REPAIR—Rapid Encapsulation of Pipelines Avoiding Intensive Replacement

PROJECT DESCRIPTIONS

Oak Ridge National Laboratory – Oak Ridge, TN

Structural Materials-aided Advanced Renewal Technology for REPAIR (SMART REPAIR) - $5,000,000

More than 60,000 miles of cast iron and bare steel gas distribution pipelines are still in service. Oak Ridge National Laboratory and its partners will develop a cost-effective and efficient smart structural coating deposition system and advanced high-end technology tools to inspect and rehabilitate gas distribution pipelines. The team will build on ORNL's success in developing low-cost carbon-fibers, composites, smart polymer materials, and non-destructive evaluation methods by leveraging expertise of partners on coating deposition and robotic inspection tools for smart repair of gas pipes. The designed polymer composite coating materials provide structural strength and facile processability with smart functionalities. Integrated robotic technologies for coating deposition and non-destructive multiscale interrogation of the pipe enable delivery of the complete solution for rehabilitation of gas distribution pipelines.

University of Colorado, Boulder – Boulder, CO

Testing and Analysis of Pipeline Encapsulation Technologies - $5,400,000

The University of Colorado Boulder will lead a multi-institutional team to develop a data-driven framework of physical testing and modeling to enable the gas industry to better evaluate products to rehabilitate cast iron and steel natural gas pipes and enhance their performance and longevity. The objective is to validate a 50-year design life for innovative pipe-in-pipe (PIP) systems by developing numerical, analytical, and physical testing protocols. Attributes of each approach are merged to deliver a comprehensive framework for PIP technologies composed of a variety of materials and deposition methods. University of Colorado Boulder's framework characterizes failure modes and establishes performance criteria for pipe replacement technologies to support recommendations for PIP material properties suitable for acceptable design-life performance.

General Electric Global Research – Niskayuna, NY

PipeLine Underground Trenchless Overhaul (PLUTO) - $5,000,000

General Electric (GE) Global Research plans to deploy PipeLine Underground Trenchless Overhaul (PLUTO), a long-distance, minimally invasive pipe repair system that provides structural rehabilitation of gas pipelines at unprecedented speed and efficiency at lower cost than traditional open-cut excavation replacement. The GE team, including Warren Environmental and Garver, will develop and integrate a highly dexterous long-range pipe crawling (robotic) system, high-speed non-destructive evaluation technologies, and advanced spray-on thick-coating epoxy lining systems that achieve results in the water and wastewater domains. The PLUTO system to provides efficient pipeline maintenance, a key enabler to lower emissions by reducing pipeline transit loss and maintenance burdens.

University of Maryland – College Park, MD

Pipe-in-Pipe by Rapid, Continuous, Smart Alloy Coating - $1,000,000

The University of Maryland (UMD) proposes a multifaceted and integrated approach to develop a smart alloy coating for use in pipe-in-pipe configurations with UMD's patented high-temperature sintering process. A novel smart alloy coating is rapidly sintered with a high-temperature Joule heating bar directly from the alloy powders in approximately 10 seconds. The coating can be scaled to meet commercial market demands due to its high sintering density, mechanical strength, and self-healing properties. UMD's technology is targeted to be capable of generating new steel pipe to replace older infrastructure at a lower cost for gas service and with improved mechanical strength and corrosion resistance on a 50-year lifetime.

Autonomic Materials – Champaign, IL

Autonomous Rehabilitation and Maintenance of Natural Gas Pipes - $5,000,000

Efforts to excavate and replace legacy natural gas distribution pipes are increasingly costly. Autonomic Materials offers a cost-effective and durable solution: the robotic construction of a novel, structurally independent self-healing and self-reporting pipe placed inside of the legacy infrastructure with minimal disruption of gas services. The modular robotic platform will not only construct the new pipe, comprised of a tough and durable polymeric material, but will also inspect the old and new infrastructure. The solution will eliminate manual efforts to detect and repair damage in the new pipe material by providing real-time data and visualization.

Carnegie Mellon University – Pittsburgh, PA

Confined Space Mapping Module for In-Pipe Repair Robots - $1,200,000

Field technicians and engineers require 3-D maps of pipeline infrastructure, and REPAIR technologies also need 3D maps to record items such as anomalies, leaks, wall thickness, and results of coating deposition. Map creation is challenged by the limitations associated with confined spaces, including those related to the size of sensor payload and the minimum offset distance between sensor and environment. Carnegie Mellon University (CMU) will develop comprehensive tools to rapidly deploy next-generation inspection and service machinery into pipes by integrating sensory signals (such as Lidar, ultrasounds, eddy current, etc.) with advanced robotics systems to create an in-pipe map. CMU will work with REPAIR teams to demonstrate its mapping system with other robots. The result will be a "box" containing all necessary software, electronics, and sensors that can integrate with any robot, to perform mapping in a pipe.

University of Pittsburgh – Pittsburgh, PA

"Innervated" Pipelines: A New Technology Platform for In-Situ Repair and Embedded Intelligence - $1,000,000

The University of Pittsburgh will pursue a new vision for in-situ repairs of pipelines and embedded intelligence: "innervated" pipelines. The technology has value-added enhanced corrosion protection and embedded sensing to complement existing non-destructive evaluation and in-line inspection techniques. Experimental and physics-based models of defect acoustic signatures within a pipeline will identify defects through supervised training of artificial intelligence-based pattern recognition algorithms. Additionally, a digital twin framework will integrate technologies and be applied to a representative distribution pipeline incorporating enhanced corrosion resistance of new coating technologies. The team will develop an economic model for in-situ repair and sensor-embedded coating as well as a detailed set of modifications to existing and standard regulatory requirements.

University of Delaware Center for Composite Materials – Newark, DE

TuFF Internal Wrap for Rapid Pipeline Repair (TuFF iWRAP) - $5,954,637

The University of Delaware has created the "TuFF internal WRAP for Rapid Pipeline Repair" (TuFF iWRAP) program, establishing a novel composite material feedstock and robotic placement process to fabricate stand-

alone structural pipe within existing pipelines. The project's innovation is enabled by a low-cost, high-performance, and conformable short fiber feedstock based on the Tailorable universal Feedstock for Forming (TuFF) material. A two-step repair strategy is proposed, where straight and slightly curved pipe sections will be internally wrapped and then repaired using complex geometry pipe transitions, such as T-joints, diameter reductions, and steep bends. A new robotic-based design will be deployed for straight sections, allowing for continuous placement of the TuFF material and creating a stand-alone structural liner within the legacy pipeline without shutting it down. The material is supplied nonstop using a tethered material feeding system and is placed and UV-cured with the internal Wound Rapid Automated Placement (iWRAP) system. If successful, the TuFF iWRAP project would lower costs by 50%, extend the length of pipe repair sevenfold, and reduce societal costs by maintaining gas delivery to customers during repair.

White River Technologies – Newton, MA

New and Innovative 3D Mapping Technology to Enable Rehabilitation of Natural Gas Pipe Infrastructure - $2,000,000

White River Technologies will deliver an improved capability to reliably detect, locate, and position natural gas distribution mains and associated utilities in pipe corridors. The proposed approach optimizes mature advanced 3D electromagnetic technologies to solve specific pipeline detection and location problems, offers an innovative in-pipe positioning system to pinpoint the location of REPAIR robots, and delivers a modern and efficient REPAIR data management and visualization system. Additionally, the project includes a comprehensive, inclusive, and robust REPAIR data management and visualization system to provide an integrated and interactive data delivery system.

ULC Robotics – Hauppauge, NY

Cold Spray Additive Manufacturing for New Pipeline Fabrication in Live, Natural Gas Distribution Mains - $1,000,000

Old cast iron and bare steel natural gas pipelines nearing the end of their life are prone to leaking, potentially releasing methane into the environment. Replacement is expensive, which deters pipeline operating companies from fixing leaks. ULC Robotics will research and test a method for fabricating new pipes using Cold Spray Additive Manufacturing. New pipes will be built inside of existing natural gas pipelines through a small excavation site without shutting off gas to customers. This will lower the costs of rehabilitating pipelines. Optical fiber sensors incorporated into the newly fabricated pipe will allow for continuous monitoring of the pipe's health enabling operators to make better risk-based decisions for preventing future leaks.