Quarterly Report 4 – Public Page

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Contract Number: *DTPH56-06-T-000005*

Prepared for: *DOT/PHMSA and AwwaRF*

Project Title: *Differential Impedance Obstacle Detection Sensor (DIOD) – Phase 2*

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Objective

The objective of the Differential Impedance Obstacle Device project is to develop a tool that can be coupled with a pipeline drill rig to detect pipeline obstacles in the drill path. The final deliverable is a device that can be commercialized. The form factor of the prototype must be such as to minimally impact the design of commercial drill heads. GTI will conduct a series of in-ground tests to prove that the DIOD can detect obstacles of at least three different materials (plastic, ceramic and metal) in at least three different soil materials (loam, sandy soil, and clayey-silt) and demonstrate that the sensor is robust enough to withstand HDD operating conditions.

Louisiana Tech University's Trenchless Technology Center is also assisting with the technical work. An advisory group with representatives from AGA, AGA, and APGA is overseeing the project.

Team Project Activities from Agreement

- **Task 1: Modeling.** Finite Element modeling of the Phase 1 prototype and the alternate configurations being considered will be discussed with the advisory group. The top choices will then be modeled by GTI and TTC.
- **Task 2: Fabrication/Testing of Prototypes.** One or more prototypes will be fabricated based on the models created by GTI and TTC. These models will be tested at one or both indoor testing facilities. Ideally they will be tested in a variety of soils with a variety of obstacles, but not yet tested with HDD equipment.
- **Task 3: In-Ground Testing/Commercialization.** The successful prototypes from the fabrication tasks will be tested with HDD rigs during simulated or live installations. Some initial testing may take place separately at GTI and TTC, but

it is expected the real tests will take place at TTC facilities. A commercial manufacturer will be pursued and invited to the in-ground tests.

- **Task 4: Program Management.** An updated state-of-the-art assessment that outlines different technologies being considered, their pros and cons, etc. will be submitted. The remainder of the task will include reporting, meeting, presentation, and demonstration requirements for DOT. It will occur throughout the life of the project, and will be performed in conjunction with the other work tasks, until such time as they are complete.

Progress to date

The Quarter 1 report described the functioning of the original DIOD model and a proposed modified design. The finite element analysis in that report utilized an electrostatic formulation mode and assumed that the drill head is suspended in air, which is equivalent to the drill head placed on a work bench in the laboratory. The dataset generated was intended to form the basis for validating the model during the experimental phase of the project. There was also some preliminary modeling performed to examine the feasibility of incorporating other technologies, such as Ultra-wide band (UWB.) The state-of-art assessment was completed and submitted to DOT/PHMSA.

In Quarter 2, modeling was performed to compare the original and alternative DIOD designs when embedded in soil. The quasi-static electric current mode was used in all simulation series. The analysis demonstrated that by limiting the source to a location in the forefront of the drill head assembly the field lines are better focused towards the center of the object. Furthermore, the field lines are projected further ahead in the case of the modified design and follow shorter return paths.

In Quarter 3, research progressed from the modeling task to the fabrication/testing task. All the external circuitry will be replaced with components that can fit within the pod. In Q3, most of the external components were replaced by smaller, more efficient components that will fit inside the sensor pod. Further re-redesign was conducted to incorporate other components and improve the circuit. Tests to validate the finite element models commenced. A fixture was designed to stand the pod on end and take measurements of pipe obstacles suspended in mid-air. The pipe obstacles are currently raised and lowered with a rope mechanism. Testing will take place in Q4. If results are similar, modifications will be made to the prototype to verify the results approximated by the alternate configuration. In Q3, a preliminary CAD model design of the next prototype. This model will be further improved as testing and electronics redesign continues. A “Success Story” Document for DIOD Phase 2 was created and submitted to DOT. Non-confidential background material and meeting notes were shared with members from the North American Society for Trenchless Technology (NASTT) Cross-bore Committee and the Common Ground Alliance (CGA) R&D Committee. It is expected both committees would serve in an additional advisory role, but there may be others involved with those groups that could be involved with DIOD-Phase 2 as operators or potential users.

The following took place in Quarter 4:

Task 2 (Fabrication/Testing of Prototypes)

- GTI continued with electronics re-design. All external excitation/sensing components are currently in the pod, except for a power connection and the RS232 connection that controls frequency selection for testing.
- GTI continued to take measurements above ground in the indoor pitlab with plastic and metallic objects. Test results show repeatability of data is improving. GTI is looking at incorporating other components to improve results more.
- La Tech ran additional models and compared their results with earlier GTI pitlab results. The overall behavior exhibited by the output of the numerical simulation matched the expectation as well as the overall trend of the experimental results. This provides some confidence on the model's predictions. From a purely theoretical stand point the sensitivity of the current design could be improved by reducing losses and interferences. Current redesigning efforts of the electronic components by GTI are aimed at achieving this goal. Many HDD related utility hits occur during the reaming process rather than the pilot bore stage. Thus, even with limited "see ahead" capabilities, DIOD proved "see aside" capabilities are of value in practice. Its simplicity, robustness and relative low cost of the system provide it with unique advantage over current competing technologies. The incorporation of a directional UWB antenna in the drill bit could augment the "see ahead" capabilities of DIOD.

Task 3.20 (Initial Contact with CM)

- Chris Ziolkowski met with members of the Common Ground Alliance (CGA) R&D committee at the PHMSA R&D Forum to discuss how CGA could get involved in the project, and see if they could assist in defining a commercial manufacturer. A request was made to present at the CGA R&D meeting March 6. DIOD-Phase 2 was presented with other GTI obstacle detection technologies by GTI personnel at the PHMSA Forum.
- Status of the project was presented at the Common Ground Alliance (CGA) R&D Meeting in Orlando March 6. GTI will send out the market study criteria created at the kick-off meeting for review/feedback by CGA. This was not originally budgeted in the OTA, but after discussion with the COTR, it was determined it was a worthwhile activity. Since there is some potential for a commercial manufacturer, it was decided to bill the activity to 3.20. No additional task 3 activity will be billed until approved by the advisory group (i.e. after Task 2 results presented.)
- Separately, GTI's commercialization specialist is reaching out to other sources to gauge interest in becoming a commercial manufacturer.

Task 4.01 (Project Management and Reporting)

- Submitted draft, final paper, and presentation for the No-Dig conference to be held April 15-20, 2007 in San Diego. Held a conference call March 22 with advisors (included in this report.)
- Took part in annual project peer review March 28, 2007.
- This quarterly report serves as milestone item 30, 4th Quarterly Status Report.