3D technology and the *H.L. Hunley*: Beyond documentation.
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Since raising the *H.L. Hunley* submarine (1863) from the seabed in 2000, the project has incorporated 3D technologies including laser scanning, patterned light scanning, Vulcan© point system, and computer modeling. Archaeologists developed the use of 3D technologies primarily for site plan development and artifact documentation. As the project progressed, conservators found other applications for the technology in conservation treatment assessments and in the rotation of the *H.L. Hunley* in 2011.

After the recovery and throughout the excavation, 3D technology has been instrumental in documenting the Hunley and establishing the site plan. Before the excavation began, surface mapping with the Cyrax©3D laser scanning system generated a global 3D model of the submarine’s outer surface. With that documentation in place, the submarine was opened to allow for excavation of the interior. During the excavation, point mapping with the Vulcan© 3D point system spatially recorded artifacts, human remains and submarine features. After these items were removed from the submarine, detailed 3D scans were taken with a Minolta © Vivid 910 laser scanner and a Breuckmann© OptoTOP-HE structured light scanner. Integrating this information into the master site plan has produced a powerful visualization of the site and archaeological record (Rennison et al. 2009; Scafuri and Rennison 2012).

The most recent documentation has utilized the Breuckmann© OptoTOP-HE structured light scanner, which provides high resolution 3D data capture integrated with color photography, to document the outer concretion of the hull. Since conservation treatment demands the removal of this concretion, which contains archaeological data regarding site formation, a comprehensive 3D documentation was undertaken. Conservators have also taken advantage of this sophisticated scanning technology to assess conservation treatments (Crette et al 2010). Organic materials such as wood and cork have been scanned before and after conservation, to digitally compare the shrinkage of the objects. Iron artifacts have also been scanned to assess experimental conservation treatments.

3D technology served an important role in the engineering studies of the hull, as well. To prepare for the rotation of the *Hunley*, successfully completed in 2011, a 3D geometric model was created to perform finite element analysis using nominal measurements from the submarine (Blouin et al 2011). This model was used to visualize potential stress distributions on the *Hunley* and aided in developing an overall approach to the rotation. Once decided that the rotation would proceed using the pull and release of 15 supporting slings to rotate the *Hunley*, more detailed spatial information was needed to compute the amount of pull and release for each sling. The simplified model created for the finite element analysis did not take into account the submarine’s relationship to its supporting slings or the outer concretion on its surface. To acquire this information, conservators and engineers collaborated with archaeologists to process existing data and collect new data. Using the site plan, virtual cross-sections were created for each sling location that accurately accounted for the concretion and overall shape. New data was collected using the Vulcan 3D point system to define the spatial relationships of the submarine to its supporting elements. With this information, engineers calculated the amount of pull and release for each sling using numerical modeling. Cross-sectional measurements were also used to create a full scale sectional mockup to test and refine the computer-based calculations.

Although some problems arose while using 3D data collected for archaeological documentation for engineering purposes, the outstanding contribution of 3D technology to the project remains undeniable. Having completed the comprehensive scanning of the hull and hundreds of artifacts, archaeologists have now laid the foundation for future collaborations.
Works Cited:


