FINAL PROJECT SUMMARY REPORT

BUSINESS AND FIRM ADDRESS

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DOT SBIR Program

U.S. Department of Transportation/OST-R

DOT CONTRACT

6913G620P800102

PERIOD OF PERFORMANCE

07/27/2020 – 01/26/2021

PROJECT TITLE

Fiber Optic Sensors for Direct Pipeline Monitoring Under Geohazard Conditions – Geohazard Identification and Quantification for Pipeline Risk Models

SUMMARY OF COMPLETED PROJECT

The Department of Transportation (DOT) states in SBIR solicitation 6913G620QSBIR1 that there is a need for geohazard identification and quantification to improve and validate pipeline risk models. For reference please see this site: https://www.phmsa.dot.gov/news/phmsa-report-pipeline-risk-modelingoverview-methods-and-tools-improved-implementation which describes the current, as of February 2020, state of the art pipeline risk models. Our advanced multi-sensor fiber optic arrays, which include strain, temperature, and acoustic sensors, and in the future, pressure, will generate Industrial Internet of Things (IIoT) data that can be used for accurate and real-time input to enable continuous updating of risk models updated in real-time. The optical sensor array technologies we will deploy on and near pipelines will allow both periodic and continuous monitoring and identification of potential geohazard conditions and events surrounding pipelines in real-time. This will facilitate timely operator interventions that will mitigate the identified risks, thereby making the pipeline system much safer and more efficient.

The goal with our SBIR Phase I research is to demonstrate that distributed fiber optic sensing is a viable, robust, and cost-effective means to monitor pipelines in general and natural gas pipelines in particular. Specifically, we proposed the monitoring of those sections of pipelines located in potential geohazard areas and then plan to use the results to (i) gain insights into

improving pipeline risk modeling by making relevant data available, and (ii) develop fact and data-based monitoring solutions for geohazard prone locations. PI will work with PG&E to use the data gathered for improving the integrity management of their Natural Gas pipelines (ASME B31.8S), including nearly 7,000 miles of transmission, and 42,000 miles of gas distribution lines. In addition to the geohazard applications, the proposed technology can offer insights into the corrosion management, pipeline inspection, leak detection, maintenance, and 3rd tampering aspects of the risk assessment model. Distributed Strain Sensing (DSS), Temperature Sensing (DTS), and Acoustics Sensing (DAS) will all be investigated as viable means of pipeline monitoring for all aspects mentioned above. Properly installed, distributed fiber sensing offers a cost-effective long-term solution for pipeline operators. Upon project completion of this SBIR project, the pipeline operators will have several tested and verified options for both continuous and periodic monitoring systems:

1. A permanent monitoring system that will consist of the following components: A DSS configured to alarm both locally and remotely upon a detection threshold of strain or strain-rate. The monitored strain outputs can also be used to update risk models and adjust detection and alarm thresholds as needed and warranted; A DTS system for determining when external factors such as rain and shadows could cause temperature induced changes in the DSS response. Note, depending on the final fiber configuration, the DTS can be eliminated by using temperature nulling (Wylie, Colpitts, & Brown, 2011); A DAS system that can monitor for immediate threats such as nearby events that would cause an acoustic signal from leaks, rocks or soil moving, tampering, vehicles, animals, etc.

2. A periodic service, including machine learning data analysis, where the pipeline is monitored including a real-time report delivered to the operator. The results can then be used for risk model updates and possible adjustments in the monitoring schedule. The DSS will give static strain changes between time-lapse surveys and the DAS response will enable a check of the acoustic mode of the pipeline sections for possible defects (Hussels, et al., 2019).

APPROVAL SIGNATURES

Name	Title	Date
Bjorn Paulsson	CEO & President	Feb. 23, 2021