FINAL PROJECT SUMMARY REPORT

1. BUSINESS AND FIRM ADDRESS

Creare LLC, 16 Great Hollow Road, Hanover, NH 03755

2. DOT SBIR PROGRAM

U.S. Department of Transportation/OST-R

3. DOT CONTRACT

6913G618P800118

4. PERIOD OF PERFORMANCE

9/10/18 – 3/9/2019

5. PROJECT TITLE

Multimodal Acoustic Tool for Inline Pipe Inspection

SUMMARY OF COMPLETED PROJECT

The United States has a vast network of pipelines used for fuel transport. Traditional non-destructive inspection (NDI) methods are inadequate as they provide no means of extracting material properties. Many of these non-destructive evaluation (NDE) techniques have been developed for the sole purpose of identifying structural flaws, defects, corrosion, and the degradation of material thickness. Other techniques claiming to provide NDE through indentation methods are completely inadequate, initiating dangerous surface defects which could potentially propagate as cracks.

Through Department of Transportation (DoT) funding in collaboration with the Pipeline and Hazardous Materials Safety Administration (PHMSA), Creare has been developing a Multimodal Acoustic Tool for Inline Pipe Inspection (MATIPI). The focus of this work is the creation and testing of MATIPI, a compact, automated, and robust system simple enough to be used by minimally trained technicians to extract pipeline fracture toughness. MATIPI integrates independent methods of material characterization. Ultrasound pulse-echo and mechanical vibration measurements are cross-correlated to provide material fracture toughness of any pipeline vintage. The MATIPI consists of integrated high frequency ultrasound devices and accelerometers. One of these subsystems utilizes a pulse-echo technique to extract an ultrasound attenuation coefficient. The attenuation coefficient is a measure of the dissipation of total acoustic energy as an acoustic wave travels through the thickness of the material. The second technique relies on the vibratory response of an object to structural excitation. The material is mechanically excited, and the object's transient vibratory response is acquired and post-processed. The material's attenuation of ultrasound (AU) and attenuation of mechanical vibration (AMV) are then correlated to the material fracture toughness. Correlations are similarly

used to compute fracture toughness from Charpy V-notch (CVN) test data, which is a standard method used to report fracture toughness. In addition to directly reported material properties, our system is ultimately capable of reporting the maximum allowable operating pipe pressure.

As part of our SBIR funded Phase I project, we assembled and tested a proof-of-concept MATIPI system. Our system was tested at the Pipeline Research Council International (PRCI) located in Houston, Texas. A dozen fielded pipe cutouts, representing a wide range of diameters (8–40 inch), vintages, mechanical properties, and chemical compositions were inspected with our tool. Using our multimodal approach, data analysis algorithms, and developed correlations, we were able to predict fracture toughness for these pipes with high accuracy ($R^2 = 0.99$).

In Phase II, we will design and build a full-scale prototype and carry out fielded demonstrations with support from industrial collaborators. We will also continue to refine our Phase III commercialization strategies, working closely with venture capital firms for industrial environments. The Pipeline Monitoring System market is extremely attractive to potential investors, as it is projected to grow from USD 4.39 billion in 2016 to USD 6.14 billion by 2021.

We are extremely pleased with our technical achievement in Phase I. Our compelling results place us in an advantageous position as we culminate Phase I activities and request Phase II funding. We look forward to continue working with PHMSA representatives towards the common goal of enhancing pipeline safety during Phase II of this program.

The data in this Final Report shall not be released outside the government without permission of the contractor for a period of four years from the completion date (March 8, 2019) of this project from which the data was generated.

APPROVAL SIGNATURES

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR (Signature)
Francisco I. Valentin