

Explorer Wireless Range Extender

Description: Develop technology(ies) to extend the range of the wireless communication of the Explorer series of robots to improve efficiency and productivity of inspections of unpiggable pipelines.

Status: Detailed design complete; Project moving to field testing and initial commercialization.

BENEFITS

Increasing the range of the Explorer series of robots has been an early target of the NYSEARCH consortium. Having developed a full range of Explorer platforms, having developed a suite of sensors able to detect corrosion defects, cracks, and mechanical damage, and having developed a system to provide additional power to the robot via energy harvesting methods, in recent years, we have focused our efforts on extending the range of the wireless communication system used on the robots. This is the last known barrier to long range operations, significantly higher operational efficiencies, reduced inspection cost, and lower risk inspections.

BACKGROUND

A Phase I project was approved by NYSEARCH members in June 2021 to initiate the effort to develop the technology(ies) that will allow the extension of the wireless communication range of the Explorer series of robots. Work was focused on carrying out a feasibility study to identify concepts for the mechanical, electrical, and communications subsystems.

A final report presenting the results of this effort was issued in February 2022. It details a concept based on a modified Explorer drive module to which deployable antennas could be attached. These antennas are to be deployed on the pipeline wall once wireless signal power and bandwidth have dropped significantly, thus re-establishing proper communication with the robot and allowing the robot to travel further.

A preliminary mechanical design of these deployable antennas and the system to deploy them and retrieve them was carried out. A proposed

electrical hardware concept was also created to assist in lab testing of the various options in InvoDane's radio frequency (RF) signal test loop to compare new communication network devices and protocols that have recently emerged commercially and which provide longer wireless signal ranges (see Figure 1).

Four potential electrical hardware options were studied extensively with two of them finally deemed the most promising. The combination of the two selected hardware options with the deployable antennas, provides an increase in inspection range of more than five times the current one, while the latter may offer increases in inspection range of more than ten times the current one.

InvoDane/Intero, the technology developer, recommended that Phase II of the project develop an engineering prototype for the dual-radio mesh option, and further study the feasibility of the software-defined radio technology in order to better define its potential.



Figure 1: The GL.iNet GL-AR750S wireless system was one of many considered for integration on Explorer

TECHNICAL APPROACH

The project objective was to develop the technology(ies) that will allow the extension of the

wireless communication range of the Explorer series of robots. Increased range improves efficiency and productivity of inspections of unpiggable pipelines. The work by InvoDane focused on designing, building, and laboratory testing the deployable antenna systems with their associated mechanisms for attachment to the robot and the pipe. Also, the wireless technology itself was upgraded.

This project was organized in six tasks. At the outset, the focus was on design and included detailed mechanical, electrical, and software design. The drive modules were modified to include the deployable antenna modules. The nose modules were modified to accept the new receivers/transceivers and software. Next, manufacturing and assembly of the range extender antenna modules as well as the deployment apparatus on the drive modules were carried out. The assembled antenna modules were then installed on the Explorer 2026 test robot.

Full system laboratory testing of the new antenna systems was carried out and any needed changes to the design were implemented. Other robot sizes (by pipe diameter) were investigated and challenges that need to be studied with respect to implementing the new system in the other Explorer platforms, from the X6 to the X3036.

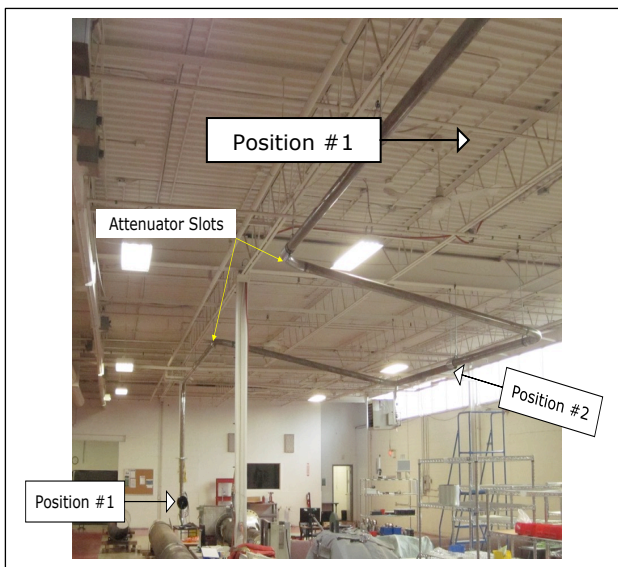


Figure 2: Test Loop for Antenna Deployment

The aforementioned study will indicate whether this basic design concept can be used for the other robot sizes.

Communication protocol enhancements were explored related to the use of software-defined radio as a future, longer term improvement of the communication system. Initial results indicate that approach could result in further improvements in range.

Finally, the deliverables for Phase II of the project included a final report which details the final design of the system and testing results and analyses, as well as implications for a future implementation of the software-defined radio communication system. It also includes a plan for the next phase of the project which involves development of the software-defined radio communication operation, full field testing, and initial commercialization.

PROGRAM STATUS

The detailed design of the Explorer wireless range extender is complete and a design prototype was successfully manufactured, assembled, and integrated onto and tested on a 26” test robotic platform. The new antenna system was designed, tested, and deployed along with the selection of enhanced communication protocols. These new methods are comprised of dual systems, which significantly increase the wireless range of the communication system, thereby increasing Explorer’s operational efficiency and productivity.

Highlights

- An innovative antenna system was designed, developed and adapted to the EXP2026 robotic platform.
- Communication protocol enhancements were identified and successfully tested, with a combination of new equipment offering the highest efficiency improvements.

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