LiDAR SURVEYING

DELIVERING INCREASED SAFETY AND EFFICIENCY ON PUBLIC WORKS PROJECTS

by Bob Gilbert

The roots of surveying trace all the way back to ancient Egypt and the Great Pyramid of Khufu. Today more and more technology is being integrated into the profession, to the benefit of both surveyors and those ultimately using the survey data.

One such example of survey technology is Light Detection and Ranging (LiDAR). A LiDAR scanner gives surveyors the ability to measure complex areas more quickly, accurately, and safely than traditional methods of survey.

LiDAR equipment quickly captures very detailed data by using the reflection time of rapid pulses of laser light to map a surface. LiDAR refers to a remote sensing technology that emits intense, focused beams of light and measures the time it takes for the reflections to be detected by the sensor. This information is used to compute ranges, or distances, to objects. It allows for development of precise, realistic, three-dimensional representations of roadways, railroads, bridges, and buildings.

After collection, the raw point data is processed to deliver the information in the form of contours and surfaces for use in standard design programs.

The mobile scanner offers extremely high measurement rates and provides dense, accurate, and feature-rich data at high-driving speeds.

Types Of LiDAR

LiDAR is collected from ground-based static, mobile, or aerial platforms.

- **Static (Stationary):** Ground-based, static LiDAR systems are used for close-range, high-accuracy applications, such as bridge and dam monitoring, facilities inventory, erosion mapping, and manufacturing. Ground-based LiDARs pulse at rates up to 1,000 Hz, and can map objects from two meters up to 1,000 meters away, with accuracies of millimeters to a few centimeters.
- **Mobile:** A ground-based, mobile scanner offers extremely high measurement rates and provides dense, accurate, and feature-rich data at high driving speeds. Mobile LiDAR is perfect for applications like mapping roadways and rail corridors, as well as extended urban and vacant areas. This unit provides measurements at a rate of up to 1.1 million per second, and can measure objects from 1.5 meters away with accuracy of a few millimeters.
- **Aerial:** Aerial LiDAR allows for rapid surveying over large areas with accuracy of down to five centimeters. Uses for aerial imagery, include: monitoring and managing environmental change; planning for towns; and determining optimal route location and design for major infrastructure projects. This technology can measure 10 to 80 points per square meter, and can capture hundreds of square miles in a single day.

Safety And Efficiency

Traditional means of survey only allow for an educated best guess in some instances. Safety concerns can hinder highly accurate measurements of roadways and stockpiles. Transmission lines and as-built indoor facilities are difficult to measure using traditional survey methods.

LiDAR technology allows surveyors to obtain highly-detailed information about terrain and mass in ways never before possible. The density of the gathered data set from one trip can save the need for additional survey work if plans are altered or additional information is needed.

"Traditional survey methods still have their place on many public works projects, but in certain instances, such as on high-traffic roadways when the safety of the survey crew is a factor, LiDAR provides us the ability to capture extremely detailed survey-grade information quickly while mitigating safety risks," said Herb Bailey, a project engineer at the Jefferson City-based engineering and technology firm Bartlett & West. "For example, since LiDAR works off of surface bounce-back, we have the option to scan a roadway at night if we are looking to capture the details of the roadway during a lighter traffic time. This helps keep the survey crews off the road while getting accurate measurements to take into the design program."

Highway 5 Nighttime Sidewalk Mapping

One such example of performing LiDAR work at night to minimize disruption of traffic flow and increase safety was the Missouri Department of Transportation's (MoDOT) mapping and survey of Highway 5 in Lebanon, Missouri. In November 2012, MoDOT used Bartlett & West to establish horizontal and vertical survey controls; survey utility locations; design a survey of the project corridor; and provide base mapping for the project.

With a tight time frame, unknown weather delays and a high-traffic area, the firm decided the design survey would be completed using a Terrestrial LiDAR scanner made by Riegl. The horizontal and vertical control was set with Global Positioning System (GPS) technology utilizing the MoDOT Global Positioning System Reference Station Network. Utility locations were tracked utilizing the Missouri One Call system. The utility mapping was completed using GPS technology and Robotic Total Stations. Field crews worked through the overnight hours to minimize traffic delays to the public, obstructions to the scanner, and to keep the crew out of harm's way.

MoDOT Aerial Road Mapping

Another example of MoDOT utilizing LiDAR services is a statewide aerial LiDAR program that was completed in 120 days between March and July of 2014. In this case, Bartlett & West partnered with Surveying and Mapping (SAM) of Austin, Texas, to provide aerial LiDAR services for eight Missouri Department of Transportation (MoDOT) mapping projects. The projects ranged from widening and shouldering projects to relocations, and from two-way rural projects to four-lane urban freeways. Two of the projects were in the St. Louis area, two in southeast Missouri, two in central Missouri and two in the Kansas City area.

SAM provided the aerial scan using a helicopter that was trucked rather than flown in to minimize mobilization costs. All eight projects were flown and scanned during four days in the same week. Bartlett & West's survey manager provided quality assurance controls to SAM's office in Austin that were used during calibration of the aerial data. SAM submitted the calibrated data on each project to Bartlett & West's processing team in Topeka, Kansas.

As data sets were collected, processing team members were able to extract and classify topographic features and to create a basemap complete with contours. These features were extracted from the LiDAR data using specific software.

"The benefits of using LiDAR rather than a traditional survey for these MoDOT projects include our ability to minimize human exposure to fast moving traffic; the thoroughness of the point data we are able to collect; and the accuracy of that data," said Bailey.

LiDAR can reduce costs on certain complex projects and be used to provide design-ready digital data deliverables efficiently. "LiDAR isn't the solution for every survey project," Bailey said. "Yet, when it fits, the technology really provides innovative solutions."❑

Bob Gilbert is a professional engineer and the location manager for Bartlett & West's Jefferson City, Missouri, office. He has served as project manager, quality control/quality assurance reviewer, technical advisor, and project engineer on projects ranging from storm and sanitary sewer projects, roadway and roundabout projects, and facility improvements involving pumping, lighting, and control systems throughout the surrounding communities.