Taking TECHNOLOGY to New Heights

Joseph Bartorelli

Cessna 310Q used to fly the project.

Surveying and mapping a growing metropolis like sprawling Las Cruces, New Mexico, is challenge enough. However, completing the task within an expedited schedule is another thing. That's exactly what the experts at Vertical Mapping Resources, Inc. (VMR) did—two months ahead of schedule—using state-of-the-art technologies such as airborne global positioning (GPS) and inertial measurement unit (IMU) systems.

Crews coupled the airborne GPS, which accurately records the X, Y, and Z coordinates of each exposure—or phase center—with an Applanix IMU; the latter provided inertial measurement information including Omega, Phi, and Kappa. Scanning for the project was performed on precise PhotoScan scanners using rolled negatives. And, all triangulation, mapping, and orthorectification was completed on Softcopy workstations utilizing the same software platform. The result? Precision mapping produced quickly through a cost effective, efficient workflow process.

Using New Technology To Reduce Costs, Shorten Schedules

The effort, which was conducted for Souder, Miller & Associates, a Santa Fe, NM-based engineering consulting firm, entailed creating 1"=100' map scale black-and-white and color digital orthophotography, digital terrain models and two-foot contours of an area served by the Rio Grande natural gas company and encompasses portions of the City of Las Cruces, the Village of Hatch, and the Town of Mesilla. The area, which roughly extends north and west of the city of Las Cruces, encompasses approximately 400 square miles.

Joseph Bartorelli, president of Scottsdale, Arizona-based Vertical Mapping Resources, Inc., (VMR), says the first crucial time and cost saving technology the company employed during flight was implementation of the POSAV inertial position and orientation system.

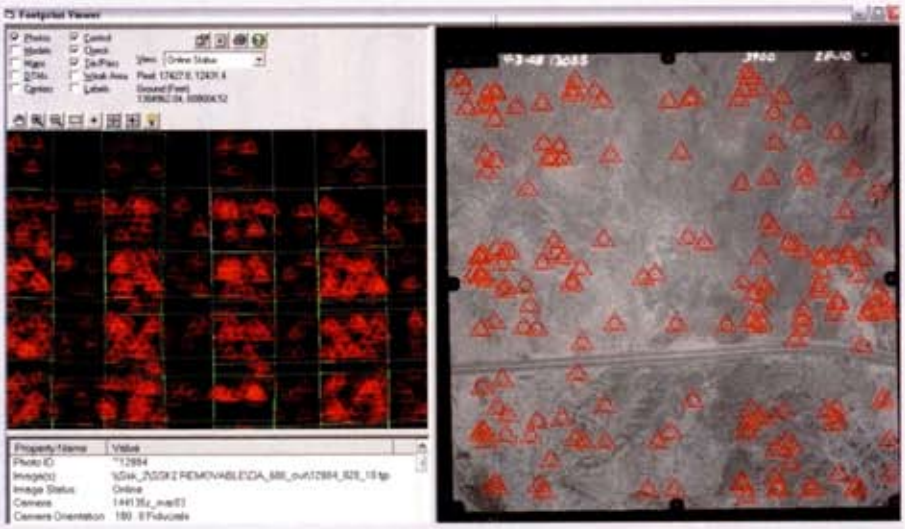
"Using Applanix IMU with airborne GPS technology guaranteed a minimal amount of ground control and greatly reduced the aerotriangulation production time," says Bartorelli.

Essentially, the system integrates precision airborne GPS with inertial technology to provide real-time measurements of the position, roll, pitch, and heading for each exposure or phase center.

Getting Underway

In preparation to perform the complex aerial mission, VMR contracted Tulsa, Oklahoma-based Aerial Data Service, Inc. (ADS). Prior to making the flight from Tulsa, ADS chief pilot Ron Rinas and his team thoroughly researched and planned the photo mission. The group began by equipping the company's twin engine Cessna 310Q with a Zeiss RMK TOP 15 aerial mapping camera, airborne global positioning system (ABGPS), and Applanix POSAV IMU technology to guarantee a successful mission. Eddy Seaton, ADS's registered professional land surveyor, placed GPS receivers on the project site to create an accurate baseline for ABGPS/IMU calculations in conjunction with the aerial photography mission.

After the flight was completed and the film processed, the VMR team began scanning the images using a Z/I Imaging PhotoScan scanner. The PhotoScan system incorporates technology developed by Carl Zeiss, Germany, a world leader in photogrammetric optics and mechanical systems. Approximately 600 black-and-white and color exposures were scanned directly from the roll in



Footprint view of a portion of the entire AT adjustment within ISAT

batch mode at a resolution of 14 microns using Z/I's sophisticated AutoScan software.

"The scanner worked unattended as it scanned entire rolls of negatives," says Kurt Okraski, VMR's chief executive officer. "In order to save production time, a lossless JPEG compression was utilized to reduce the total project data from 250 gigabytes to about 80 gigabytes."

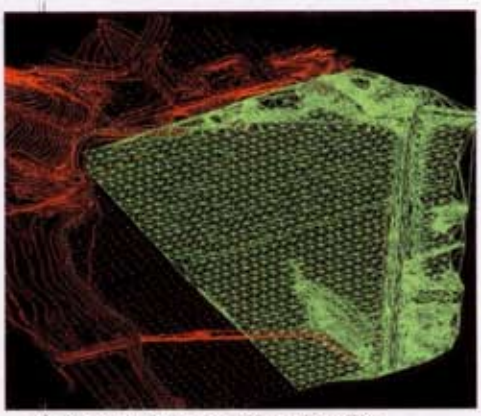
Putting It All Together

The next production step was the implementation of Softcopy Aerotriangulation (Soft AT), a routine FAAT digital photogrammetric procedure for establishing additional control points without the need for extra ground surveys. This procedure densifies the targeted ground control and acts as a check for ground control measurements. Z/I Imaging's ISAT (ImageStation Automatic Triangulation) was the selected software for this procedure. Built on Z/I's ISDM (digital mensuration) engine, the combination is a powerful multi-image point transfer and measurement environment.

Okraski says that the use of auto correlation and online integrity checks improves accuracy and decreases production time while improving overall reliability in the bundle adjustment. ISAT adds fully automated aerial triangulation from interior orientation, to the determination of tie point through the final block adjustment analysis with delivery of orientation parameters.

So, why didn't VMR consider traditional aerotriangulation techniques for the New Mexico project?

"The use of traditional aerotriangulation would have resulted in approximately 500 man-hours of computation



Portion of the triangulated surface showing TIN triangles

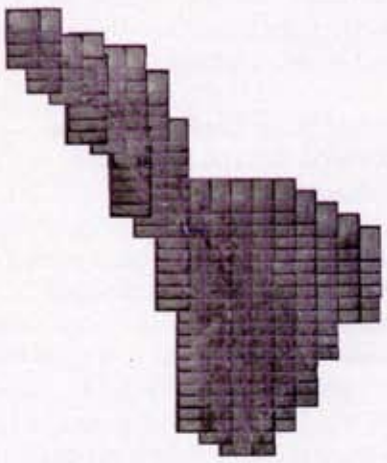
time and about 4,500 passpoint measurements (nine per image) the bundle adjustment," says Bartorelli. "By using ISDM/ISAT in combination, VMR was able to perform the Soft AT process in approximately 100 man-hours and about 38,000 passpoint measurements (75 per image). As a result, tapping into the Soft AT process cut production time by 60 percent while immensely increasing the number of project passpoints and overall AT adjustment accuracy."

After the AT was complete, the imagery was ready for DTM compilation. Compilation, or stereo digitizing, was performed on state-of-the-art Z/I Imaging digital photogrammetric workstations know as ImageStation SSKs. These workstations use CADmap/dgn mapping software, which provides a superior, easy to use, map feature digitizing system for stereo scanned imagery. CADmap/dgn offers an efficient map feature digitizing system that extends the normal capabilities of the software it is mounted on—Microstation v.8. This software features screen-based menus to provide a user interface that is specifically designed for map production.

Wrapping Up

The majority of the compilation created for the Dona Ana project consisted of a comprehensive digital terrain model (DTM)—the basis for contouring orthophotography—TIN calculations and other surface modeling. DTMs are comprised of break lines that delineate various terrain defining features such as ravines; ridges, tops and toes of slopes; and mass elevation grid points which are used in flatter areas. Grid spacing was collected at a 50-foot interval, or at about a half-foot at map scale.

"Normally, grid points are collected at about one foot at map scale, per national mapping standards," says Bartorelli. "In this case, we easily had twice the amount of grid points that would normally be required. We then enhanced that DEM with hard and soft break lines for the entire project area. This gave us an extremely accurate DTM for modeling purposes."



Overview of the entire B/W project before mosaic stage.

Scanner used for the project

The VMR team managed to compress the project schedule during the compilation process. This achievement is attributed to the SSK workstations. In addition, the DTM data received quality assurance/ quality control as it was compiled using SSK's stereo superimposition. Traditionally, diapositives—or plates—have to be switched to change steremodels. Using an SSK, models could be switched and reloaded in mere seconds. The reason? Scanned imagery can be shared by multiple technicians on various systems while diapositives cannot.

Project Conclusions

The result of using these revolutionary technologies in concert was a *very* accurate photogrammetric dataset. In fact, the Dona Ana DTM was collected exceeding National Map Accuracy Standard (NMAS) requirements and more than eight weeks ahead of schedule.

The final stage of the mapping project was digital orthophotography. Digital orthorectification corrects image distortion introduced by camera tilt, terrain relief displacement, film deformation, lens aberrations and atmospheric refraction. Okraski says VMR employees used Z/I ImageStation OrthoPro for its ortho processing.

"OrthoPro is a high-throughput production system that includes ortho project planning, rectification, tonal balancing, mosaicking and quality assessment," adds Okraski. "Digital orthophotos couple the high visual information content of a photograph with the geometric accuracy of a map. Globally, the use of geographic information systems (GIS) for land, facilities, and resource management is on the rise, which makes digital orthophotos very attractive. They can be created with an accuracy that makes them ideal for CAD and GIS users."

GPS/IMU unit utilized during flight

Okraski says that because orthophotos are georeferenced, they also can serve as a backdrop to existing vector or other GIS base maps. In addition, they are valuable for direct interpretation, GIS updating and digitizing new layers of information.

VMR personnel used the aerotriangulation and ground survey control to tie the digital images to actual ground coordinates. The highly accurate DTM was used during the digital orthorectification process to adjust each image pixel into its correct position. Bartorelli and his team implemented an exponential algorithm in orthophoto processing —one of the most accurate techniques available. The Z/I OrthoPro software, which allows for batch processing, reduced major rectification time because large blocks were run overnight in batch mode.

ZI Imaging image station SSKs used to collect the DTM features

"The majority of the orthophoto production time was spent drawing seamlines, or joinlines, where the images meshed to form an overall mosaic," says Bartorelli. "VMR uses only the most nadir position, or "sweet spot," of every exposure in orthorectification."

RMK TOP 15 from ZI Imaging, used to collect the photography.

The nadir position, or the portion of the image closest to the center of the photograph, has the least radial displacement. The end result was a completely seamless, tonal-balanced orthophoto of the project area that had the least radial displacement in above ground features. The final touch involved cutting individual tiles from the mosaic and put into the client's specified tiling scheme.

In addition to achieving accuracy and mapping standards that were above the norm, VMR's cost to complete the Dona Ana project was 25 percent less than that of its competitors. Even with two client-requested change orders that were requested mid-way through the project, the mapping professionals delivered the final product ahead of schedule—which pleased the client. VMR is one of a handful of U.S. firms to incorporate these revolutionary technologies into everyday applications.

About the Author

Joseph Bartorelli is president and chief operating officer for Scottsdale, Arizona-based Vertical Mapping Resources, Inc. He has more than 10 years of experience in the fields of photogrammetry, GIS, and remote sensing.

Images courtesy of Vertical Mapping Resources, Inc., Aerial Data Service, Inc., Applanix Corporation, and Z/I Imaging.