goal has been to fit this new product to existing, off-the-shelf software so clients don’t have to rebuild their technological infrastructure.

Oblique Imagery Has Multiple Applications

The State of Tennessee is using this pilot project to determine the best and most cost-effective approach for moving forward with its statewide base mapping program.

“Tennessee state and local governments have successfully partnered to develop traditional nadir orthoimagery through the initial efforts of the program,” Pedersen said. “But local officials, particularly property assessment and public safety personnel, see the value of enhancing the base product with additional oblique imagery.”

SmartView will allow users of both standard orthoimagery and oblique imagery to view and gather valuable visual information. End users now have a unique tool for feature analysis and critical decision-making. Using OAV imagery, clients can examine, measure, annotate and view photos that will help them respond to their daily challenges. They can display imagery, import data layers, and measure vertical and horizontal objects from various angles and directions.

Users will be able to operate and create visual products, export to ArcGIS, save and/or print image files with minimal training or instruction. Some of the wide-ranging applications using SmartView include:

- Assessment
- Planning
- Engineering
- Urban Modeling
- Emergency Response

As oblique imagery continues to become more popular, SmartView will provide progressive agencies like the Tennessee Office of Information Resources and communities like Nashville imagery that truly produces a melody for the eyes. †

JEFF PADGETT, CP, PSM, served as project manager on Woolpert’s first commercial application of the SmartView process. He has more than 30 years experience in photogrammetry and GIS. Woolpert is a multi-disciplinary company headquartered in Dayton, Ohio.

GREG WEHRLI is president of Wehrli & Associates located in New York. He has a master’s degree in software engineering and a bachelor’s degree in business management and computer science. He has been involved in all facets of the photogrammetric industry (map production, hardware and software development, equipment vendor) since the 1980s.

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