MDT R01B
SHRP2 CASE STUDY

Better Managing Utility Conflicts in Michigan through the SHRP2 Solution:
Utility Locating Technologies (R01B)

Photos courtesy: Leif Skoogfors, FEMA; Gas Technology Institute; District DOT; FHWA

Combining Utility Locating Technologies
Montana Department of Transportation Case Study

Product Information

Subsurface utility engineers and geophysical service providers need the ability to detect, locate, and characterize subsurface utilities but face numerous challenges in doing so. Underground utilities can be made from many different types of materials and can be located at random depths in soil conditions ranging from silty clay to sandy loam. Because of this constantly changing pattern of interference, it may take several different technologies to locate and identify unknown utilities.

The best overall practice is to employ multiple types of geophysical technologies, deployed in multiple channel modes when possible. Using digital geophysical mapping in conjunction with common pipe and cable locating tools enhances utility detection and data interpretation. This combined approach produces more complete mapping and supports a more targeted and less expensive test hole program. Limitations in the technologies indicate that careful considerations need to be taken regarding soil type, the terrain, and other geophysical attributes to determine which technologies of a multi-sensor system will be most effective for each applicant's implementation.

As part of *Utility Locating Technologies* (R01B), the second Strategic Highway Research Program (SHRP2) identified two advanced utility identification technologies to help transportation agencies obtain more detailed information about subsurface conditions, position and depth of the target utilities. The first is Multi-Channel Ground Penetrating Radar (MCGPR), which consists of deploying a commercially available multiple antenna and/or multiple frequency radar system capable of illuminating targets (i.e., utilities) due to the increased system width, antenna array and frequency range. Because the MCGPR data are synchronized with very accurate GPS, these advanced systems produce results in three-dimensional (3D) volume images of the area(s) investigated. MCGPR results provide accurate positioning of the utilities, as well as a reliable depth to the utility with the goal to achieve Quality Level-B utility locates. Since it is well documented that the GPR technology does not work well in clay-rich soils, another technology was identified by the research to be applicable for SHRP2 implementation. The second technology is Time Domain Electromagnetic Induction (TDEMI), which involves deploying an array of electromagnetic coils which are highly sensitive metal (ferrous or nonferrous metals) detectors that provide digital plan-view mapping of metallic utilities. TDEMI is unaffected by clay-rich soils; however, it cannot detect non-metallic utilities without a tracer wire (e.g., PVC or HDPE). Similar to MCGPR, TEDMI systems are commercially available and can be used in narrow or lane-with mode configurations for flexibility to survey roadways or less-accessible right-of-way areas. TDEMI results are presented in 2D plan view maps, and do not provide insights to the depth of buried utilities. These two technologies were deployed on selected state agency projects as part of the FHWA/AASHTO Implementation Assistance Program.

MDT Project Implementation

The Montana Department of Transportation (MDT) received SHRP2 Utility Bundle funding, including 3D Utility

Location Data Repository (R01A), Utility Locating Technologies (R01B), and Identifying and Managing Utility Conflicts (R15B). MDT has on-call consultants under contract to provide subsurface utility engineering (SUE) services throughout the state as part of its two-phase preconstruction program. Phase I SUE uses non-invasive conventional techniques and Phase II SUE involves vacuum excavations. MDT's long-term goal is to combine this conventional SUE data with data provided by the R01B technologies and other techniques like LiDAR and SPAR in a data repository to generate 3D models of utilities.

MDT applied utility bundle funding to develop and refine effective, systematic means and methods for collecting, organizing, analyzing, and managing utility infrastructure within the right of way (ROW). The funds were also used to improve digital methods for managing and inspecting utility ROWs, anticipating in particular, an influx of fiber optic installations.

The goals of the MDT R01B project were to:

- Develop a comprehensive utility management solution which includes a 3D digital utility database for systematic and standardized collection, uploading and storing of information about utilities within MDT's ROW.
- Implement the R01B advanced geophysical technologies and methods to rediscover and 3D map existing buried infrastructure.
- Implement systematic conflict analytical methods and engineering procedures that enable MDT staff, consultants, and contractors to fully leverage utility infrastructure information for planning, coordination, design, construction, operations, and maintenance.

Setting this system in place will reduce duplication of effort, mitigate rediscovery costs, enable better coordination between MDT and stakeholders, reduce utility relocation costs, reduce risk and contingency costs, enhance damage prevention, and improve worker and public safety within MDT ROWs.

Project Summary

MDT used the R01B funds to conduct MCGPR and TDEMI surveying on the Custer Avenue project in Helena Montana to determine project typical section and alignment. MDT also obtained data using conventional SUE methods and LiDAR survey data in order to calibrate the MCGPR and TDEMI results, and to obtain a full picture of potential utility-related impacts. Custer Avenue is a 1.6-mile urban reconstruction project currently in the early concept design phase.

Because the Custer Avenue project had not advanced beyond the early survey phase, existing utility information beyond one-call marks was not initially available. MDT augmented the SHRP2 funds with regular project funds to accelerate Phase I SUE efforts by obtaining utility data with conventional methods earlier than normal. From a timing perspective, the data obtained using R01B methods were gathered far enough in advance to allow data-processing work to occur without a tight deadline. The data took around 2-3 weeks to process and several more weeks to generate a 3D model. Processing time is a key consideration for future uses of the technologies, as many projects may require useable data and/or 3D models to be delivered in a matter of days. The consultants responsible for data processing indicated that there is a learning curve associated with the processing efforts, so processing time would be expected to decrease on future projects.

While MDT used the R01B technologies very early on this project, these technologies and other innovative methods can be used at any point throughout project development from project conception through construction assuming the limitations of these technologies are considered. This concept fits in with MDT's goal of obtaining and retaining utility data using the data repository (ULDR) throughout the lifecycle of highway projects. Figure 1 shows MDT's preconstruction utility activities (blue boxes) along with utility data typically available as MDT project design progresses.

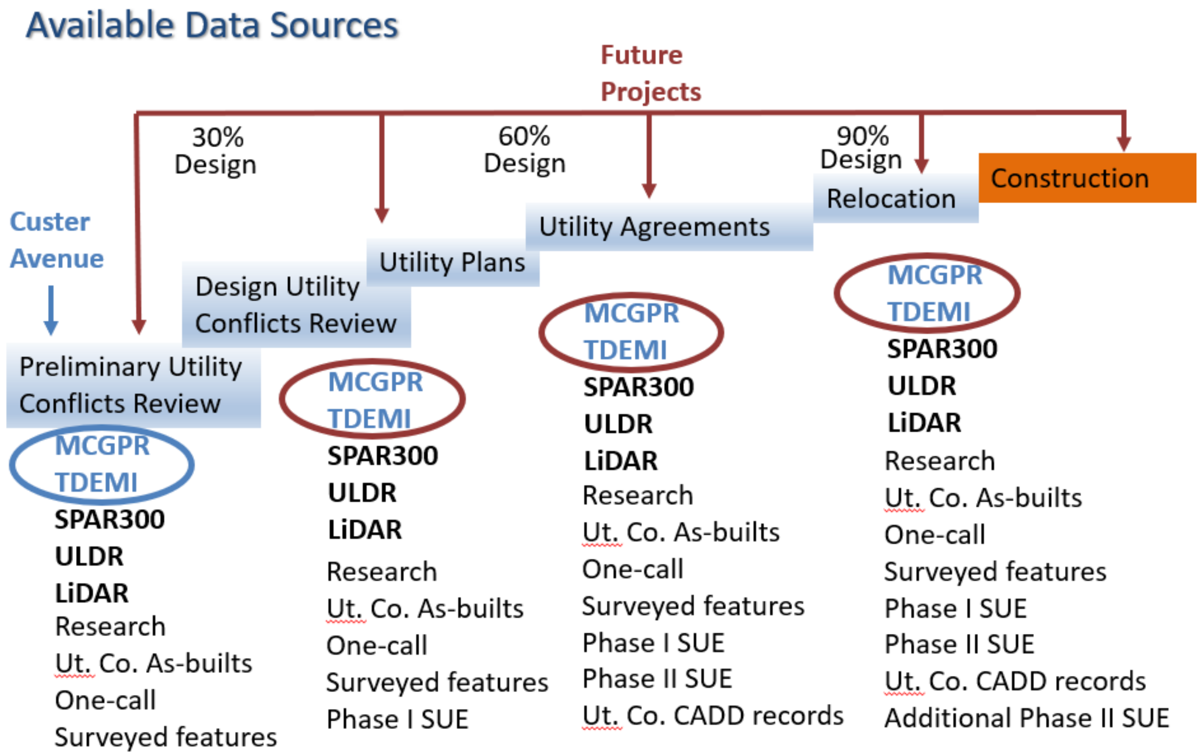

Figure 1. Preconstruction Utility Activities

Results of Technology Evaluations

The results of TDEMI indicated 352 anomalies not associated with the Phase I SUE utility data; these can be further broken down into 172 total new features including linear and point features that are not surface features or other known features but may be further investigated as design advances. The results also correlated well with known metallic features such as the Yellowstone Gas Pipeline. The TDEMI data allowed MDT to map traffic signal detection loops and related subsurface communications and power cabling, paved over or covered manhole lids and valves, and metallic pipes.

The MCGPR results identified 617 anomalies not associated with the Phase I SUE; these can be further broken down into 84 total new features including linear and point features that are not surface features or other known features but may be further investigated as design advances. MCGPR was effective in identifying certain apparent utility crossings that would otherwise have been missed; for instance, the MCGPR captured the dipping vertical alignment of a pipe or cable that had been bored under Custer Avenue. The MCGPR also identified pavement distress and cracking.

Lessons Learned

- The TDEMI trailer's length and low clearance limited its ability to detect areas constrained by fences and other topographic barriers. The inability for TDEMI to provide depth information is significant limitation for the technology to include the results in 3D.
- The MCGPR consistently did not detect the 10-inch, steel, high-pressure, Yellowstone Gas Pipeline which may have been a result of the soil composition and the depth of the pipeline. The lesson learned was that saturated soils play a role in being unable to obtain useful MCGPR data on the east end of the project.
- The number of anomalies identified with the R01B technologies is both a benefit and a potential challenge, as deciphering which anomalies require additional investigation took substantial time. This may result in increased costs for unknown returns on investment.
- In terms of scoping of future MCGPR investigation efforts, having the same vendor conduct the MCGPR and complete test holes for calibration will allow for more accurate and timely calibration at some locations. On this MDT project, the vendor was able to derive radar-wave velocity adjustments from nearby data, but test holes were not available in the exact calibration locations in some instances.

- TDEMI and MCGPR methods provide an assortment of information by identifying unknowns and other infrastructure not collected during the Phase I SUE investigation. It is anticipated the MCGPR will provide sufficient 3D data to create or substantially augment a 3D model of the existing infrastructure at certain locations.
- In addition to being successful at identifying anomalies discussed above, the R01B workshop exposed a variety of MDT staff disciplines, including Utilities Section to these new tools in MDTs subsurface characterization toolbox.

Next Steps

MDT will continue to explore the anomalies identified using the R01B technologies and will likely conduct Phase II SUE to positively identify what is producing them. They will continue to develop the 3D model to ensure that as the Open Roads 3D designs advance, the data can continue to provide a basis for design decisions. One of the most relevant uses of the data is expected to occur during the hydraulic design. If MDT can avoid relocating the Yellowstone Gas Pipeline, a cost savings of up to $6 million may be realized.

MDT’s work showed both technologies are useful on certain projects with the right types of soils, topography, and scope; however, regardless of variables, R01B tools should be used in conjunction with other standard SUE methods and instruments.

Time Domain Electromagnetic Induction (TDEMI) instrumentation used during the SHRP2 R01B Utility Locating Technology program for the MDT Custer Avenue project. Shown here is a towed-array of three Geonics EM61-MK2A geophysical instruments mounted on a single trailer, with RTK GPS mounted for centimeter positional accuracy of data. In this configuration the EM61-MK2A remains a single transmitter and receiver coil electromagnetic *system; however, it is slaved with multiple systems (i.e., three independent transmitter-receiver coils) to create a lane-width TDEMI utility mapping array. This trailer array gets towed at 4-5 mph and is used for high-precision mapping of metallic utilities. (Photo courtesy of P. Sirles).*

Time Domain Electromagnetic Induction (TDEMI) instrumentation used during the SHRP2 R01B Utility Locating Technology program for the MDT Custer Avenue project. Shown here is the tow-vehicle and towed-array geophysical instrumentation, with RTK GPS mounted for centimeter positional accuracy of data. This towed configuration of Geonics EM61-MK2A single transmitter and receiver coil systems has three slaved independent transmitter-receiver coils to create a lane-width TDEMI utility mapping array. (Photo courtesy of MDT).

Multi-Channel Ground Penetrating Radar (MCGPR) instrumentation used during the SHRP2 R01B Utility Locating Technology Program for the MDT Custer Avenue Project. Shown here is the tow vehicle and towed MCGPR instrument, the IDS GeoRadar Stream-C system. The Stream-C is a *compact manually-pushed or vehicle-towed GPR system with 34 dual-polarity 600 MHz antennas, all tied to RTK GPS for centimeter grade data positioning. The Stream-C can be towed at approximately 3 mps, and covers a swath width of 47 inches (3.9 feet). (Photo courtesy of MDT).*

For more Information:

To learn more about Montana's use of *Utility Locating Technologies* (R01B), contact Gabe Priebe, MDT Utilities Engineering Manager, MDT at gpriebe@mt.gov.

To learn more about SHRP2 and the *Utility Locating Technologies* product, contact Julie Johnston, Utility & Value Engineering Program Manager, FHWA at Julie.Johnston@dot.gov.

AASHTO SHRP2 Website: http://shrp2.transportation.org/Pages/UtilityRelatedProducts.aspx
AASHTO's product page offers case studies, training modules, presentations, factsheets, guidance documents, and a list of other states implementing the SHRP2 utility products.