

## Engineers Scan Lady Liberty

By: Sharon Boranyak

High-definition, 3-D, laser-scanning technology was used to survey the Statue of Liberty's interior conditions as part of an extensive life and safety upgrade project.

December 6, 2011--Using new high-definition, three-dimensional (3-D), Laser scanning technology, East Hanover, New Jersey-based Matrix New World Engineering, Inc., has captured millions of data points for a precise view of the Statue of Liberty's interior. The firm surveyed the iconic monument before renovations designed to improve the statue's safety began in late October. Natoli Construction of Pine Brook, New Jersey, the prime contractor for the \$27-million project, chose Matrix to survey the interior conditions of the statue's base and pedestal.

"I am personally honored that Natoli Construction and the U.S. National Park Service selected Matrix as a team partner to survey the interiors of the Statue of Liberty for the Life and Safety Upgrades project," said Dennis Petrocelli, P.G., a senior vice president of Matrix, in a written statement to Civil Engineering magazine online. "We were thrilled to deliver the results of this task on the 125th birthday of this national treasure."

Indeed, the survey was delivered on October 28, the anniversary of the monument's dedication in 1886 and the day before the statue and pedestal were closed for renovation. According to the National Park Service website, the Statue of Liberty renovation project calls for removal and replacement of the stairs and elevator and upgrades to restrooms, electrical systems, and fire suppression systems. Keast & Hood Company, an engineering firm based in Philadelphia, in collaboration with Mills & Schnoering Architects, LLC, of Princeton, New Jersey, is serving as the structural engineer-of-record for the year-long renovation project.

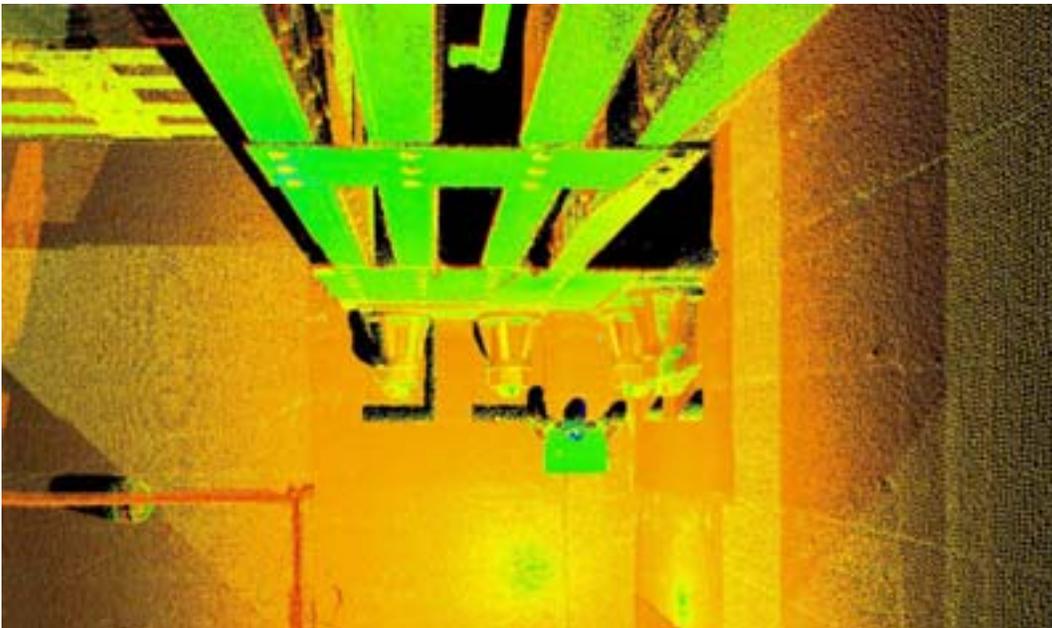


*The narrow passageways and poor lighting conditions inside the pedestal of the Statue of Liberty made the use of laser scanning techniques the best choice for capturing data about the structure's existing conditions. Courtesy of the National Park Service*

James Sens, P.L.S., Matrix’s director of high-definition surveying and mapping, said in an email that Natoli needed to provide detailed survey information to the Park Service, but at the same time needed to immediately begin fabricating the stairways to meet the client’s one-year deadline. Natoli hired Matrix quickly because waiting until after demolition to capture survey data would have jeopardized the time line.

Sens said the goals of the survey were to verify the existing vertical dimensions between the six stairway and elevator landing points (called “P levels”), verify points of critical clearance, and check the vertical alignment of the shaft through the pedestal. Because Matrix used state-of-the-art technology for the survey, not only were these goals achieved, but the client received added benefits as well.

“We collected the data in about twenty percent less time than using traditional survey methodology,” said Sens. “The fact is that scanning provides added value by collecting more complete information.” He explained that the scans collected roughly 240 million data points in the time it would have taken to record merely hundreds if a traditional total station survey were used. The density of data points yielded detail almost resembling photographs.



*Four steel supports designed by engineers Alexandre-Gustave Eiffel and Eugene-Emmanuel Viollet-le-Duc form the main structural support of the Statue of Liberty. A recent scan of the beams produced a detailed image that will assist in the statue’s rehabilitation. Courtesy of Matrix New World Engineering*

With this detail, the scanner could capture virtually all of the existing conditions—not just points of concern—uncovering issues that may not have been anticipated prior to demolition. For example, the data can alert metal fabricators if they need to make any modifications from the plan as they manufacture parts for the stairs or elevator.

Sens said the team first debated whether to use traditional survey methodology or to scan the interior. After visiting the monument, it became clear that scanning would

be the most cost-effective and efficient approach to the project, he said. The only way to move about the shaft was along narrow and steep stairways that wind their way through the pedestal, the vertical change between landing points 1P and 6P being 110 ft. The traditional survey method of using a level would have required numerous setups and would have been difficult to maneuver. In addition, the vertical alignment would have required repeating the process. Adding to these challenges was the poor lighting inside the pedestal.

“These site conditions made the use of traditional surveying methodology difficult to impossible, but were less of an obstacle using laser scanning,” Sens noted. Additionally, he said, the poor lighting and limited access could have introduced errors to the measurements using traditional survey methods. “In contrast, the scanning survey methodology can capture both vertical and alignment data at the same time, reduce the error that can result from multiple setups required with traditional methods, provide flexibility for measurement locations and

alignment correlations, and capture virtually all existing conditions through the shaft,” he said. To control both the horizontal and vertical components, the Matrix survey team used a combination of fixed-height targets and paper targets, registering the scans together. All measurements and elevations were based on the plan datum for the project’s architectural drawings and were relative to the 1P elevation of -0 ft, 1/2 in.

No single point that was measured in the 125-year-old pedestal varied more than 1 1/8 in. from the baseline at 1P, Sens said. “The fact that there was such a small deviation in the alignment of the shaft is certainly a testament to those who constructed the pedestal,” he noted.

Sens said the survey work was conducted at night when the park was closed, with the dramatic backdrop of the New York City skyline. “One of the things that struck me was how much this monument means,” he said. “I feel truly honored to be a part of this project team. The opportunity to be even a relatively small part of this project is so special it is something I will never forget.”