

## EXPLORER-II™: An Integrated Robotic Platform and Sensor System for the Inspection of Unpiggable Pipelines

**Description:** Sophisticated, self-propelled robotic platform and innovative sensor system to address live NDE inspection for 6" and 8" diameter pipelines up to 750 psi pressure.

**Status:** Field Demonstrations underway.

### BENEFITS

**Explorer-II™** is a modular, tetherless, robotic platform featuring a Remote Field Eddy Current (RFEC) sensor for the non-destructive evaluation of gas transmission and distribution pipelines. This system is adding to the capabilities of the EXPLORER™ platform, which has already been developed for the visual inspection of 6" and 8" distribution mains, by integrating a sensor able to provide non-destructive evaluation of the pipeline and by upgrading the platform so it can operate at transmission pipeline pressure levels. As a result, Explorer-II will allow the use of Non-destructive Evaluation (NDE) technology both in the distribution and transmission systems, and particularly in the 6"-8" unpiggable pipelines sector, a diameter range particularly popular in the industry.

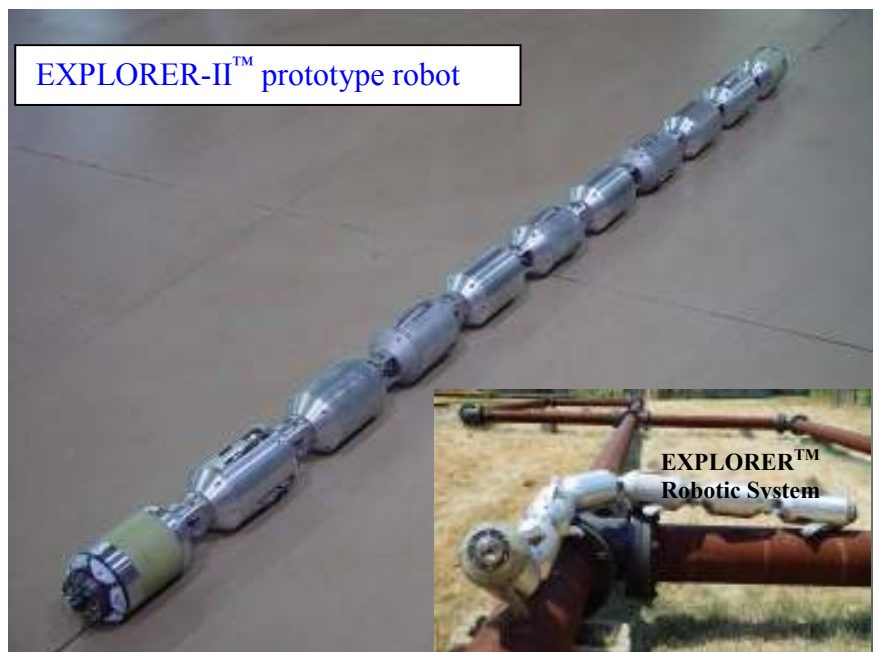
The use of this technology will allow the gas industry to meet the requirements of the 2002 USDoT/OPS ruling regarding the management of the nation's transmission pipeline infrastructure. It is anticipated that it will result in savings in excess of \$500,000 per year in the case of

inspection of a 200-mile gas transmission system, in addition to providing pipeline condition data of quality that cannot be generated by any other available technology.

### BACKGROUND

The EXPLORER™ development effort, initiated in January 2000, was completed in 2004 and has entered the commercialization phase. EXPLORER™ was designed as a visual inspection tool, and features a modular design that allows the robot to negotiate bends, tees, and other obstacles within a main. The robot is

self-propelled, using on-board batteries, and is tetherless due to its use of wireless communication between robot and operator, for the transmission of control commands and live images from the robot's cameras. The modular design of the system allows the future addition of complementary capabilities that could expand its field of use. The introduction of non-destructive evaluation (NDE) tools for both transmission and distribution lines are thus possible and were the focus of the present effort towards the development of EXPLORER-II™.



## TECHNICAL APPROACH

NYSEARCH, the research, development, and demonstration organization within the Northeast Gas Association, with co-funding from the National Energy Technology Laboratory of the US Department of Energy and the Office of Pipeline Safety of the US Department of Transportation retained the Robotics Institute at Carnegie Mellon University (the developer of EXPLORER™) to develop EXPLORER-II™, a modular tetherless, self propelled robotic platform for the NDE of transmission and distribution natural gas pipelines. The NDE sensor technology used was developed by the Southwest Research Institute (SwRI) and is based on the Remote Field Eddy Current technology.

EXPLORER-II™ is an inspection tool for the visual and NDE characterization of gas transmission and distribution pipelines. Given that it is self-propelled and can negotiate mitered bends and tees, it is able to inspect pipelines that are presently unpiggable due to either low flow/pressure or the presence of mitered bends or other obstacles (excluding plug valves). This platform is able to operate in and inspect six to eight inch diameter pipelines at pressures up to 750 psig. An EXPLORER-II™ unit consists of two camera modules, two drive modules, two or more battery modules, three support modules, and two sensor modules. The use of radio communication and rechargeable battery power has freed the robot from a power / communications tether, thus offering long ranges of opera-

tion from a single launching point.

The two camera modules at the two ends of the robot contain the lighting and cameras (with a 190-degree field of view) for visual data collection. In the future, the miniaturized, rugged cameras will be supported with dewarping and mosaicing software for better images of the pipe wall. On-board wireless communication allows EXPLORER-II™ to broadcast real-time color images of the pipe interior to the operator who controls the unit's speed and direction of travel. In addition, the data collected by the sensor will be transmitted live to the operator, offering the capability of near-real time view of the NDE data. The robot is introduced into the live gas pipeline through a launch chamber, which is attached to a commercial tap-and-drill system, designed for live access to the pipe.

The RFEC sensor was especially designed for Explorer-II so that it does not limit its ability to operate in unpiggable pipelines. Two modules are used to deploy the sensor. One is used to store the fixed diameter excitation coil, which is driven with alternating current to produce the flow of eddy currents in the circumferential direction in the pipe wall. Sensors placed adjacent to the pipe wall in another module measure these electric currents, which are sensitive to material-loss defects such as corrosion.

## PROGRAM STATUS

The EXPLORER-II™ effort was initiated in late 2004. Extensive laboratory testing

was completed in early 2007 at which time the RFEC sensor was integrated into the platform. Following extensive laboratory testing of the integrated system in the laboratory, the system was successfully deployed in a live pipeline in the Fall of 2007. Experience gained from this deployment is used to further improve the system prior to additional live testing during 2008.

## FOR ADDITIONAL INFORMATION

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