Trenchless Technology Center Newsletter

JUNE 2011

Advanced Electromagnetic Research and Testing Facility to Support the Development of Cutting Edge Sensors for Trenchless Applications

In January 2010 the Trenchless Technology Center (TTC) and the Center for Applied Physics Studies (CAPS) at the Louisiana Tech University were awarded $385,000 by the National Science Foundation (NSF) under NSF's 'Major Research Instruments' program to establish a multi-disciplinary research and testing facility capable of supporting cutting-edge fundamental and applied research.

Specifically, the facility is designed to support conceptual design, fabrication and testing of advanced electromagnetic (EM) sensors for applications related to mechanical damage prevention, conditions assessment and robotic-assisted rehabilitation of buried structures. The facility includes an electromagnetic characterization lab, a PCB design and fabrication lab and one of the largest anechoic chambers in a public university in the southern part of the United States, and it's staffed by full-time technicians and research engineers. The facility provides unique opportunity for researchers in the trenchless industry to design novel electromagnetic sensor technologies and take them through the various stages of development required to successfully convert them into market-ready products. In addition, the facility provides a platform to conduct testing of existing products under realistic and controlled environments in support of technology enhancement or pre-certification. Table 1 lists the capabilities offered by the facility in support of typical phases in a sensor technology development project.

The anechoic chamber (20 ft x 20 ft x 10 ft) houses a below-grade soil chamber for studying the interaction among geological materials, mechanical equipment and electromagnetic sensors under various conditions. The anechoic chamber also includes a customizable antenna testing table with 250 lbs capacity, allowing mounting the sensor along with its mechanical housing (e.g., drill mounted 'see-ahead' sensor for HDD applications) on to the table, where it can be rotated 360 degrees for measuring radiation patterns, gain and directivity. The anechoic chamber also provides the opportunity for commercial vendors to conduct preliminary radiation tests mandated by the Federal Communications Commission (FCC) in a cost-effective manner.

The laboratory is home to state-of-the-art instruments, including vector network analyzer (up to 65 GHz), spectrum analyzer (up to 20 GHz), high-speed oscilloscopes (up to 50 GHz), time domain reflectometer (TDR), impedance analyzer, pulse generators capable of producing ultra-short impulses with duration ranging from several nano-seconds to as low as 65 pico-seconds and more. Variety of sensor applications operating at different frequencies such as a capacitive sensor (few kHz to several MHz) for moisture measurement, through

Typical stages of EM sensor technology development	Available Facilities/Capabilities
Numerical design	• Custom developed numerical codes • Simulation software packages • Multi-processor supercomputing cluster for large scale simulations
Prototype fabrication	• PCB circuit and board layout design • Multi-layer microwave board fabrication • Semi-automatic pick and place system for populating PCB boards • Reflow soldering oven and multi-layer board press
Design validation	• Anritsu Vector Network Analyzer (up to 65 GHz) • Tektronix sampling oscilloscope with TDR (up to 50 GHz) • Tektronix real time oscilloscope (up to 6 GHz) • Spectrum analyzer (up to 20 GHz) • LCR impedance tester (up t o 2 MHz) • Pulse generators (65 pico seconds to several nano seconds) • Probes to measurement of dielectric properties of materials such as soil formation, concrete and asphalt cement
Full scale testing	Soil chamber (20' x 20' x 11' tall) for controlled tests; Three acres outdoor test site for full scale testing
Pre-FCC emission testing	Custom designed anechoic chamber (20' x 20' x 10' tall) with soil chamber for studying multi-path interaction of EM sensors with geological materials and mechanical equipment

ultra-high frequency 'see through-surfaces' imaging system (several GHz) to cutting edge millimeter wave sensors (up to 65 GHz) for studying sub-millimeter surface cracks in high pressure natural gas lines can be developed and tested. To interpret the data collected, it is often necessary to know key material properties such as dielectric constant and electrical conductivity. A coaxial waveguide setup coupled with the vector network analyzer is available for measuring the complex permittivity of geological materials, concretes/grouts and asphalt cements for frequencies of up to 6 GHz.

A full-fledged, rapid printed circuit board (PCB) prototyping facility allows designing, fabricating and optimizing the layout of PCBs 'in-house' at greatly reduced turn-around time and costs, greatly accelerating the development of pre-commercial prototypes. A circuit board plotter with automatic tool changer capable of fabricating circuits with resolution of 0.5µm on microwave substrates, a semi-automatic pick-and-place system for populating PCB boards with tiny surface mount components, a multi-layer board press and a programmable reflow soldering oven are available. The experimental setup is supported by computer workstations running design software packages and a Linux based supercomputing cluster for performing large scale numerical simulations, including wave propagation studies (both acoustic and electromagnetic), microwave circuit design, antenna modeling and multiphysics modeling.

We hope that this state-of-the-art, exciting research facility will provide the academic community and practitioners across the trenchless industry with new tools and capabilities, inspiring the development of innovative sensor technologies for tackling the complex challenges facing the trenchless industry. We would like to thank our esteem external collaborators on this project: Dr. Chris Rodgers (Univ. of Birmingham, U.K), Dr. Samuel Ariaratnam and Dr. Jason Lueke (Arizona State Univ.), Roland Waniek (IKT, Germany), Dr. Dulcy Abraham (Purdue Univ.), Dr. Assaf Klar (Technion, Israel) and Dr. Ramalingam Radha (Prairie View A&M Univ.) .

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Trenchless Technology Industry Reaches Out to LaTech Students

The TTC has completed a highly successful year not only with our research program, our industry outreach through Municipal Forums, but with the undergraduate students at Louisiana Technical University. The LaTech Student Chapters of the AGC and the NASTT combined together to act as a single body to become a highly active group. The Student Chapters participated in the UCT conference in Houston, the NASTT No-Dig Show in Washington, D.C., an estimating competition in Dallas, organized a field day demonstrating the latest trenchless technologies, and completed a Capstone course featuring trenchless technology.

Perhaps the most exciting event was the trenchless technology field day that was organized by NASTT Student Chapter president Anthony Macaluso and AGC Student Chapter Jake Carpenter on May 7. This event had J-Bar Construction demonstrating pipe-bursting, Sekisui SPR Americas demonstrating their spiral winding rehabilitation process, Baroid Industrial Drilling Products demonstrating drilling fluids, and the TTC opening its doors for public tours. The Trenchless Technology Field Day was held at TTC's National Trenchless Technology Research Laboratory on South Campus.

Incoming NASTT Student Chapter President Bryan Halterman, is already planning next year's field day and hopes to invite even more industry participation. The student chapters wish to thank J-Bar, Sekisui, and Baroid from their support for this event.

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