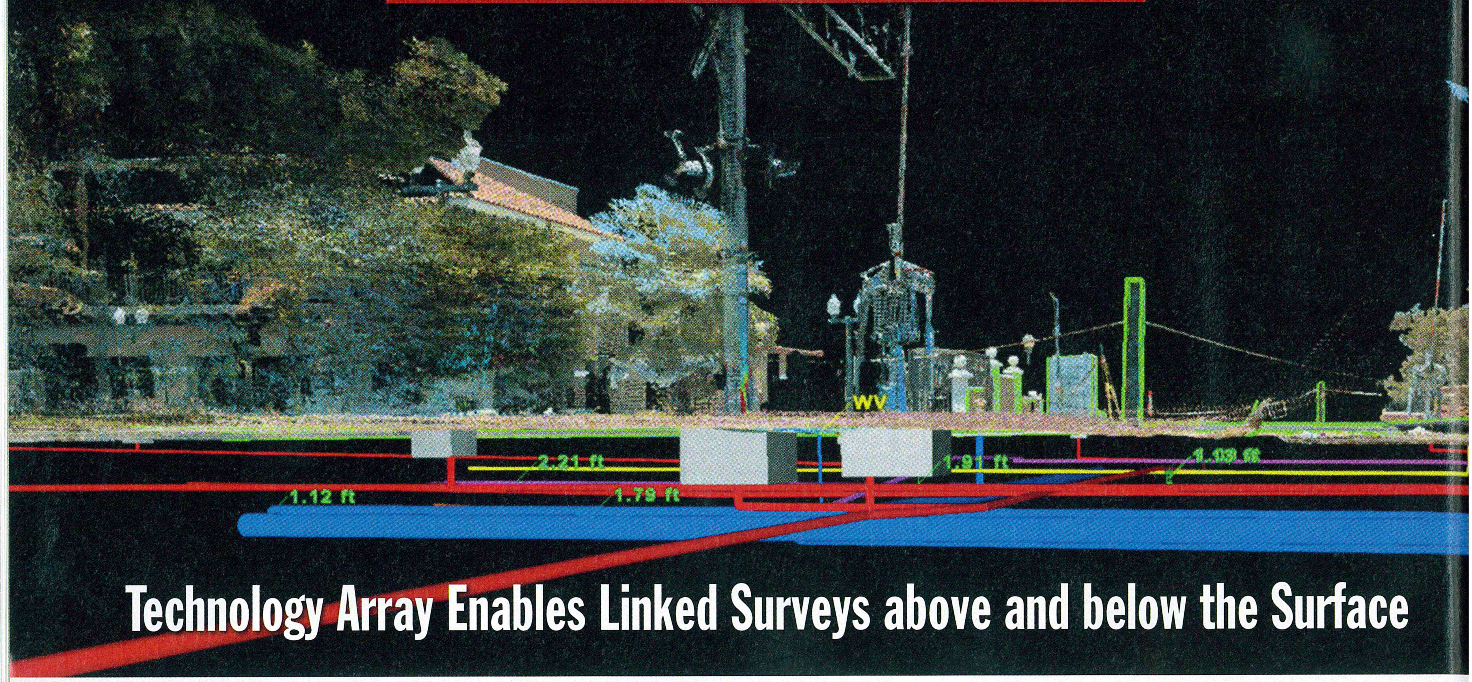


Technology Array Enables Linked Surveys above and below the Surface

COURTESY OF DAVID EVANS AND ASSOCIATES INC. AND GEL GEOPHYSICS LLC

CONSULTANTS at GEL Geophysics LLC, a geophysical and subsurface utility engineering consulting firm based in Charleston, South Carolina, in collaboration with the Ontario, California, office of David Evans and Associates Inc., a professional consulting firm, have combined existing surveying technology to create a system that is far more than a sum of its parts. The innovation is a multisensor system that performs 3-D surveys of spaces above- and belowground.

The system combines 3-D lidar, 3-D photogrammetry, and high-speed, 3-D ground-penetrating radar (GPR)—among other conventional geophysical tools—to create a comprehensive survey. The lidar and GPR tools can be deployed simultaneously to gather information by connecting them to an SUV, or can be deployed separately to gather data that are then stitched together with information that has been gathered from the additional tools.

GPR technology has been available for more than a decade, but collecting images in 3-D using traditional versions of the technology was often very slow and cumbersome, according to Matthew J. Wolf, the chief technology officer at GEL Geophysics. However, ImpulseRadar, a GPR company based in Malå, Sweden, recently developed radar capable of working much faster; its version can collect data while the vehicle it is mounted to travels at highway speeds, according to Wolf.

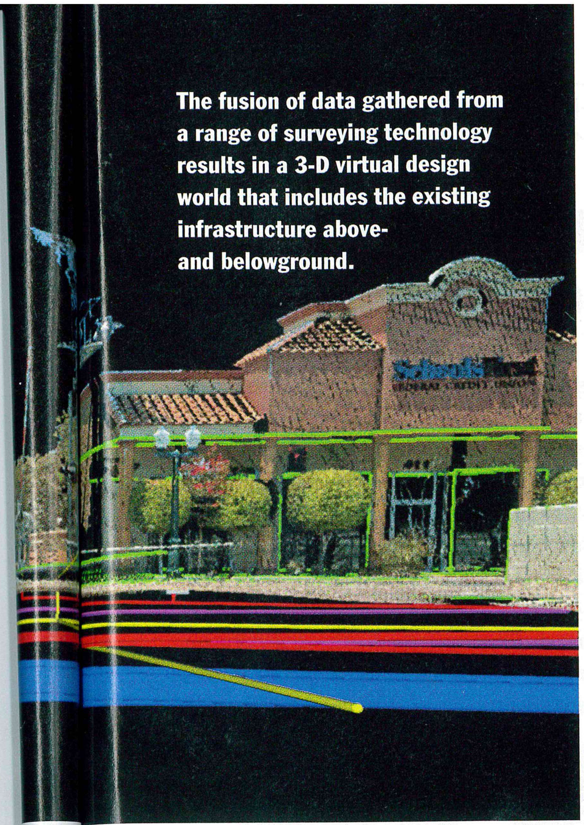
By integrating this speedy GPR system with other off-the-shelf technology, the team has created a system that can quickly create nearly complete virtual models of existing aboveground and belowground conditions. The integrated system was used to do just that in a pilot project in Redlands, California, led by Robert D. Vasquez, PLS, a professional land surveyor and business development manager at David Evans and Associates. Vasquez also coordinated the project's aboveground surveying and laser scanning.

"We are using cutting-edge instrumentations, and we are combining them and using them in a unique way," says Jorgen Bergstrom, P.Gp., a senior geophysicist in GEL Geophysics' Marietta, Georgia, office, who led the geophysical and ground-penetrating surveying on the Redlands project. Wolf adds, "I think the major coup is that Robert brought in the geomatics—the lidar scanning—[so] we can stitch that above- and belowground virtual world together. As far as I know, maybe a handful of people have actually done this in any way, and most of the examples that I've seen involve archaeological investigations. There are not a lot of people pushing it in engineering practice."

Vasquez explains: "By using 3-D lidar equipment with supplementary imagery, we were able to capture true 3-D, above-surface, as-built scans of each of the areas selected for utility mapping. Ground-painted mark-outs [showing] the positions of the underground utilities were seen in the 3-D point clouds and were extracted to georeference them to above-surface features, such as poles, pull boxes, and features that people can relate to.

"By combining 3-D point-cloud data with 3-D subsurface utility networks in a 3-D CAD [computer-aided design] environment, not only will the user know where utilities are in a horizontal and vertical position beneath the surface, they will also understand the relationship to other subsurface utilities and aboveground features and improvements," Vasquez says.

The combined technology has not only improved the quality of the site survey, it has also done so within the parameters of CI/ASCE *38-02 Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data* (ASCE, Reston, Virginia; 2002). "One thing that is really unique in the United States is that we fully integrate this type of advanced system into a standardized process," Bergstrom explains. While the standard does not currently include



The fusion of data gathered from a range of surveying technology results in a 3-D virtual design world that includes the existing infrastructure above- and belowground.

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guidance for the addition of 3-D utility designation and depiction, ASCE is well into the process of adding 3-D into the next generation of the standard, according to Wolf. That next generation standard is expected to be available late this year.

Of course, the quality of the belowground survey depends on the site's soil. Any kind of sand, gravel, or highly resistant, nonconductive soil is best, but the signal would attenuate when used on conductive clay, for example, Wolf says. He is quick to point out that even in soil that doesn't necessarily lend itself to this type of GPR, however, the system can still offer a benefit because it clearly identifies the locations of trenches, which often indicate the presence of utilities. This gives workers a good starting point for using more traditional methods, such as vacuum excavations, to explore the subsurface.

"Typical 2-D deliverables only show the location of where the engineer can expect a potential conflicting utility and [which] will necessitate vacuum excavation…under *38-02*," Wolf says. "Using [this new] technology to at least get depth-estimate information in the drawing can significantly reduce the amount of costly vacuum excavations."

The utility-mapping pilot project performed last summer proceeded quickly. "In Redlands we scanned 32 intersections in four days. There is no equivalent 2-D system or workflow that can accomplish this task," Wolf says. Using a 2-D system would have required lane closures, and each intersection could have taken up to a day to scan, he notes. In addition, the information gathered would not have provided the same density or image quality as this system did, according to Wolf.

"The biggest challenge is assimilating all these data into a workflow and synthesizing the information to upload to CAD or other software solutions for the design/project engineers to utilize in their workflow," Wolf adds. It is also important to have qualified, skilled personnel to process the complex data sets collected from the sensors and to understand their limitations.

"We're on the front end of what will probably be an avalanche in five years," Wolf says. "Everyone is going to want to see above- and belowground [in] 3-D."

A video demonstrating the concept is available at https://youtu.be/NUmiuqhrv5M.

—CATHERINE A. CARDNO, PH.D.

TECHNOLOGY BRIEFS

Cambridge Develops Overpass Sensor

OF ALL THE REASONS for traffic congestion, perhaps none is as frustrating to car drivers as a truck crashing into the deck of a bridge, especially one that is clearly marked with its height. In Durham, North Carolina, an 11 ft 8 in. high railroad trestle has been struck so many times, and sheared off the tops of so many trucks, that it has earned the nickname "the can opener." A few years ago, resident Jürgen Henn installed two video cameras to capture the incidents and established a website, 11foot8.com, to document the problem. Since then more than 4 million viewers have watched Henn's repetitious but captivating compilation videos on YouTube. In the United Kingdom, meanwhile, it is estimated that a tall truck hits a bridge every four and a half hours, costing £5,000 to £25,000 (U.S. $6,937 to $34,688) per strike. But now researchers at Cambridge University are using video cameras, computers, and "smart" roadside signs to try to prevent such incidents and catch perpetrators when prevention is unsuccessful. Bella Nguyen, Ph.D., an engineering alumnus of the university, led a team that developed a method that uses computer vision technology to detect in advance whether an approaching vehicle is at risk of hitting a bridge by comparing its height to a continuously calibrated line in the camera's plane of view. One camera is posted in each direction at the height of the bridge and paired with a roadside light-emitting diode display. When the camera detects a vehicle that it determines will be too high, it directs the sign to warn that driver specifically that he or she is at risk of hitting an upcoming bridge. And the signs can be posted far enough in advance so that they can direct the driver to a specific off-ramp and alternative route. If a bridge strike nevertheless occurs, accelerometers placed on the bridge will instruct the cameras to save the relevant portion of the video feed and transmit it to authorities. The cameras can also capture images of license plates for use in assisting law enforcement. The research on this new methodology is being conducted in a joint project with Transport for London and is funded in part by the Centre for Smart Infrastructure and Construction.

3-D Printers Build Model Cities for Wind-Tunnel Tests

BMT, AN INTERNATIONAL DESIGN, engineering, and risk management consulting firm, has developed a pair of robotic 3-D printers, called Bert and Ernie, that can turn 3-D digital models into accurate physical models for use in wind-tunnel tests. The additive manufacturing machines can operate 24 hours a day, reducing the amount of time needed to create the physical models by up to 50 percent, according to the company. The robots also offer greater flexibility, repeatability, and reliability than traditional methods, the company says. A video of Bert and Ernie in action can be seen here: https://youtu.be/WSgPA2TOhKE.