A New Model of History

It is one of the most thoroughly studied and documented sites in the world. Built on a limestone outcrop known as the "sacred rock," the Acropolis rises from the center of Athens, Greece, to a height of 150 m (490 ft) above sea level. Covering roughly 30,000 m^2 (7.4 acres), it features steep cliffs and a flat top accessible mainly from the west. Three ancient temples (the Parthenon, the Erechtheum and the Temple of Athena) occupy the rock, along with several smaller buildings and a series of perimeter walls.

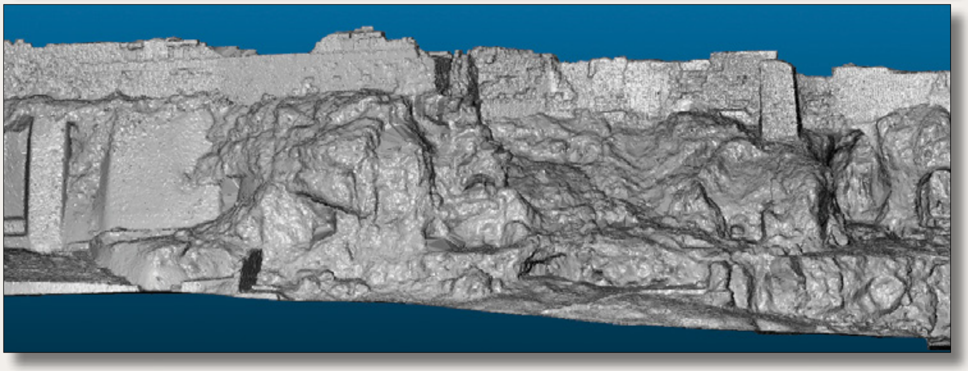
In support of ongoing studies, the European Union and Greek government jointly funded a project to develop a GIS for the Acropolis. Supervised by the Acropolis Restoration Service of the Hellenic Ministry of Culture and Tourism (YSMA), the project's goal is to produce the most detailed and accurate description ever made of the Acropolis. The GIS will be used for scientific research as well as maintenance and restoration purposes.

In addition to accurate 3D data, the project called for realistic depictions—including color and textures—of the walls and structures. Producing such a GIS requires survey-quality data with an exceptionally high level of detail, and the project managers realized that the effort would require a blend of skills and technologies. YSMA turned to a joint venture of two companies, ELPHO Ltd. and GEOTECH UGP, to do the job. Knowing the project would require integration of precise surveying, 3D scanning and photogrammetry with data management and visualization, the team selected Trimble equipment and software for the work.

Project Control

The first task was to install a network of precise 3D control points as the basis for the measurement and imaging operations. Specifications called for horizontal accuracy of <3 mm (<0.01 ft), and <7 mm (<0.02 ft) vertical. The team used Trimble 5800 GPS Receivers and static GPS methods to establish 13 new triangulation points on the site. The GPS data was processed and adjusted into the national coordinate system using Trimble Geomatics Office™ Software. To obtain the needed vertical accuracy, the surveyors used a Trimble DiNi® Digital Level.

With the triangulation network in place, surveyors installed points from which the scanners would operate. The team installed 52 points inside the perimeter walls, and another 106 points outside of the walls. The work combined conventional traversing with RTK GPS. The surveyors used a Trimble 5600 DR200+ Total Station with Trimble ACU Controller for the optical measurements. For the RTK work, the team connected to the HEPOS RTN, which uses Trimble VRS technology and 98 reference stations to



provide RTN services throughout Greece. For high-resolution scanning of the Acropolis rock face and perimeter walls, the team used a Trimble GX™ 3D Scanner with Trimble PointScape™ Software.

The Acropolis is a popular place, and heavy tourist traffic posed a constant challenge. As a result, roughly half of the surveyors' work "days" took place at night. Work began at 5 p.m., when the site closed for the day to visitors, and continued until around 3 a.m. With limited vehicle access, they often carried the instruments, batteries and targets across rough terrain to the setup points.

The crews used multiple methods to control the location of the features, buildings and walls. "For most scans, we used a survey workflow to manage the scanner like a normal total station," Dr. Christos Liapakis, managing director of Geotech UGP. "We set up on a known point and oriented to a second known point. At the same time, we used standard spherical targets placed on pre-surveyed points in the scanning area." In many scans, unique objects could be identified and used as control points instead of the spherical targets. The reflectorless function of the Trimble 5600 DR200+ made it possible to measure points that were otherwise not accessible.

The team planned their operations in detail, setting up and measuring targets with the Trimble 5600 DR as well as checking for gaps in the scanned areas. The surveyors used handheld cameras to capture digital photographs of the scanned areas. In a typical day, the crew could complete between two and ten scans. At the end of each day, the crew downloaded and backed up the data. They conducted daily checks of the data to verify quality and look for gaps or errors. They noted any missing data and added it to the work plan for upcoming days.

The field work ran smoothly. In roughly three months, the surveyors installed the control and completed scans from 125 locations and collected more than 330 million individual points.

Measuring from Above

Despite the careful planning, several areas of the site could not be scanned using a traditional tripod setup for the Trimble GX. To solve the problem, the team developed a custom apparatus to enable them to scan walls and inaccessible areas from above. The team took care to ensure that the mount was strong enough to safely carry the scanner and avoid damage to the instrument. To protect the public, they used the mount only when the Arcopolis was closed to visitors.

"To be sure that the scanner would be secure, we made plenty of test measurements in a safe environment," said Dr. Liapakis. "Not until we installed it on site did we realize how risky it was with a 40 m (130 ft) drop beneath it. But when you have undertaken such a project with all the relevant deadlines and obligations, maybe it is more risky not to do this installation!"

When suspended over the walls, the scanner could not be located or oriented in the normal manner. The surveyors relied on target spheres and coordinated ID points to connect the scans into the project's coordinate system. The approach worked well, and over the course of the project the team used the apparatus 21 times.

To obtain imagery for the orthophotos, the team used a specialized digital camera carried beneath a large helium-filled balloon. During post processing, photogrammetry technicians used the photographs to create a digital terrain model (DTM) with sufficient accuracy and density to blend into the 3D model created from the scanned data. The ELPHO team used Trimble INPHO Software to complete the photogrammetry, create the orthophotos and develop the DTM information.

Electronic Data

As the field work moved ahead, office technicians used Trimble RealWorks® Software to process the scanner data. It took roughly 12 months to complete the office work, which produced 12 separate models containing 25 to 30 million points apiece. Photos from the handheld and balloon-mounted cameras were then added to provide texturing and detail.

When the work was completed, the team provided an impressive set of deliverables. Clients received point cloud information, cross-section profiles and technical reports. The technicians developed AVI files with fly-through views of the scene, and also delivered the models and image texture maps in Trimble RealWorks format. Project stakeholders can use the free Trimble RealWorks Viewer to create their own 3D views of the entire project.

Even Dr. Christos Liapakis is impressed by the results. "Although it was really tough, it is worth the effort," he said. "When you perform a project like this, it is something that we have never managed to do in the past, using any other technique. Without the scanner, this project would not be possible. The quality and accuracy of the photorealistic 3D model is unbelievable."

For more information and to see images from the 3D models, visit the YMSA website at: http://acropolis-gis.ysma.gr/