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Field Trial Results of a 14-channel GPR Integrated with a U.S. Program for 3-D Utility Mapping

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Existing underground utilities continue to be a leading cause of highway construction delay claims in the United States. Although 80-90% of existing utilities can typically be discovered and mapped using a wide range of geophysical tools, there is a recognizable need to improve the process. Existing shortcomings to the utility mapping process include a lack of viable depth attributes, long field occupation times, low experience level of the field technicians, and separate survey / geophysics functions. The U.S. National Academies and its Transportation Research Board recently concluded a project on alleviating the existing utility mapping shortcomings through the development of enhanced GPR. An existing commercial 400MHz 14-channel towed array was enhanced with positioning and interpretation hardware and software over a 3-year US$ 2M program. Field trials for effectiveness were conducted in a city suburb commercialized environment where the relative permittivity values averaged 9.4.

The effectiveness of enhanced GPR was compared to traditional utility mapping techniques (Single Channel GPR, FDEM, Acoustic, Sondes, Gradiometric Magnetometers) during the project. The project area utilities included natural gas, water, electric, telephone, cable, storm, sanitary, traffic control, and several unknown function lines. Depths for these utilities were mostly unknown. 81% of known (from records and field appurtenance visual observation) utilities were detected via traditional geophysical means. These traditional geophysical means also detected 14% additional and previously "unknown" utilities.

The enhanced GPR detected approximately 40% of the known and unknown utilities, and found an additional 6% of utilities that were previously undetected. These additional utilities were subsequently determined to be small diameter abandoned water and gas systems in very poor and broken condition. Although it did well with metallic water and gas lines, communication and electric utilities were mostly undetectable. Through a ground-truthing program of test holes to expose utilities, the depth values derived from the enhanced GPR were fairly consistent and within 15 cm of actual depth. The incomplete underground picture determined by the enhanced GPR reinforces previous studies that show that the mapping of existing underground utilities is a multi-tool effort that takes highly trained and skilled field technicians and data interpreters. The addition of a new GPR tool is valuable in determining continuous depth profiles of imaged utilities. A second and significant benefit is the interpretation of other geotechnical data that benefit project designers. This might include showing geometry, location, intensity, and depths of either areas of anomalies, or of known structures, such as paving thickness, substrate thickness, voids, water table, soil lenses, boulders, bedrock, and so forth.

The Florida Department of Transportation has decided to take advantage of this new technology and has entered into an experimental contract with Cardno TBE to incorporate several enhanced GPR arrays with traditional utility detection tools. The goal of this contract will be to provide a 3-D model of existing underground utilities for use in automated construction. The GPR 3-D data model will be melded with conventional subsurface utility engineering and mapping practices and will be required to follow the ASCE 38 standard for utility data reliability.