Customer:
English Heritage

Project:
Surveying Stonehenge

Solution:
Integrated Surveying with Trimble GPS and Total Station Technology

Case Study

A new view of Stonehenge

Integrated Surveying data brings a new view of the world famous archaeological site of Stonehenge in Wiltshire and captures several hitherto unrecorded features.

For centuries, the ruins at Stonehenge have been the focus of archaeologists, engineers and scientists throughout the world. Designated as a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO), Stonehenge is one of the most heavily studied archaeological sites in the world. The origin and function of the familiar stone circle, which was constructed more than 4,000 years ago, remain a topic of discussion. In spite of decades of research and investigation by arrays of increasingly sophisticated technologies, Stonehenge still offers more questions than answers.

Stonehenge isn't alone. But with up to one million visitors each year, it is easily the most famous of some 900 stone circles in the British Isles dating to the Neolithic period of the late Stone Age—before the reigns of the Pharaohs in Egypt. Located roughly 120 km (75 mi) southwest of London, the Stonehenge ruins and surrounding earthworks are under the supervision of English Heritage, a government agency charged with managing, preserving and promoting historic locations in England.

In 2009, the Archaeological Survey and Investigation Team of English Heritage, headed by David Field, conducted a new survey of the prehistoric site using state-of-the-art equipment and techniques. The survey, which focused on the land under and around the famous stones, was the first topographical survey of the monument since the early 20th century.

The survey achieved two main objectives: First, it provided a modern analytical survey of the monument and its earthworks; Second, the survey created a dense digital terrain model (DTM) of the site. The DTM provided valuable research information and could be made available for use as a display in a planned new visitor centre.

To create the DTM, the English Heritage survey team recorded some 20,000 individual three-dimensional (3D) points at closely spaced regular intervals across the monument. Most of the data was collected using real-time kinematic (RTK) techniques with four Trimble R8 GNSS Receivers and Trimble TSC2 Controllers. One receiver operated as a GNSS base station, with the other three serving as rovers. A fifth Trimble R8 operated as a VRS Rover; it connected to the British Ordnance Survey OS Net

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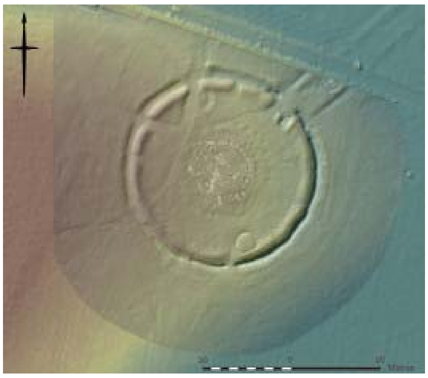
real-time network (RTN) using Trimble VRS Now™ technology. The bulk of the ground measurement points were collected using RTK. When the surveyors needed to collect points close to the upright stones at the center of the monument, they used a Trimble 5600 Total Station with a Trimble TSC2 Controller. Data collected with the total station could be placed into the same dataset used for the RTK surveys, and the GNSS and total station data were combined to produce a single DTM.

To successfully integrate data from GNSS and total stations, the height values recorded by GNSS needed to agree with those recorded by the total station. Even a small datum shift or difference in accuracy between the two systems would create discontinuities in the resulting DTM. Because later analyses would look for subtle variations in the DTM, any discontinuities could be mistaken for actual surface features. Rather than trying to match the GNSS and total station data in the office, the team integrated the two data sets in the field. Because the Trimble R8 and Trimble 5600 use the same controller and field software, the teams used resections to orient the total station into the same 3D reference datum as the data collected using GNSS. The approach worked well, and the resulting DTM depicted a continuous surface of 3D points recorded with GNSS and the total station.

Spatial Imaging and Integrated Surveying

To supplement the topographic surveys, surveyors collected point cloud data and imagery of the stones. For this work, KOREC's Matthew Lock supplied a Trimble Spatial Imaging Rover, which combines a

▲ KOREC's Matthew Lock



◀ Stonehenge Ground Model (copyright English Heritage

◀ Resulting scan from combining the VX Spatial Station and R8 GNSS

Trimble VX™ Spatial Station with a Trimble Integrated Surveying™ (IS) rover. The Trimble VX Spatial Station provides spatial imaging capability including scanning and image capture. The Trimble IS Rover consists of a Trimble R8 GNSS Receiver mounted directly above a 360° prism on a pole that also holds a Trimble TSC2 Controller. The Trimble TSC2 controls both instruments simultaneously, communicating with the Trimble VX over a radio link and with the Trimble R8 via Bluetooth. The solution enabled Lock and the surveyors to collect points on the site with RTK GNSS, the Trimble VX, or both.

The reference frame for the survey work at Stonehenge was the British Ordnance Survey coordinate system (OS Grid). To tie the Trimble VX into the OS Grid, the surveyors used Integrated Surveying to conduct a resection based on points created using RTK GNSS in conjunction with the local Trimble VRS Now™ service. As each resection point was captured with RTK, the Trimble VX measured to the prism and developed the solution for the spatial station's 3D position. This method enabled the team to create geometrically strong resection solutions and to develop precise, accurate ties to the OS grid. Lock noted that the method does not require setting any ground marks, which is an important consideration on the sensitive Stonehenge site.

Once the Trimble VX was positioned, the surveyors captured photos and initiated scanning routines to capture point clouds of the stones. With the Trimble VX running autonomously, the team was free to use the Trimble R8 to survey the surrounding landscape and collect data for the DTM. The Trimble VX and Trimble R8 could operate simultaneously; data from the two sensors was recorded into the same Trimble TSC2 Controller. In the office, the 3D survey points collected by the Trimble R8 and Trimble VX were merged with the point clouds to provide a surface DTM, a 3D model of the stones and photographic data for the site

When the survey results were analysed, the DTM illustrated the topographic setting of the monument on the edge of an eastward-facing spur. A small ditch encircles the Stonehenge site, and the DTM showed how the form of the ditch and ditch bank changes in various locations around the monument. In some locations the ditch is deep and wide, while in others it barely exists.

Perhaps the most striking outcome of the survey work was the discovery of a slight, flattened mound near the center of the stone circle. The mound, which had not been mapped before, attracted the attention of historians and archaeologists. The purpose of the mound remains a mystery. It could be an artificial mound covering a prehistoric burial, or it might be a natural feature that was incorporated into the construction of the stone circle over four thousand years ago. Once again, Stonehenge has a new secret.

With many thanks to Trevor Pearson of English Heritage

Contact us:

Please do get in touch for further information on any of the products or services mentioned in this case study, a demonstration, support or just a chat about your requirements.

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