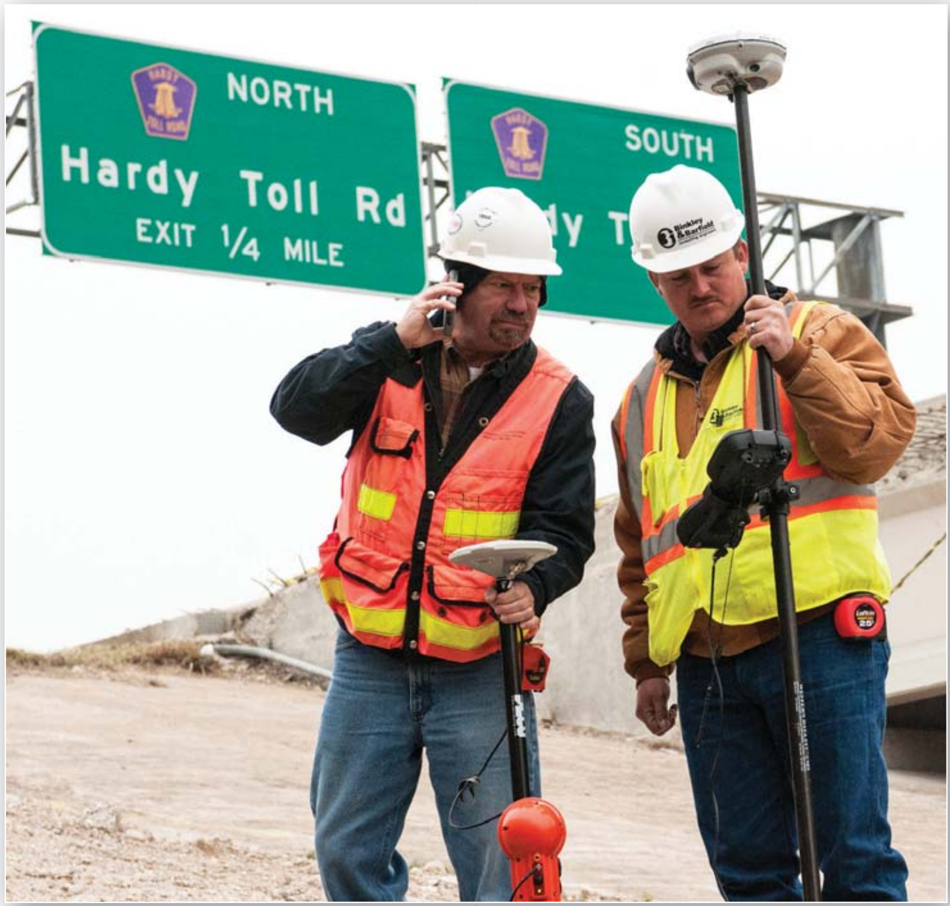
Utilizing 3D Technologies to find Subsurface Utilities

BY JOHN JAEGER

It seems that we are hearing of new technologies or new uses of existing technologies almost on a daily basis. We hear about government agencies using technologies that allow them to know where we are and predict things about us like what we will buy or where we will go. Our world has become completely flooded by technology innovation. The millennial generation has never known a time without computers. Their reality of the world is different from the rest of us. When told that a technology doesn't exist, they are completely confused and ask, "Why not?"

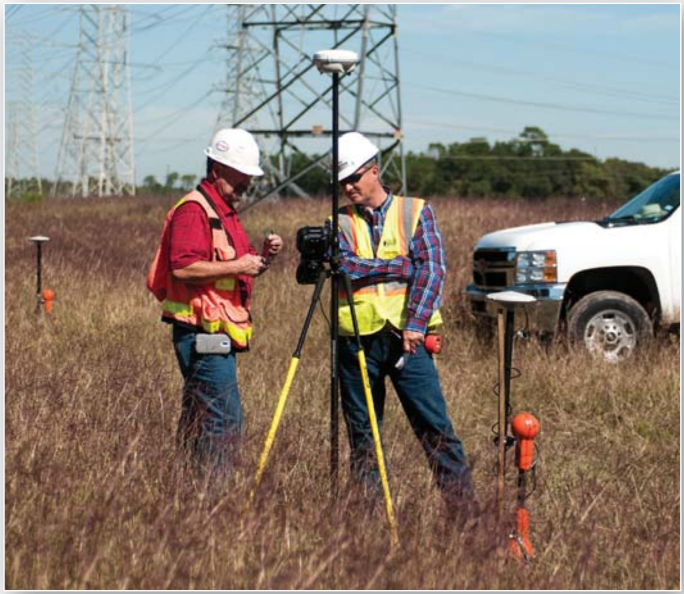
So, with all the amazing technological advancements we are all hearing about, where are the big advancements in the technology used to find the position of subsurface utilities? Over 20 years ago, the American Society of Civil Engineers (ASCE) created Standard 38-02 for Subsurface Utility Engineering (SUE) as a framework to manage risk associated with locating and identifying subsurface utilities through the Quality Level A through D System (QL-A: Test Holes, QL-B: Designation, QL-C: Surface Feature Survey, QL-D: Records Information). This has proven to be a highly beneficial methodology and has been a powerful contributor to reducing utility damage throughout the nation. Compliance with this framework has created a demand for advancements in subsurface locating equipment. The locating industry has supplied equipment that renders more accurate horizontal positioning of utilities, while the vertical positioning has remained a function of the SUE QL-A Test Hole (exposing the utility by use of a vacuum truck). With all the amazing technologies we now have, why don't we have advancements in finding the vertical position of a utility without digging it up? What technologies can be used to help us find deep utilities? What are the alternatives when a utility is not accessible to a vacuum truck or the cost of exposing the utility is economically unfeasible?

The (SUE) Group of Binkley & Barfield, Inc. (BBI), a Houston, Texas-based engineering design firm, struggled with these questions in trying to fulfill the needs of their clients. Several of their projects presented challenges of being deep, in locations that were inaccessible to vacuum trucks and economically unviable by standard methods. All of these utilities were at risk of damage due to directional drilling or other construction activities. An alternative method had to be found.



In 2013, BBI was asked to find the horizontal and vertical position of two natural gas lines that crossed perpendicular to other gas lines in an area proposed for commercial development. One of the two lines was in an area that would require building a bridge for the vacuum trucks to gain access and, economically, the utility locating wasn't feasible. After further discussions with the client, it was discovered that the data required didn't need to be the standard Test Hole accuracy of 2 cm to 4 cm. BBI proposed use of 3D Designating Technology to alleviate the access and economic issues while still rendering an accuracy well within the client's needs.

Existing utility locating technologies predominately depend on searching for peaks or nulls in an electromagnetic field by use of handheld locating equipment with two antennas mounted vertically in the equipment. This 2D technology works very well in finding the horizontal position on shallow utilities, but is ineffective and can lead to ambiguous or erroneous results on deep utilities or when detecting the precise location of the peak signal is difficult. In contrast, the technology used to locate a cell phone is done by triangulation of multiple cell towers. GPS also works by triangulation of multiple satellites. This is 3D technology and it can solve the issue of accurately establishing the depth of a utility.

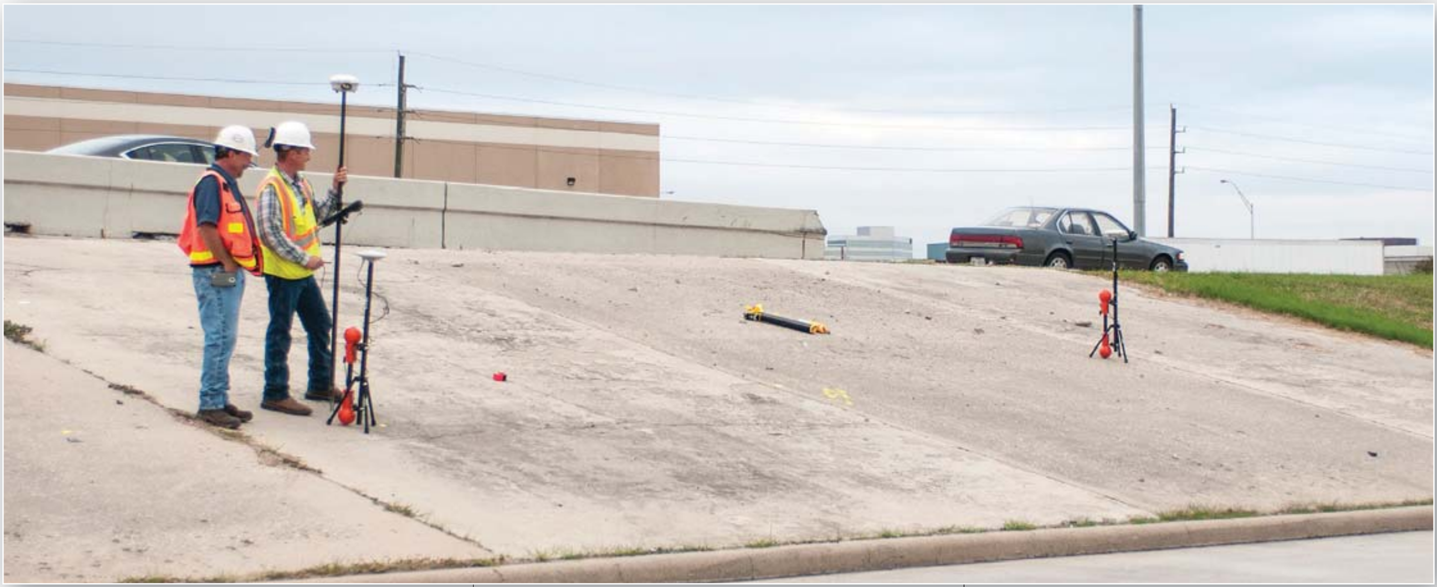


Optimal Ranging, Inc. (ORI), of Santa Clara, California, manufactures geospatial utility surveying equipment that provides highly accurate utility location and survey. The equipment is operated using Trimble Access controllers and running a Trimble-supplied application called Utility Survey. BBI selected ORI's Dual Spar Model-Based Technology System for its ability to 3D render highly accurate X, Y, and Z locations of deep utilities without excavation or line incursion. With this technology, a utility can be accurately positioned without the equipment being placed directly above it, or at any other special location. Vegetation, water, or other obstructions over the utility path do not interfere with accurate positioning of the utility. This type of system is better able to characterize the expected circular model of the magnetic field arising from a current applied to deep and directionally bored lines. The method uses simultaneous field measurements from both spars and is a generalization of the simple ratio measurement that handheld locating tools make at the peak signal (top of the circle). An advantage of this new approach is that the accuracy of the estimates (statistical confidence) is computed based on the non-circularity of the measured field. In comparison, standard locating equipment (2D equipment) relies on a simple ratio measure-

ment and cannot provide error estimates with the 3D position.

While most state laws require a call to 811 prior to any excavation, since the Spar equipment does not disturb the ground, BBI was able to immediately start work without the need to make the call or wait the required time. The setup process involved connecting a low frequency (98 Hz), high output transmitter directly to the gas line test station. The Base and Rover Spar units were then placed perpendicular to the gas line, with spacing determined by the anticipated gas line depth, using an approximate geometry that would render an equilateral triangle enclosing all three points (Base Spar, Gas Line and Rover Spar). After turning on the Spar units, achieving satellite lock and connection to the Trimble VRS System on the Trimble Data Collector, the gas line and its orientation appeared on the screen along with the signal strength and confidence level of the data. Geospatial data collection of ground level, offset location, utility location and utility depth were obtained by simply pushing a button. The gas line data was collected at eight- to ten-foot intervals to ensure a smooth profile, and then the transmitter was removed from the test station and reconnected to another test station on the other side of the area to be designated (designating from two directions – Best Practices). The two gas lines were completed in less than four hours and did not require any surface restoration or probing (or building a bridge). The resulting horizontal and vertical positioning from the data matched the gas utility location information and was delivered much faster and at a much lower cost than QL-A Test Hole excavation.

The success of this project led to a request to locate an Enterprise gas line reported to be 35 feet deep. Enterprise's efforts to locate this line with a variety of 2D handheld locating equipment and excavating 35-foot deep Test Holes, had been ongoing for more than a month and substantial money had been spent without any success. With the use of the Dual Spar Technology, the gas line was designated in less than two hours and shown to be at a depth of 33.5±1.2 feet. The gas line was immediately exposed by use of hydro-excavation, at the locations the Dual Spar System indicated, and surveyed



at a depth of 34.1 feet (an eight-inch difference between the exposed depth and the remote sensing depth, and within the reported error).

On that same day, BBI was then asked to go to another Enterprise gas line location and use the Dual Spar Technology to locate two gas lines crossing under a major freeway. These gas lines had proven to be un-locatable by standard methods due to interference from electric transmission towers. Both of these pipelines were to be crossed by a directional bore. Knowing the horizontal and vertical locations of these lines to complete the design of the directional bore was critical.

Again, the Dual Spar System quickly collected the X, Y, and Z data on the two gas lines and work was completed within four hours. The collected data showed the gas line depths to be 16.1±0.9 and 15.4±0.8 feet deep at the crossing of the directional bore. With this new information, Enterprise requested a QL-A Test Hole on each gas line at the proposed crossing of the directional bore. The Test Holes were excavated at the locations the Dual Spar indicated and the depths were at 16.8 and 15.8 feet deep (nine inches and five inches difference, and within the confidence intervals reported by the software).

Successfully establishing the horizontal and vertical position of utilities in a single day, that previously had not been found after months of work, led Enterprise to request designation on a deep pipeline locating project that had been ongoing for approximately one year. Bridge improvements on a major freeway required drilling 60-foot piers. In the area of the proposed piers was an existing eight-inch gas pipeline running diagonally, and reported to be 48 feet deep, threading the needle between the proposed bridge piers. There had been numerous unsuccessful designation attempts over a period of a year, including digging a 60-inch diameter by 50-foot deep Test Hole. Not knowing the exact location of the gas line had become an issue and was endangering the project schedule of the roadway. A smart pig had been used to give an approximate location of the gas line and showed the proposed pier locations to be within eight feet. Enterprise wanted additional verification of the gas line location and, due to the depth, there wasn't adequate time to perform another Test Hole excavation.

During field investigations, BBI found substantial utilities at varying depths, crossing and running parallel to the gas line. Direct connection via a Test Station was successful and the transmitted signal could be picked up through the area of interest, but traveling beyond, it stopped at an electric tower. Direct connection to a Test Station on the other side of the project was successful, but the signal again stopped at the same electric tower (which was now between the test station and the area of interest). Unlike the other projects, this forced use of a single direction in performing the designation. During data collection, it was noted that the Dual Spar was showing that many locations did not have a good confidence level due to the presence of other utilities in the same right-of-way. This required adjusting the locations of both the Base and Rover Spars, and the separation between spars. Other challenges involved the existing highway overpass shadowing the GNSS satellite signals from the Spar units, which require GPS time synchronization in Dual-Spar mode. This was quickly solved by placing "Spar points" with a total robotic station and pole-mounted prism and manually entering them into the Data Collector. All the collected data was processed to render an output in the coordinate system used by the bridge designers and the smart pig. The resulting line very closely followed the smart pig and showed that the 50-foot Test Hole had only missed exposing the gas line by a few feet. From mobilization to the site, collection of and processing data, to issuing a report, took three working days.

Completion of this work marked the successful horizontal and vertical designation of three pipelines in two troubled roadway areas that were greatly affecting major highway projects. This caused the Texas Department of Transportation (TxDOT) to request designation on one of their projects to find a Quest Fiber Optic Line reported to be 21-26 feet deep. Previous months of locating attempts by TxDOT, and even excavation by trenching, had failed to find the line. Again, the project schedule was in danger.

A field investigation revealed that the Fiber Optic Line had been directionally drilled and the area of interest was along an 18-foot retaining wall and three lanes over was a bridge. It was like being in a narrow canyon. Traffic from the freeway exited down the three lanes and didn't allow for much room to work. Many utilities crossed in the area and high voltage lines were above the 18-foot retaining wall. To overcome the challenges of the canyon effect, antennas were used on the Dual Spars and Data Collector. This type of antenna utilizes technologies that will pick up reflected GPS satellite signals. The Dual Spars work in frequencies that are unaffected by the high voltage lines and positioning of each Spar can be adjusted to avoid interference with crossing utilities. Since the setup and data collection time of the Dual Spar is very fast, BBI was able to work within the traffic without causing delays or backups. This work was performed from two directions (Best Practices) over a 1,000 foot area and produced a smooth profile of the horizontal and vertical position of the Quest Fiber Optic line. In the area of interest, the line was found to be 23.5±0.8 feet deep. This work took one day in the field. In the area of interest, TxDOT ordered a Test Hole to be performed on the location designated by the Spar. The Quest Line was found to be at 23.75 feet (three-inch difference, and within the confidence intervals reported by the software).

The 3D technology of the Dual Spar is greatly in keeping with what all of us have come to expect from today's technology. This technology is safe, economical, and a convenient way to find both the horizontal and vertical location of utilities. It can also be used in places where excavation is not feasible or economically practical. The Dual Spar reports geospatial elevations of the targeted utility and renders vertical accuracy which has not been previously realized by existing electromagnetic 2D locating equipment. Should this be considered a replacement for performing Test Holes, which can cost thousands of dollars (or much more, depending on depth)? Where some variation in the location is acceptable, the answer is "yes." For those occasions where absolute location is necessary, the answer is "perhaps not." At a minimum, the reported horizontal and vertical accuracy of a Dual Spar measurement can help determine where Test Holes are required. There will always be times where nothing but exposing a utility will satisfy the project requirements, so Test Hole utility elevation determination will remain a key component of the Subsurface Utility Engineering. But in situations similar to those presented here, Dual Spar 3D technology represents a more economical alternative when managing SUE risk. DP

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