

**O**n the morning of Aug. 29, 2005, the third-strongest hurricane ever recorded to hit the United States rolled across Louisiana and Mississippi, creating a massive clean-up and reconstruction challenge. The force quickly became widely known as Hurricane Katrina. Destruction from the hurricane was seen everywhere; in the city of New Orleans, much of which is situated below sea level, flooding from breached levees proved catastrophic. Recognizing the critical importance of the levee

ern shore. The project started at the 17th Street Canal and extended east to the Inner Harbor Navigational Canal, and included the levee protection system.

Our company, Martin & Whitacre Surveyors & Engineers Inc. (Muscatine), was subcontracted by Stanley Consultants to produce 3D laser scan surveys for the flood gates, seawalls and structures of the significant site. For this project, we used a new Leica Geosystems (Norcross, Ga.) HDS3000

# SCANNING the Levees



Laser scanning technology plays critical role in mapping damage from Hurricane Katrina.

BY GARY WHITACRE, PLS

With a Leica Geosystems HDS3000 laser scanner, Martin & Whitacre Surveyors & Engineers Inc. of Muscatine, Iowa, produced 3D surveys of the flood gates, seawalls and structures in New Orleans following Hurricane Katrina.

system for the city's protection, the U.S. Army Corps of Engineers (USACOE) worked with a number of surveying companies to map the damaged levees and related structures as a first step toward improving and strengthening these vital protective barriers.

The Rock Island District of the USACOE contracted with Stanley Consultants, an engineering, environmental and construction services provider located in Muscatine, Iowa, to map a six-mile stretch of Lake Pontchartrain along the southeast-

laser scanner. Our crew consisted of my son Seth, a land surveyor intern, and me.

To aid us in mapping the remaining earthen levees and collecting utility information, we subcontracted C.H. Fenstermaker of Lafayette, La. The utility data was captured primarily using RTK GPS, while the topography was captured using a Leica ScanStation. (For details on Fenstermaker's work in New Orleans, read "Aiding the Katrina Recovery," *POB*, October 2006.)

## Holding Control

Working in post-Katrina New Orleans presented a number of interesting challenges. One was control. Existing survey control monuments were known to be subsiding in the wake of post-Katrina flooding. The USACOE Interagency Performance Evaluation Task Force determined that the most stable of the existing monuments was a point called ALCO, a bronze triangulation station disk set in the massive concrete seawall; therefore, project specifications were written so that ALCO would be held as the primary control point for all work in that area. This



also meant that every surveyor onsite was scrambling to work from one common point. At one particular time, we counted 10 different survey crews working in the designated area. And many of them were utilizing ALCO for static observations or RTK, which typically involved setting up on the point for an entire day, preventing others from using it.

ALCO was set in 1931 by the U.S. Coast and Geodetic Survey. Its current vertical datum at the time of our work was NAVD88 (2004.65) and horizontal datum NAD83 (1992), Louisiana South Zone State Plane Coordinate System.

When using ALCO as a single control point, we held it vertically and ran a series of closed loops each day using a Leica NA3003 digital level and barcode rods all the way to the east end and back through about 15 control points that were set in the seawall. Those points were also used in a horizontal control survey using static GPS and ALCO. Additionally, an OPUS solution was run on those points for a check, so the control surveys that we completed, both vertical and horizontal, and the control points that will be set in the future, will be used as control for the reconstruction project.

**Above:** Martin & Whitacre's scanner was often mounted on their ¾ ton Chevrolet crewcab pickup truck equipped with a hydraulic leveling system, giving them an instrument height of about 11 ½ ft. **Right:** Seth Whitacre (seated) and Gary Whitacre examine scan data taken at Bayou St. John's in New Orleans. Debris and overgrown vegetation often made a clear line of sight difficult.

## Daily Work

Our first task on location was to hold a brief planning session to determine where we were going to set up the scanner, how many setups we would need, what the field of view would be and the desired point density. We used a 1-megapixel camera on the scanner to take a digital picture of the entire project site. From that image we decided which areas we would take broad scans and which areas we would take dense scans. Where we came across flat walls, for instance, we didn't need much information and could make do with less density. We

zeroed in to capture high-density scans of various details, such as hinges on the gates and construction joints. Since the time it takes to complete a given scan is determined by the field of view and the density of points, the ability to vary these factors on-the-fly gave us a lot of flexibility to spend more time on those areas that needed extra attention.



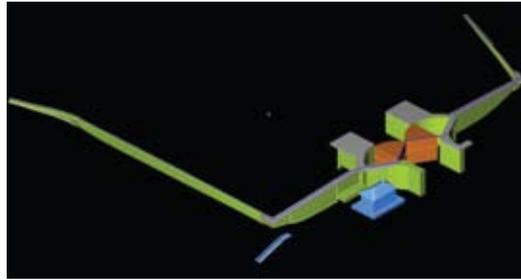
A 3D model (top), point cloud (middle) and point cloud with model overlay (bottom) of Bayou St. John's in New Orleans.

On a typical day, we were able to complete anywhere from two to six scans, including our control work. Every setup and every situation was different. For some shots we were required to operate in confined spaces, which made it difficult to set up the scanner. To get a higher view, we often had to mount the scanner on our ¾ ton Chevrolet crewcab pickup truck equipped with a hydraulic leveling system. When working from the truck, we had an instrument height of about 11 ½ ft, giving us a big advantage over the normal 5-6 ft of elevation. On one occasion, we set up on a balcony at the harbor master's building in the Orleans Marina so we could have a view down between the condominiums and the seawall to capture a small courtyard. Another time we had to set the scanner on top of the seawall.

### The Six-Mile Point Cloud

A point cloud was required for 3,000 ft on the west end of the project in the vicinity of the Orleans Marina, which included more than 2,000 ft of a continuous flood wall and seven flood gates. We also provided high-definition point cloud data for an additional 10 flood gate structures along the six miles of the levee protection system.

Once the initial control surveys were completed, Fenstermaker teams utilized



the levee as a baseline and occupied stations at about 100 m intervals to capture the terrain with the ScanStation. This system of intervals created an overlap of data collected, which was registered to create a five-mile point cloud. The result of this combined effort was a six-mile-high density XYZ database.

From the registered point cloud, topographic information was extracted to create planimetrics (horizontal data of mapping features) for the mapping, as well as contours, profiles along the toe and top of the walls and cross sections at 500-ft stations. In addition to the basic mapping information, we created 3D models of all the walls and the 17 flood gates throughout the six-mile project. Leica Geosystems HDS Cyclone software was used to create the 3D models, and will aid in the design of the new flood protection system.

Final deliverables included 34 sheets of 100-scale topographic mapping of the six miles of levee protection system, as well as profiles of the top and toe of all slopes on the levee, cross sections at 500-ft intervals, utility surveys of the entire six-mile stretch and digital terrain models.

### A Scanning Workhorse

The HDS3000 proved to be a real workhorse on this complex and difficult job. Since our company was one of the first to place an order for the HDS3000 when it was introduced in 2003, we already had considerable experience working with this instrument on numerous scanning projects. One of the greatest advantages of the laser scanning system on this particular project was the complete capture of anything in the field of view. The high density XYZ data along with the digital photo image was invaluable for documenting the existing conditions. We were able to leave the project site and return home almost a thousand miles away with complete confidence knowing that no information was left uncollected.

When it comes to capturing detailed information on a complex structure like this, laser scanning technology offers clear advantages over other surveying

ALCO, a bronze triangulation station disk set in the massive concrete seawall, was held as the primary control point for all work in the area and often caused delays when other survey crews were using it.



## Working in Post-hurricane Conditions

Working in New Orleans after Hurricane Katrina proved difficult. Having never been to the city before, Whitacre and his son Seth initially had a lot of trouble finding their way around. The category 5 storm eradicated many street signs and twisted one-way signs to point in the wrong direction. It took them a while to get oriented.



An unforeseen difficulty the Whitacres encountered on the project was overgrown vegetation. They needed a clear line of sight for the laser scans. Although they did get good cooperation when asked to have the vegetation cleared, they sometimes had to cut the weeds and high grass themselves before scanning could begin.

Vibration from the large pumping station in the vicinity of the 17th Street Canal and from pile-driving activity nearby was another obstacle, causing the team to lose about three-quarters of a day's work because they initially did not understand why their data was so bad. They eventually caught on to the vibration impact and rescheduled work around the pump testing and construction work.

tools. There is no comparison in terms of speed and accuracy. Without this technology we would have had to take a large number of single measurements and connect the dots—and probably do a lot of hand sketches on a clipboard.

I can truthfully say that I would never consider taking on a job of this type or magnitude without 3D laser scanning. I believe, especially from this experience, that high-density laser scanning will have as big an impact on surveying as the advent of RTK GPS a few years ago. 🌐

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