



THE American Surveyor

A FOOT IN THE PAST... AN EYE TO THE FUTURE

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K Laser Scanning Katrina-Damaged

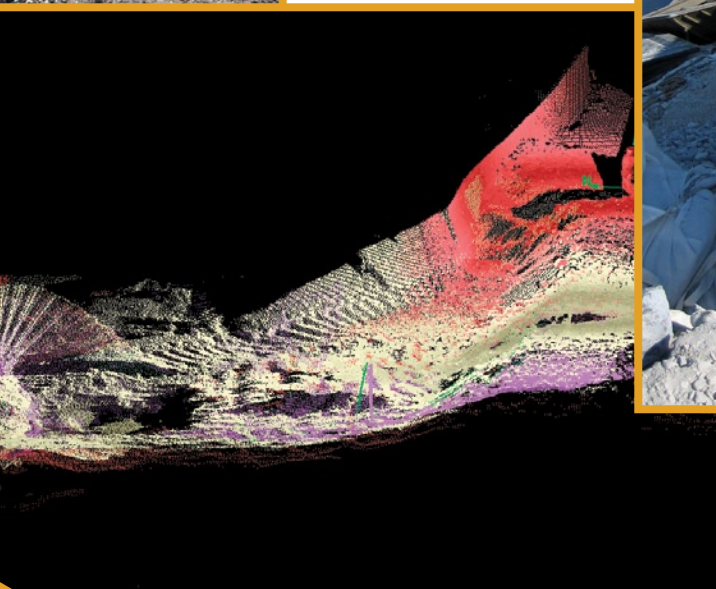
>> By Tom
Greaves

Six weeks after Hurricane Katrina devastated New Orleans, two researchers, Dr. Robert Kayen and Dr. Brian Collins from the United States Geological Survey (USGS), were on site to scan. Their mission – to measure the magnitude and geometry of the structural and geotechnical deformations associated with the levee failures. The team mapped ten sites with a Riegl Z210 laser scanner owned by the USGS. I-SiTE software was used to post-process the point cloud data to produce geo-referenced surface models.

Kayen, a research civil engineer at the USGS, says he got the late-night call to perform the work specifically because the investigative team sponsored by the National Science Foundation believed laser scanning would be the best way to capture the data quickly with sufficient detail and accuracy. Kayen says speed was critical because the sites were being



Facing page: An unorthodox “tripod” supports a roof-mounted LIDAR unit as Brian Collins scans the 17th Street Canal levee breach. Flowing water flipped cars, floated houses, and created huge debris fields at the levee failures. *Photo: Robert Kayen, USGS, Menlo Park, CA.*



Above: LIDAR unit on the edge of intact I-wall levee at the north end of the 17th Street breach.

Left: Composite LIDAR image of northern levee breach on the Inner Harbor Navigation Canal.

Levees

actively modified to provide flood protection – it was necessary to capture the failure geometry before the evidence was covered up by emergency berm material used to repair the levees.

The laser scanning survey took place October 9-14, 2005.

For most of the work, the tripod-mounted Riegl scanner was fixed to a platform on the roof of the field vehicle four meters above the ground. Elevating the scanner to this height reduced shadow zones and extended the coverage area of each scan. Other configurations involved mounting the scanner on its side; for example, toe scour was measured by scanning downward from the top of T-wall sections. Where available, the scanner was set up over existing survey bench marks to geo-reference the data, but in most cases a separate, local coordinate system was required for each site.



Brian Collins scans
at the Lower 9th Ward,
northern levee breach on the
Inner Harbor Navigation Canal.
Photo: Robert Kayen



One of the many homes damaged by flowing
water at the 17th Street Canal breach.

Kayen says laser scanning had some additional advantages compared with conventional total station work. One is that the long range and speed of the device allowed not only the damaged areas to be surveyed but also undamaged areas adjacent to the breached sections. Measurements of cross sections of undamaged areas will aid the forensic analysis of failed areas.

As well as length, area and volume measurement, scanning enables highly accurate computation of rotation displacement, which was common at areas of levee T-wall distress. The scan data shows that in some cases, blocks of ground moved approximately 14 meters away from the levee break during failure.

Yet another benefit is that direct measurement of scour trenches allows comparison of scour depth with sheet pile embedment. The data sets, typically 15 to 20 merged scans per site (approximately 2.3 million points per scan), are complete enough to allow cross sections to be extracted in almost any orientation. Capturing the geometry of the surrounding areas provides the investigators rich context for the analysis.

Going forward, Kayen says he'd like to see some new capabilities in laser

scanning instruments. He'd like next generation instruments to have position sensors on board to enable global registration of the data as it is captured. Location of the scanning instrument with differential GPS systems with 10 cm accuracy or better (RTK-GPS or OmniSTAR HP differential GPS and the like) to allow initial coarse registration would be valuable. Kayen would also like to see a compass on board to guide orientation of the instrument.

Kayen also sees an opportunity for terrestrial instruments that have the capability to see underwater using dual blue/green lasers. The ability to measure

scour from bridges or the tops of T-walls would be a boon to diagnosing structural integrity. Airborne LIDAR systems used for coastal bathymetry are already available on the market – in the future perhaps these will be repurposed for tripod-mounted applications. A significant component of the expense of airborne systems is IMU (inertial measuring unit) hardware required to measure roll, pitch and heading, which is unnecessary for fixed-position scanning.

On November 2, 2005, the U.S. Senate Committee on Homeland Security and Governmental Affairs heard testimony based on forensic investiga-

tions performed by a National Science Foundation-sponsored team led by the University of California at Berkeley, the American Society of Civil Engineers, the U.S. Army Corps of Engineers and Louisiana State University's Hurricane Research Center. Chapter 7 of the Preliminary Report on the Performance of the New Orleans Levee Systems in Hurricane Katrina on August 29, 2005 provides details about the scanning work process. The complete report is available on the website for the Senate Committee on Homeland Security & Governmental Affairs.

Brian Collins, PE, PhD, and Robert Kayen, PE, PhD, Research Civil Engineers from the U.S. Geological Survey, will present their work on scanning the New Orleans levees on March 27-28, 2006 at the SPAR 2006 conference in Houston, Texas. Details about the conference may be found at www.sparllc.com. *AS*

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Left: Mounted to Kayen and Collins' vehicle, the fixed roof base allowed for the leveling of the tripod and LIDAR instrument on sloping ground. Here the instrument scans scour around the floodwall at an Entergy plant in east New Orleans (survey site 10). *Photo: Robert Kayen*



LIDAR unit at Lower 9th Ward, northern levee breach on the Inner Harbor Navigation Canal. Photo: Robert Kayen

