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An Ellingson Companies surveyor works on an underground utility line.

ALIGNING BRICKS AND MODELS

Surveying is both an ancient profession and one of today's most technologically advanced. Surveyors are among the first on the site of a new construction project, staking out its corners and boundaries, and mapping elevation contours, as well as among the last, surveying the project "as built." This is particularly important for features that will no longer be visible once the project is complete, such as underground utilities.

While many surveyors work in quiet, uncrowded environments — such as surveying the boundaries of farm fields — those who work on large construction projects operate among the hustle and bustle of bricklayers, carpenters, electricians, plumbers and other tradespeople, as well as cranes, backhoes and other heavy machines. This chaotic environment means that in addition to accuracy and efficiency, surveyors also are concerned with safety.

In this month's cover story, a Minnesota-based construction company describes a new system it developed for surveying and mapping underground utilities. Also, professional surveyor Gavin Schrock discusses the benefits of a flexible approach to GNSS rover accuracy and of adding scanning capabilities to robotic total stations.

A New Way to Map New Pipes

BY MATTEO LUCCIO, EDITOR-IN-CHIEF

The danger of hitting a buried water or gas pipe when digging for a construction project persists despite many efforts to reduce it, such as "call before you dig" phone numbers. For example, in Minnesota there were 4,000 such hits in 2019. That is one reason why it is very important to map "as built" underground utilities accurately. This must be done quickly and efficiently, before trenches are filled and without slowing progress of the project.

Traditionally, crews have mapped the underground pipes and cables on paper. In turn, when a construction project needs to know the location of underground utilities before digging, it typically relies on someone who consults those paper maps, uses an electromagnetic utility locating tool, and marks the ground with spray paint. The construction crew then must correctly interpret those marks on the ground. In 2019, Minnesota-based utility consultancy Ellingson Companies was asked to develop a new and more efficient process.

> "Construction crews are expected to produce a digital record of their work in real time."

Capturing Data in Real Time. By leveraging solutions from Esri and from Canadian hardware and software manufacturer Eos Positioning Systems, Ellingson Companies GIS Manager Damon Nelton developed a solution that allows his team to capture new pipe construction in real time. By streamlining documentation workflows, the new process improved field productivity and allowed Ellingson Companies to produce digital as-builts that meet the needs of its gas utility clients and improve the safety of future construction projects.

While construction crews have been putting pipe in the ground for generations, today they are expected to produce a digital record of their work in real time — for the sake of safety and efficiency.

Using Esri's Utility Pipeline Data Model, Nelton created a system that enables crews to map their as-built pipe projects while also tracking components. The system improves data integrity — in other words, reduces human error — by relying on scannable 16-digit alphanumeric bar codes developed by the American Society for Testing and Materials that provide seven attributes for each conduit, including thickness, diameter, lot number and manufacturer date. To collect and store these data, Nelton set up an ArcGIS Enterprise geodatabase.

Gas meters, which also need to be mapped, are often in locations that are hard to map directly with a GNSS receiver because line-of-sight to the satellites is obstructed by trees, roof eves, or adjacent buildings. Therefore, they must be shot with an offset. For these situations, Nelton used Eos Positioning Systems' laser mapping solution, which enables surveyors to use lasers attached to their range poles to feed data directly into their GIS.

No More Battleship. Using Eos Positioning System's Arrow Gold receiver and the MNCoors RTK network, Nelton said, his team was able to average an accuracy of 0.25 throughout a project in the city of Owatonna, Minnesota, as confirmed by spot checks with other survey equipment and with the city's survey team. "Not every shot was easy, and some took multiple attempts and tricks of the trade to get them," Nelton pointed out.

On projects in the middle of mountains, where real-time kinematic (RTK) networks do not exist, the company has used the Atlas Service, averaging accuracies of 12 in. "Given the circumstances of these projects," Nelton said, "we still consider that to be great."

Using the new system, foremen use a survey in ArcGIS Survey123 to input their inspection notes and other information, feeding it all from the field to the office and into layers shared between divisions. This way, the data are available in real time, not at the end of the project. For customers who still want a piece of paper to file in a physical folder in a filing cabinet, Nelton creates a Microsoft Word document template in their format, populates it using dynamic text with syntax in ArcGIS Pro, inserts a map, then saves the Word document as a PDF.

"At the end of the project, we got almost 17,000 digits with no human entry other than pressing the button on the barcode scanner, which means zero data errors," said Nelton. No pieces of paper with critical data on the underground utilities languish in a glove compartment or are eaten by a surveyor's dog, and all the data is available in real time.

Additionally, the combination of the barcode scanning workflow and the high accuracy GNSS receiver enables Nelton's team to locate gas asset pieces that need to be replaced — for example, due to a recall by the manufacturer — "without playing battleship," he said.